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Perceptions and practices of household heads toward malaria: a community based cross sectional study in Southwest Ethiopia

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Abstract

Background Despite ongoing preventive efforts, malaria remains a significant global public health agenda. While numerous studies focus on malaria prevalence, and inadequately assess community perceptions and beliefs regarding the disease. Addressing these perceptions is crucial for developing effective and sustainable interventions. This study aims to address these gaps by evaluating the perceptions and practices of household heads and representative family members concerning malaria.

Methods A community-based cross-sectional study was conducted with a sample size of 1,883 households, calculated using the double population proportion formula via OpenEpi calculator. This calculation was based on a bed net utilization rate of 72.2% in the Ilu Galan District, Oromia Region, Ethiopia, with a 95% confidence level, 80% power, a 3% margin of error, a 10% non-response rate, and a design effect of 2. A multi-stage stratified sampling technique was employed to select administrative Woredas and towns across six zones in Southwest Ethiopia, further divided into 44 urban and rural kebeles. Kebeles and household selections were made through simple random sampling. Data were collected using a structured questionnaire and observation checklist. After ensuring data completeness and consistency, statistical analysis was performed. Predictor variables with $p \leq 0.25$ during bivariable analysis were subjevted for multivariable logistic regression, and associations measured using adjusted odds ratios and 95% confidence intervals, considering statistical significance at $p \leq 0.05$.

Results The study achieved 82.4% response rate. Among participants, 31% from 69% of households reported that malaria they were infected in the past 28 days. Of these, 55.2% did not complete their prescribed treatments, and 61.8% believed malaria could be transmitted through contact with an infected person's sweat. Daughters and housewives showed lower knowledge of malaria transmission ($p \leq 0.01$). Higher education levels among household heads were linked to better practices regarding insecticide-treated bed nets (AOR = 0.28, 95% CI 0.12–0.63, $p \leq 0.01$).

Conclusion This study highlights a significant proportion of the population affected by malaria, alongside misconceptions that may hinder prevention efforts. Therefore, malaria prevention strategies should be comprehensive, sustainable, targeting households importantly and gender-inclusive.

Keywords Household heads, Malaria, Perception, Practices, Southwest Ethiopia

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Background

Malaria is a protozoan infection that affects red blood cells and is transmitted by blood-feeding female *Anopheles* mosquitoes [1]. Malaria is a preventable and curable parasitic disease if all vector, human, and environment-targeted prevention strategies are properly applied, as well as early diagnosis and proper treatments done as per guidelines [2]. Globally, malaria affects 3.3 billion people across 100 countries, with 241 million cases and 627,000 deaths in 2020 alone [3].

In 2021, WHO reported that the African region bore the heaviest burden of malaria, accounting for 234 million cases and 593,000 deaths, which were 95% and 96% of the global total, respectively [4]. Despite proven prevention and treatment strategies, malaria remains a devastating public health and economic burden globally, affecting all populations in endemic areas, though with varying susceptibility and severity [5]. Malaria prevalence was decreased from 2010 to 2014 but has been rising since 2015 [4]. Because progress toward malaria control began to slow after 2015, and gaps in access to equitable and quality care remain an important challenge to malaria [6].

Malaria prevalence is highly influenced by climate change and displacements [2]. Rural areas typically have higher malaria transmission rates, but urban areas in sub-Saharan African countries are also accounting for a notable increase in transmission [7]. People of all age and ethnic groups are at risk of malaria, but most malaria deaths in Africa occur in young children [4, 5]. Children and individuals new to areas of intense malaria transmission and lacking immunity from prolonged exposure are highly at risk of the disease annually [1]. Malaria's burden extends beyond public health, imposing a significant economic strain on rural households and hindering economic development in sub-Saharan African countries [8]. Malaria costs Africa US$12 billion annually, yet nearly 30% of its population lacks access to affordable, and essential healthcare [4].

The World Health Organization (WHO) recommends indoor residual spraying (IRS) as a proven method for reducing malaria cases and deaths over the past two decades by targeting endophilic vectors and reducing transmission [2]. Vector control is a crucial element of malaria control and elimination strategies, as it effectively prevents disease transmission [9]. Vector control methods vary significantly in their applicability, cost, and sustainability. For instance, insecticide-treated nets (ITNs) protect human–vector contact [2]. Indoor residual spraying (IRS) effectively reduces vector populations [9]. Effective management of indoor residual spraying (IRS) is crucial to prevent insecticide misuse and the development of vector resistance [2, 10].

Malaria control relies on integrated strategies like indoor residual spraying (IRS) and ITNs. IRS, which targets resting mosquitoes, significantly reduces transmission with strong national support and infrastructure and accounts for nearly 60% of global malaria control investments [2, 11]. Between 2008 and 2010, a significant expansion of malaria control programmes in sub-Saharan Africa led to the distribution of insecticide-treated nets (ITNs) to over 578 million people at risk of the disease [4]. Similarly, indoor residual spraying (IRS) significantly impacted malaria control in 2009, protecting an estimated 75 million people [12]. However, evidence suggests that neither ITNs nor IRS alone will be sufficient to interrupt malaria transmission in highly endemic regions of Africa [13]. Community involvement and training for community workers and supervisors are crucial factors for the effectiveness of both ITNs and IRS [14].

Despite significant progress toward malaria elimination by 2030 an official goal supported by updated guidelines and efficient implementation [2], malaria remains a major public health challenge in Ethiopia, affecting 75% of the land area and 68% of the population [2, 6]. Due to the unstable and seasonal transmission of malaria in the country, the protective immunity of the population is generally low, and all age groups are at risk [6]. Malaria-related morbidity and mortality remain a concern, particularly *P. falciparum* accounting for 70% of malaria deaths, often due to delayed treatment [4].

Malaria prevalence among adults in Ethiopia remains high (13.61%), particularly in the South West Ethiopia Peoples Region State (SNNPRS), Oromia, and Amhara regions [8]. Existing malaria control efforts have not effectively addressed persistent misunderstandings and harmful beliefs about the disease, its transmission, and treatment among at-risk populations. This, study aims to fill these gaps and recommend resource-efficient interventions and educational programmes including females and youths at household levels. This study finding will show an effectiveness of existing malaria control programmes and inform public health policy makers to enhance community empowerment.

Methods

Study area and period

This study was conducted in the Southwest Ethiopia People's Region (SWEPR), which is divided into six administrative zones (Kaffa, Sheka, Bench Sheko, Dawro, West Omo, and Konta). These zones are further subdivided into 16 town administrations, 41 Woredas, and 883 kebeles. The region's projected population for the 2023 fiscal year is 3,368,384, with females comprising 50.5% (CSA). In SWEPR, there are 14 hospitals, 125 health centres, 812 health posts, 452 private clinics, and 128 drug stores, staffed by 143 medical doctors, 1,638 clinical nurses, and 447 midwives. Malaria is a leading cause of morbidity in SWEPRS, with 24,723 cases reported in 2015 E.C. (DHIS/2). Data collection occurred from July 1 to July 30, 2023 (Fig. 1).

Study design

A community -based cross-sectional study design was carried out in six zones of Southwest Ethiopia Peoples Regional State (SWEPRS).

Source population

All existed households and family members in Southwest Ethiopia Peoples Regional State (SWEPRS).

Study population

All selected households, and residents in SWEPRS.

Inclusion criteria

This study included all permanently residing and registered households and residents within the selected kebeles, irrespective of socioeconomic, cultural, or ethnic background. The primary participants were household heads aged 18 years or older. If the household head was unable to participate due to health issues or unavailability after three visits, a randomly selected adult household member (male or female) was included instead.

Exclusion criteria

Households and residents not residing in the selected kebeles for the past six months or temporarily settled were excluded. Extended family members, visitors, or guests, and individuals who were severely ill and unable to respond were excluded.

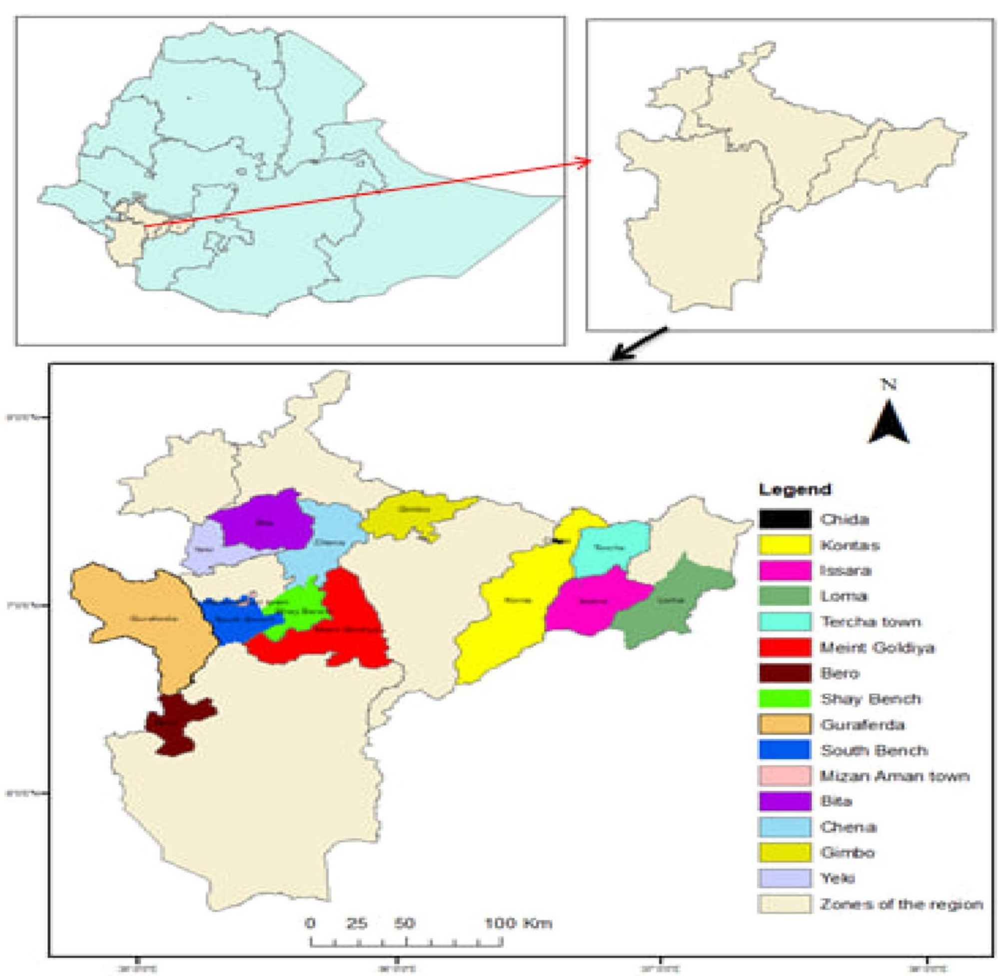

Fig. 1 Map of the study areas in SWEPR

Sample size determination

A sample size of 1,883 households was calculated using OpenEpi's double population proportion formula, based on a 72.2% bed net utilization rate from Ilu Galan District, Ethiopia [15], with 95% confidence, 80% power, 3% margin of error, 10% non-response rate, and a design effect of 2.

Sampling procedure

Using a multistage stratified sampling approach, 14 Woredas and six towns were purposively selected from six zones within SWEPRS. Selected Woredas were then stratified into 44 urban and rural kebeles, from which households were randomly selected. Data were collected via interviewer-administered observation checklists and questionnaires completed by household heads. Households were deemed non-responsive after three unsuccessful visit attempts.

Data collection methods and quality assurance

Data were collected via interviewer-administered questionnaires and structured observation checklists. The questionnaire, adapted from a previous study [16], and translated into local languages with back-translation to English, assessed sociodemographic characteristics, knowledge, attitudes, and malaria prevention practices (82 questions total). A structured observation checklist was used in outpatient departments of public health facilities. Thirty data collectors (minimum bachelor's degree) and six supervisors (master's degrees) proficient in local languages were recruited and trained. Pre-testing (5% of sample size) was conducted in excluded woredas and kebeles in the region. After subsequent corrections, data were collected using Kobo Collect on smartphones with GPS tracking, and daily supervision ensured data completeness and immediate corrections.

Operational definitions

Utilization of bed net: refers the proper and regular utilization of bed net and all house hold members slept under it during night and day time checked by data collectors and supported with structured observation checklist infection [15].

Adherence to malaria case management: Evaluated based on the recommendations of the 2022 updated national malaria case management and testing guidelines.

Indoor residual spraying: The application of long-acting chemical insecticides with a residual effect on the walls and ceilings of all houses and domestic animal shelters in a given area, on which adult vector mosquitoes rest [17].

Environmental management: refers identifying mosquito breeding areas, the planned, organized, carried out and monitored activities for the modification and/or manipulation of environmental factors, with the aim of preventing or minimizing vector breeding and reducing human-vector-parasite contacts. Draining stagnant water near the compound, removing vessels that could potentially hold water and serve as mosquito breeding sites, and clearing overgrown vegetation within 5 m of houses.

Household head: Any person either male or female who owns a particular house and responsible for the entire family.

Data processing and analysis

Data were analysed using STATA version 16. After checking data consistency (VIF <10) and internal consistency (Cronbach's $\alpha = 0.81$ for Likert-scale questions), participant knowledge, attitude, and practice levels were categorized based on mean score cut-offs ($\geq$ mean = good/favourable; $<$ mean = poor/unfavourable) [20]. Descriptive statistics were computed and presented in tables and graphs. Variables with a bivariate association ($p < 0.25$) were included in multivariable logistic regression. For this large sample sized study, model goodness-of-fit was assessed using the Hosmer–Lemeshow test ($p > 0.65$) and Omnibus test ($p < 0.003$). Statistical significance was set at $p < 0.05$.

Results

Socio-demographic characteristics

This study covered 19 of 20 Woredas (95%) and 43 of 47 kebeles (91.5%), achieving an 82.4% response rate (1552 of 1883 households). Most participants (88.3%) resided in rural areas, and the majority of households (77.8%) were male-headed. The mean age of household heads was 41.7 years (SD = 12.7), while the mean age of respondents was 34.9 years (SD = 12.8). A substantial proportion (44.5%) of household heads had no formal education, and most (74.5%) were employed in agriculture (Table 1**).**

Malaria incidence rate in terms of residents

Approximately 31% of respondents reported a history of malaria infection in the last 28 days, and 69% of household heads reported at least one family member infected. Among those reporting malaria, 56% had laboratory-confirmed infections. Of the confirmed cases, *P. falciparum* was predominant (58%), followed by *P. vivax* (30%) and mixed infections (12%) (Fig. 2). Malaria prevalence was higher in rural areas, affecting 31.5% of individuals and 68.6% of households, compared to urban areas (28.2% of individuals and 71.8% of households) (Fig. 3). Among the six zones, Dawuro had the highest individual-level malaria prevalence (35.6%), followed closely by Konta (34.5%). At the household level, the highest prevalence rates were observed in Konta (73.6%), West Omo (71.7%), and Bench Sheko (70.8%) (Fig. 4).

Table 1 Sociodemographic characteristics of study participants to assess malaria prevention practices in SWEPRS

Variable	Category	Frequency	%
Resident/location	Urban	181	11.70
	Rural	1371	88.30
HHs' head sex	Male	1207	77.77
	Female	345	22.23
Respondents' sex	Male	662	42.65
	Female	890	57.35
Role of respondent	Father	820	52.8
	Mother	166	10.7
	Daughter	534	34.41
	Son	32	2.06
HH heads' marital status	Single	49	3.16
	Married	1327	85.5
	Widowed	121	7.80
	Divorced	55	3.54
HHs' head educational status	No formal education	691	44.52
	Primary (Grade 1–8)	490	31.57
	Secondary (Grade 9–12)	196	12.63
	Diploma	88	5.67
	Degree	80	5.15
	Master	7	0.45
Respondents' educational status	No formal education	691	44.52
	Primary (Grade 1–8)	490	31.57
	Secondary (Grade 9–12)	196	12.63
	Diploma	89	5.73
	Degree	78	5.03
	Master	8	0.52
HHs' head occupation	Farmer	1156	74.48
	Daily labourer	44	2.84
	House wife	46	3.09
	Student	17	1.10
	Merchant	106	6.83
	NGO/community's org	22	1.42
	Government employee	159	10.24
Respondents' occupation	Farmer	730	47.04
	Daily labourer	37	2.38
	House wife	393	25.32
	Student	191	12.31
	Merchant	87	5.61
	NGO	15	0.97
	Government employee	99	6.38
Family size	≤5	718	46.62
	> 5	834	54.38
Type of house	Tukul (thatched roof)	274	17.65
	CIS	1278	82.35
Pregnant mother in the house	Yes	247	15.91
	No	1305	84.09
Under 5 child in the house	Yes	558	35.95
	No	994	64.05

CIS: Corrugated iron sheet, ETB; Ethiopian birr; HH: Household; NGO: Non-governmental organization

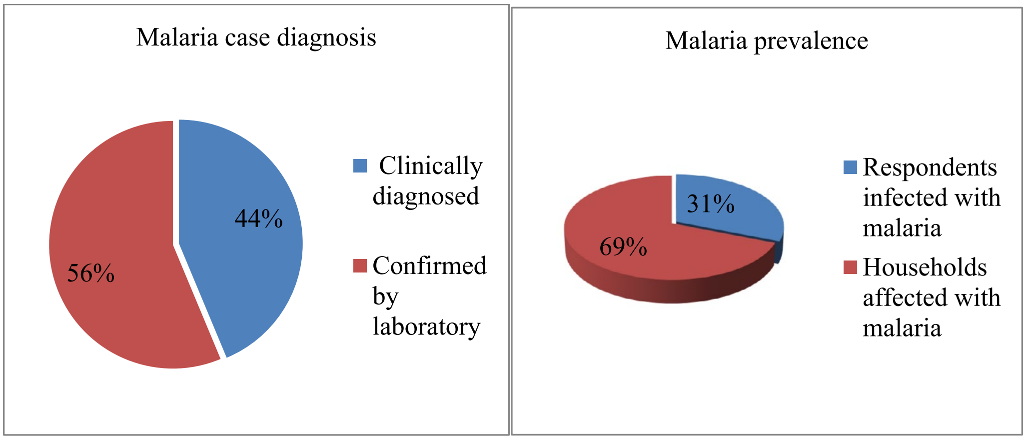

Fig. 2 Malaria diagnosis methods and prevalence among respondents in SWEPRS

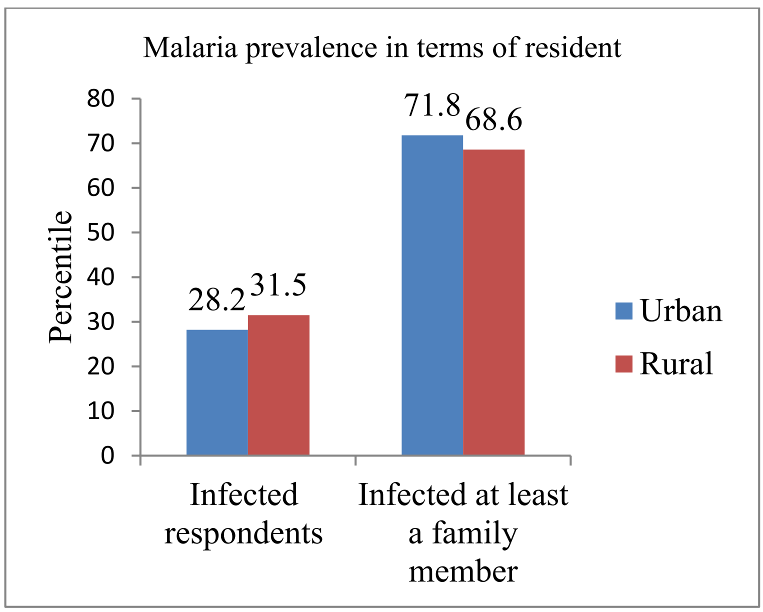

Fig. 3 Malaria incidence rate among urban and rural residents in SWEP

Knowledge toward malaria transmission modes

Respondents in West Omo (74.7%) and Dawuro (70.4%) demonstrated poor knowledge of malaria transmission, while fewer respondents in Konta (29.9%) and Bench Sheko (24.1%) showed poor knowledge of malaria symptoms (Fig. 5). While most participants (89.8%) correctly identified mosquito bites as the primary transmission mode, a substantial proportion (61.8%) incorrectly believed as malaria could be transmitted by sleeping with infected individuals. Misconceptions about transmission also included other insect bites (42.9%), poor personal hygiene (47.2%), and contact with a patient's sweat (45.4%) (Fig. 6).

Attitude toward malaria prevention methods

Above three-fourths and two-thirds of participants across all six zones held unfavourable attitudes toward malaria treatment and prevention methods, respectively. Moreover, above half of participants were demonstrated unfavourable attitudes toward the causative factors for malaria in all six administrative zones of SWEPRS (Fig. 7).

Practices toward malaria prevention methods

The majority (90%) of participants preferred indoor residual spraying (IRS) as a primary malaria prevention method. However, only 24% were beneficiaries

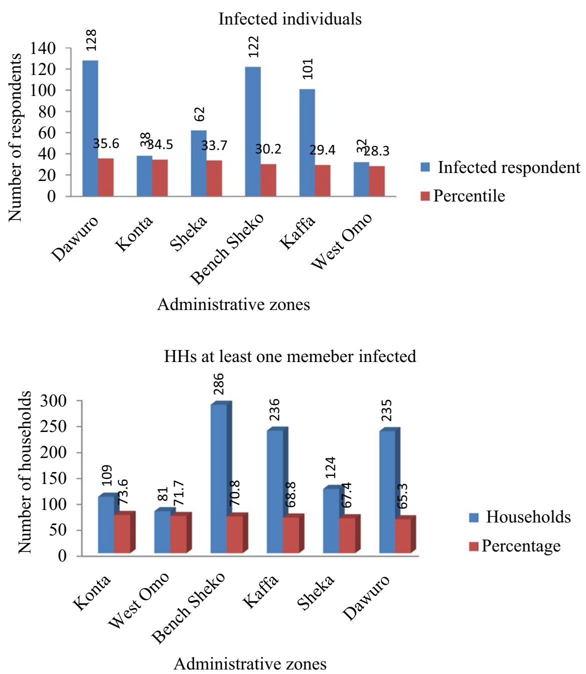

Fig. 4 Malaria incidence rate at Individual and household level in six zones of SWEPR

practically, and the barrier was lack of government-supplied chemicals. Additionally, over 80% of participants were poorly practiced environmental management activities for malaria prevention (Fig. 8).

Among participating household heads, over half (63.7%) of them demonstrated poor knowledge of malaria prevention methods, 76.2% held unfavourable attitudes toward malaria treatments, and 85.2% and 92.8% poorly practiced environmental management and IRS utilization, respectively (Fig. 9). Among the factors affecting malaria treatment adherence, sharing with others was 28.8%; feeling cured and terminating medications, 22.7%; and unaffordable costs, 19.6% (Fig. 10).

Factors associated with KAP toward malaria

Household heads aged between 40-49 years [AOR =0.55 (95% CI 0.31–0.98, $p \leq 0.04$)] and 50 - 59 years [AOR =0.47 (95% CI 0.21–1.02, $p \leq 0.05$)] were significantly associated with knowledge about malaria mode of transmission compared to younger age group (18-28 years). Family members aged between 50–59 years [AOR =2.05 (95% CI 1.02–4.13, $p \leq 0.04$)] also similarly significantly associated with knowledge about malaria mode of transmission compared to young participants (18-28 years old).

Respondents who were completed formal education (Grades 1–12) [AOR =1.38 (95% CI 1.05–1.81, $p \leq 0.02$)] and those with a college or higher education [AOR =1.72 (95% CI 1.05–2.81, $p \leq 0.02$)] were twice more likely demonstrated good knowledge regarding malaria transmission modes compared with participants who were not able to read and write. Among family members, daughters [AOR =0.30 (95% CI 0.11–0.77, $p \leq 0.01$)], and housewives [AOR =1.67 (95% CI

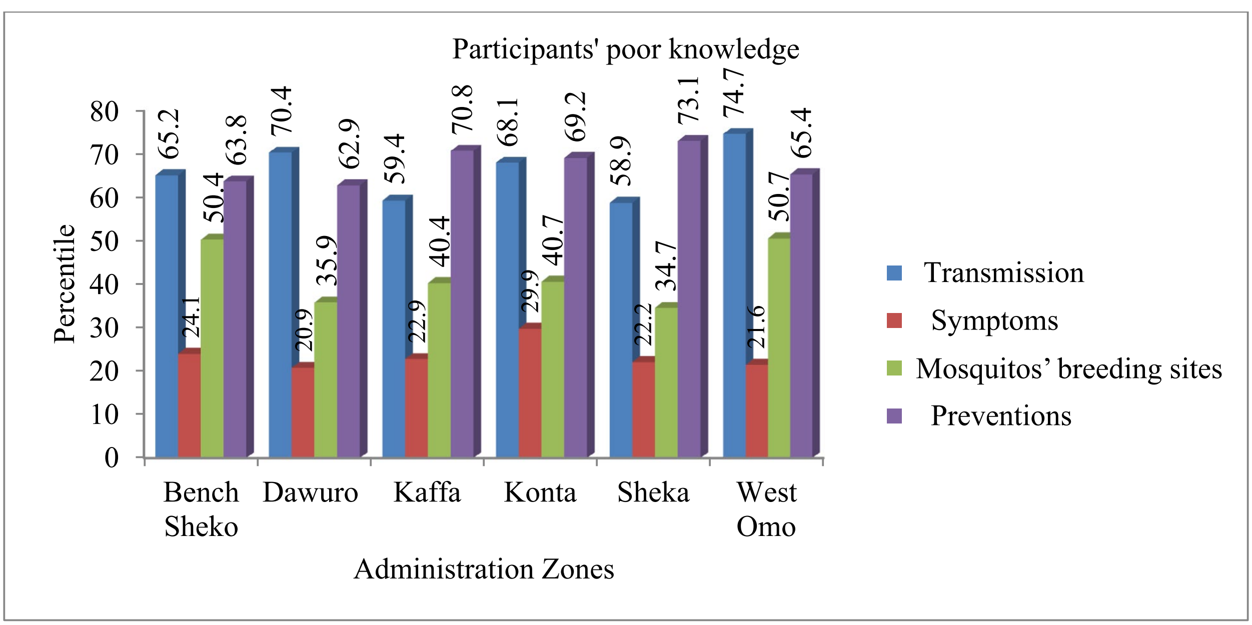

Fig. 5 Participants' knowledge status in terms of malaria transmission, symptoms, vectors and prevention methods in SWEPR

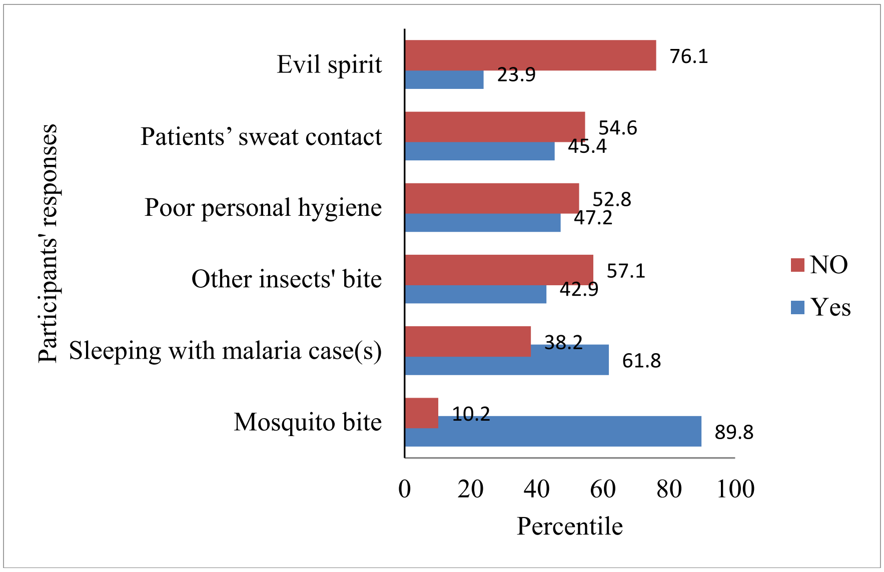

Fig. 6 Participants' knowledge status regarding malaria mode of transmission in SWEPRS

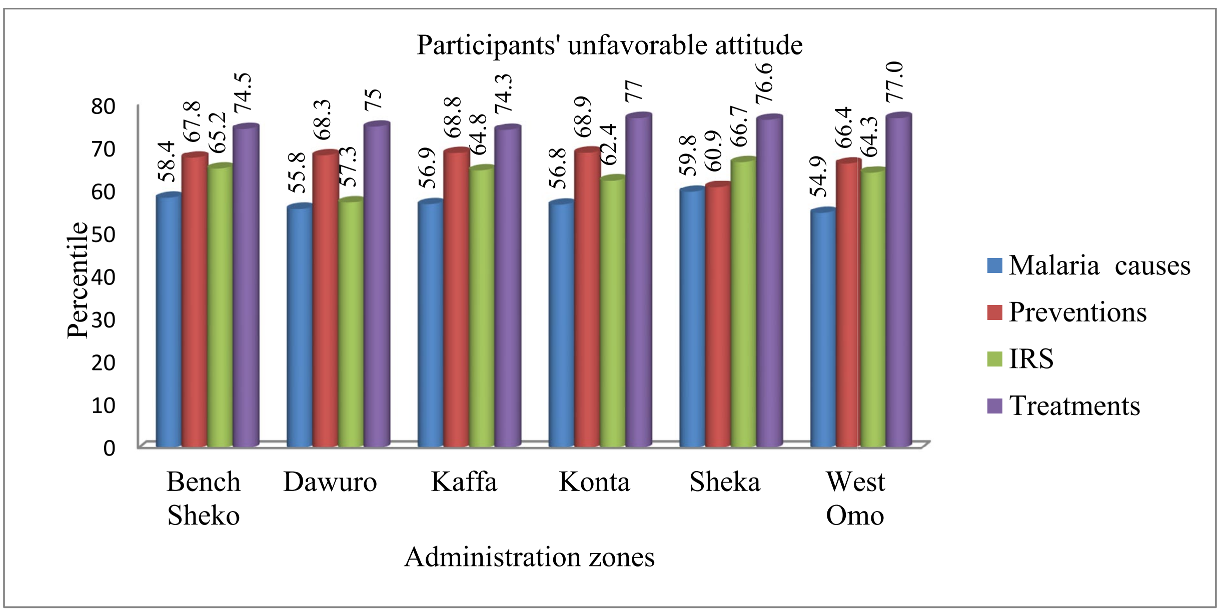

Fig. 7 Participants' attitude status toward malaria preventions, IRS utilization and treatments

1.10–2.55, p≤ 0.01)] were less likely knowledgeable compared with male household members.

Furthermore, being a student was more likely knowledgeable regarding malaria transmission routes [AOR = 1.77 (95% CI 1.26–2.48, p≤ 0.01)] compared to daily labourers. Households with a mean monthly income of between 5,001 and 10,000 ETB were more likely knowledgeable toward malaria transmission routes [AOR: 1.52 (95% CI 1.05–2.19, p≤ 0.02)], compared with households producing less than 5,000 ETB monthly income (Table 2).

Participants residing in rural areas exhibited twice less likely knowledgeable regarding malaria symptoms [AOR = 1.50 (95% CI 1.02–2.23, p≤ 0.04)] compared to their counterparts residing in urban areas. Furthermore, female household heads and the female respondents were less likely knowledgeable toward malaria symptoms [AOR = 0.67 (95% CI 0.59–1.08, p p ≤0.01)] and

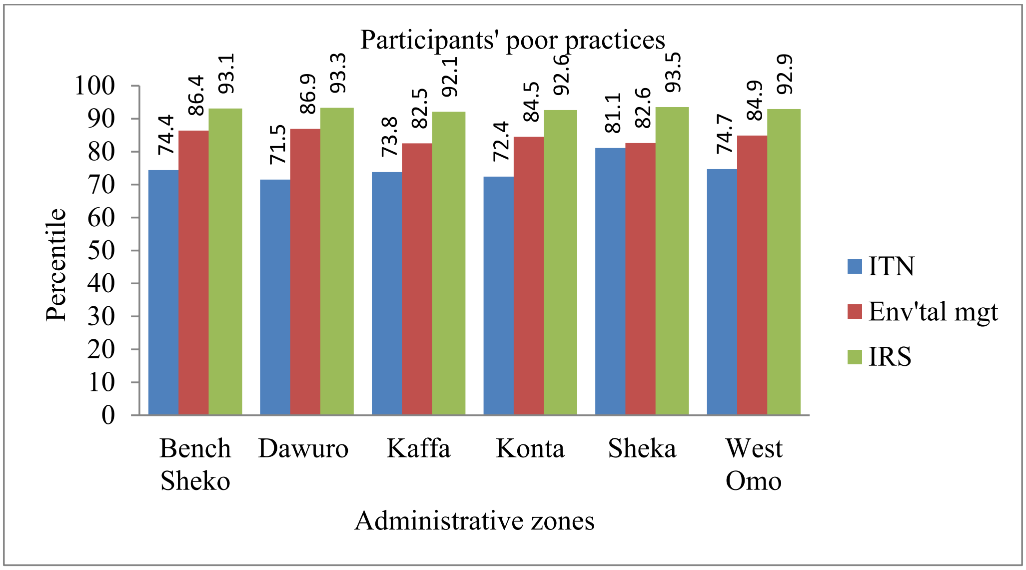

Fig. 8 Participants' practices toward malaria prevention in SWEPR

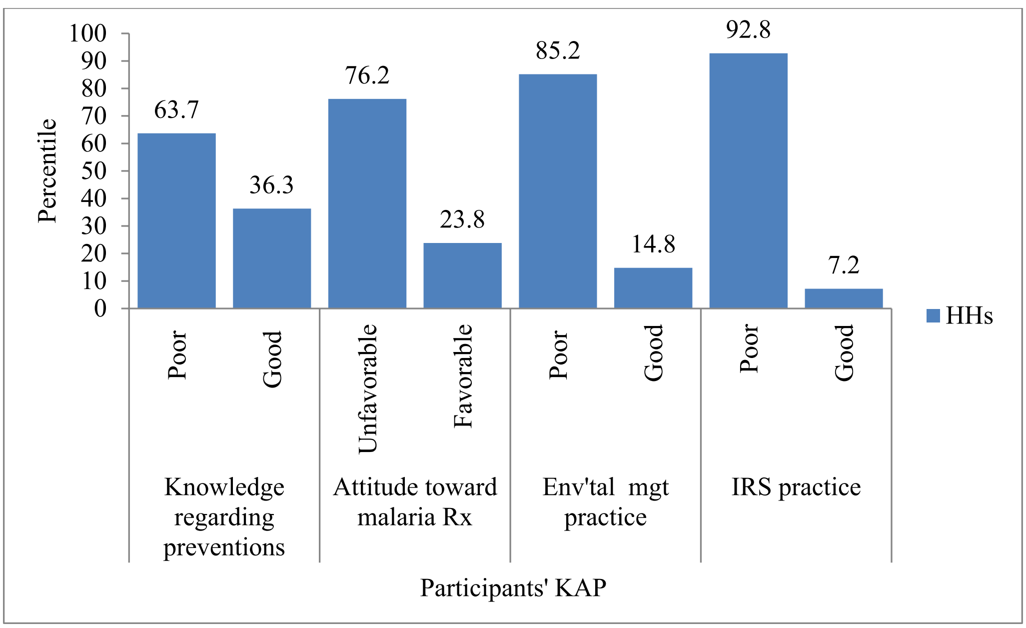

Fig. 9 Households mean KAP levels in terms of resident differences in SWEPRS

[AOR =0.36 (95% CI 0.13–0.99, p≤ 0.04)], respectively. In terms of family member roles, mothers and daughters were less likely knowledgeable regarding malaria symptoms [AOR =0.27 (95% CI 0.10–0.73, ≤0.01)], and [AOR =0.37 (95% CI 0.15–0.91, ≤0.03)], respectively, compared to male household heads or fathers (Table 3).

Respondents aged 29 to 39 years exhibited good knowledge of mosquito breeding sites [AOR =1.44 (95% CI 1.00–2.08, p≤ 0.04)] compared to those in the 18 to 28 years age group. Additionally, household heads whose primary occupation is commerce (merchants) showed a significant association with knowledge about mosquito breeding sites [AOR =1.70 (95% CI 1.04–2.76, p≤ 0.03)] compared to those employed as farmers (Table 4).

Household heads whose primary occupation is commerce (merchants) showed a significant association with knowledge toward malaria prevention methods [AOR =1.97 (95%CI 1.03–3.76, p≤ 0.04)], and respondents

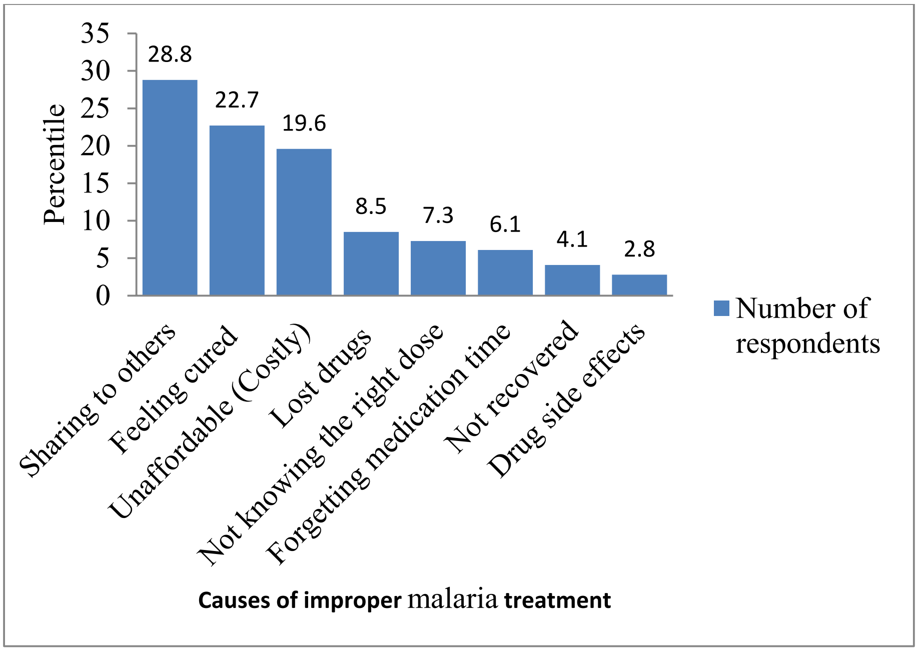

Fig. 10 Factors affecting malaria treatment adherence in six zones of SWEPR

who were involved in non-governmental organization (NGO) occupations, such as community-based organizations, were associated with knowledge regarding malaria prevention methods [AOR =0.45 (95%CI 0.21–0.96, $p \leq 0.03$)] compared to farmer occupations. Furthermore, HHs with a mean monthly income between 5,001 and 10,000 Ethiopian Birr (ETB) also exhibited an association with knowledge about malaria prevention methods [AOR =0.61 (95% CI 0.40–0.94, $p \leq 0.02$)] compared to households earning less than 5,000 ETB (Table 5).

Respondents aged 60 to 69 years were significantly associated with an unfavourable attitude regarding malaria disease prevention methods [AOR =1.85 (95% CI 1.01 to 3.37, $p \leq 0.04$)] compared to younger age groups (18–28 years). Additionally, among family members, daughters were associated with unfavourable attitudes regarding malaria diseases prevention methods [AOR =0.74 (0.57–0.96, $p \leq 0.02$)], compared to fathers in the households (Table 6).

The bivariable analysis indicated that several variables, specifically the age of household heads, occupation type, mean monthly income, respondents' sex, role, educational level, and occupation types, were associated with favourable attitudes toward malaria prevention methods ($p \leq 0.25$). However, in the multivariable analysis, none of these variables showed a statistically significant association with attitudes regarding malaria prevention methods ($p \leq 0.05$) (Table 7).

In bivariable analysis, respondents' gender, family members'role, household head age, educational status, occupation type, and marital status were associated with attitudes regarding malaria treatments ($p \leq 0.25$), but none of these variables showed a statistically significant association with attitudes regarding malaria prevention methods in the multivariable analysis ($p < 0.05$) (Table 8).

Among family members, only son respondents were significantly associated with practices related to environmental management [AOR =2.64 (95% CI 1.21–5.76, $p \leq 0.01$)] when compared to Father Roles (Table 9).

Among sociodemographic factors, household heads'education level of college and above was significantly associated with practices regarding insecticide-treated bed net utilization [AOR =0.28 (95% CI 0.12–0.63, $p \leq 0.01$)] when compared to household heads who had no formal education (Table 10).

The bivariable analysis designated that, the respondents' role, occupation, and household head age, were linked with participants' practice regarding IRS ($p < 0.25$). However, no one of these had a statistically significant association with participants' practice regarding IRS in multivariable analysis ($p < 0.05$) (Table 11).

Regarding gender and age, the majority of malaria patients were male (55%) and adults (84%). Of a total of 1,568 diagnosed malaria cases, 93% tested positive, with 58% identified as *P. falciparum*. In terms of treatment, most cases (90%) were classified as uncomplicated;

Table 2 Factors associated with respondents' knowledge regarding malaria transmission routes

variable	Category	Knowledge		COR[95%CI]	P-value	AOR[95%CI]	P-value
		Poor (%)	Good (%)				
HHs heads' age (year)	18–28	110 (61)	71 (39)	1		1	
	29–39	260 (66)	134 (34)	0.79[0.55–1.15]	0.12	0.91[0.57–1.47]	0.71
	40–49	265 (67)	128 (33)	0.75[0.52–1.08]	0.22	0.55[0.31–0.98]	*0.04
	50–59	108 (66)	56 (34)	0.80[0.52–1.25]	0.32	0.47[0.21–1.02]	*0.05
	60–69	45 (45)	24 (55)	0.83[0.46–1.47]	0.51	0.54[0.21–1.36]	0.19
	≥70	34 (62)	21 (38)	0.96[0.51–1.78]	0.88	0.72[0.27–1.92]	0.51
Respondents' age (year)	18–28	277 (64)	155 (36)	1		1	
	29–39	281 (67)	141 (33)	0.89[0.68–1.19]	0.44	1.06[0.71–1.58]	0.75
	40–49	177 (68)	83 (32)	0.84[0.60–1.16]	0.28	1.15[0.70–1.90]	0.57
	50–59	47 (58)	34 (42)	1.29[0.79–2.09]	0.29	2.05[1.02–4.13]	*0.04
	60–69	26 (68)	12 (32)	0.82[0.40–1.68]	0.59	1.12[0.41–3.10]	0.81
	≥70	14 (61)	9 (39)	1.15[0.49–2.72]	0.75	1.46[0.43- 4.87]	0.54
HH heads' marital status	Single	24 (53)	21 (47)	1		1	
	Married	715 (66)	368 (34)	0.59[0.32–1.07]	0.08	0.82[0.41–1.67]	0.59
	Widowed	58 (71)	24 (29)	0.47[0.22–1.01]	0.05	0.83[0.35–1.95]	0.66
	Divorced	25 (54)	21 (46)	0.96[0.42–2.19]	0.92	1.93[0.76–4.89]	0.16
Respondents' education	Not read and write	387 (70)	164 (30)	1		1	
	Formal (Grade 1–12)	209 (38)	340 (62)	1.45[1.12–1.86]	0.01	1.38[1.05–1.81]	*0.02
	≥College	61 (39)	95 (61)	1.52[1.05–2.19]	0.02	1.72[1.05- 2.81]	*0.02
Respondents' role	Father	439 (67)	215 (33)	1		1	
	Mother	87 (69)	39 (31)	0.92[0.61–1.38]	0.67	1.25[0.66–2.40]	0.49
	Daughter	278 (62)	172 (38)	1.26[0.98–1.62]	0.06	1.67[1.10–2.55]	* 0.01
	Son	18 (69)	8 (31)	0.91[0.39–2.12]	0.82	0.89[0.37–2.14]	0.79
HH heads' occupation	Farmer	605 (66)	311 (34)	1		1	
	Labourer	24 (71)	10 (29)	0.81[0.38–1.72]	0.58	0.63[0.24–1.68]	0.35
	House wife	24 (77)	7 (23)	0.56[0.24–1.33]	0.19	0.30[0.11–0.77]	* 0.01
	Student	7 (44)	9 (56)	2.50[0.92- 6.78]	0.07	1.47[0.47–4.62]	0.51
	Merchant	54 (58)	39 (42)	1.40[0.91–2.17]	0.12	0.82[0.43–1.54]	0.53
	NGO	11 (55)	9 (45)	1.59[0.65–3.88]	0.30	2.74[0.46–16.46]	0.26
	GO	97 (66)	49 (34)	0.98[0.68–1.42]	0.92	0.75[0.43–1.47]	0.46
Respondents' occupation	Labourer	408 (69)	185 (31)	1		1	
	House wife	21 (70)	9 (30)	0.95[0.42–2.10]	0.89	1.28[0.45- 3.66]	0.64
	Student	121(40)	178 (60)	1.45[1.12–2.00]	0.01	1.77[1.26–2.48]	*0.01
	Merchant	95 (64)	53(34)	1.23[0.84–1.80]	0.28	1.38[0.79–2.42]	0.25
	NGO	43 (56)	34 (44)	1.74[1.08- 2.82]	0.02	1.59[0.79–3.22]	0.19
	GO	10 (67)	5 (33)	1.10[0.37- 3.27]	0.86	0.42[0.05- 3.45]	0.42
	Other	67 (71)	27 (29)	0.89[0.55–1.43]	0.63	0.79[0.39–1.59]	0.50
HHs' MMI (ETB)	≤5,000	719 (67)	355 (33)	1		1	
	5,001–10,000	65 (42)	88(58)	1.49[1.05–2.11]	0.02	1.52[1.05–2.19]	*0.02
	≥10,001	15 (52)	14 (48)	1.89[0.90–3.96]	0.09	2.16[0.99- 4.71]	0.05

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; MMI: Mean monthly income; GO: Governmental organization; HH: Household; NGO: Non-governmental organization

* Significantly associated

however, 64% of these cases were not treated according to the updated national malaria treatment guidelines (Table 12).

Discussion

Malaria incidence rate

This study showed that about 31% of respondents and majority (69%) of HHs were affected with malaria. In

Table 3 Factors associated with respondents' knowledge regarding malaria symptoms

Variable	Category	Knowledge		COR[95%CI]	P-value	AOR[95%CI]	P-value
		Poor (%)	Good (%)				
Resident/ Location	Urban	47(29)	113 (71)	1		1	
	Rural	889(78)	256 (22)	1.44[1.00–2.08]	0.05	1.50[1.02- 2.23]	*0.04
HHs heads' Sex	Male	229 (22)	797 (78)	1		1	
	Female	205 (73)	74 (27)	0.79[0.59–1.08]	0.14	0.67 [0.49–0.94]	*0.01
Respondents' sex	Male	148 (26)	419 (74)	1		1	
	Female	583 (79)	155 (21)	1.33[1.03–1.72]	0.03	0.36[0.13–0.99]	* 0.04
Respondents' age (year)	18–28	106 (24)	341 (76)	1		1	
	29–39	84 (19)	352 (81)	1.30[0.94–1.79]	0.10	1.01[0.68–1.51]	0.95
	40–49	63 (25)	192 (75)	0.95[0.66–1.36]	0.76	0.79[0.49–1.31]	0.37
	50–59	20 (21)	74 (79)	1.15[0.67–1.97]	0.61	1.16[0.57–2.34]	0.68
	60–69	14 (34)	27 (66)	0.59[0.30–1.18]	0.14	0.69[0.28–1.70]	0.42
	≥70	16 (50)	16 (50)	0.31[0.15–0.64]	0.02	0.39[0.14–1.12]	0.08
HHs heads' marital status	Single	15 (35)	28 (65)	1		1	
	Married	253 (23)	857 (77)	1.81[0.95–3.45]	0.06	1.60[0.72–3.61]	0.25
	Widowed	30 (29)	72 (71)	1.28[0.60–2.74]	0.51	1.78[0.69- 4.59]	0.23
	Divorced	5 (10)	45 (90)	4.82[1.57–14.73]	0.01	5.82[1.63- 20.77]	*0.01
Respondents' role	Father	135(20)	547 (80)	1		1	
	Mother	94 (69)	43(31)	0.53[0.36–0.81]	0.01	0.27[0.10–0.73]	* 0.01
	Daughter	343 (74)	119(26)	0.71[0.53–0.94]	0.01	0.37[0.15- 0.91]	*0.03
	Son	6 (25)	18 (75)	0.74[0.28–1.90]	0.53	0.68[.26- 1.83]	0.45
Respondents' education	Informal	136 (24)	424 (76)	1		1	
	Grade 1–12	137 (24)	444 (76)	1.03[0.79–1.36]	0.78	0.95[0.71–1.29]	0.77
	≥College	30 (18)	134 (82)	1.43[0.92- 2.22]	0.11	0.98[0.56–1.72]	0.94
HHs heads' occupation	Farmer	219 (23)	733 (77)	1		1	
	Labourer	5 (15)	29 (85)	1.73[0.66–4.53]	0.26	1.62[0.48–5.42]	0.43
	House wife	24 (60)	16 (40)	0.45[0.23–0.86]	0.01	0.36[0.16–0.82]	*0.01
	Student	5 (36)	9 (64)	0.54[0.17–1.62]	0.27	0.99[0.25–3.88]	0.98
	Merchant	28 (28)	71 (72)	0.76[0.47–1.20]	0.24	0.53[0.27–1.05]	0.06
	NGO	8 (40)	12 (60)	0.45[0.18–1.11]	0.08	0.31[0.07–1.34]	0.11
	GO	22 (15)	124 (85)	1.68[1.04–2.71]	0.03	0.91[0.45–1.88	0.81
Respondents' occupation	Farmer	135 (23)	450 (77)	1		1	
	Housewife	6 (18)	28 (82)	1.40[0.57–3.45]	0.46	1.19[0.36–3.98]	0.76
	Student	86 (25)	253 (75)	0.88[0.65–1.20]	0.43	1.02[0.71–1.48]	0.89
	Merchant	44 (28)	116 (72)	0.79[0.53–1.17]	0.24	0.84[0.47–1.49]	0.54
	NGO	18 (22)	64 (78)	1.06[0.61–1.86]	0.82	1.69[0.75–3.82]	0.20
	GO	5 (38)	8 (62)	0.48[0.15–1.49]	0.20	1.51[0.25–8.89]	0.64
	Other	9 (10)	83 (90)	2.77[1.35–5.65]	0.01	2.55[1.00–6.49]	0.05
HHs MMI (ETB)	≤5000	272 (24)	850 (76)	1		1	
	5001–10000	25 (17)	126 (83)	1.61[1.02–2.53]	0.03	1.53[0.95–2.48]	0.07
	≥10,001	6 (19)	26 (81)	1.39[0.56–3.40]	0.47	1.37[0.52–3.55]	0.51

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; MMI: Mean monthly income; GO: Governmental organization; NGO: Non-governmental organization

* Significant association

terms of gender differences, the malaria incidence rate was higher in males (55%) compared to females. This finding is higher than a study in northwestern Nigeria (19.4%) and lower than a study in Arba Minch Zuria District, South Ethiopia (53.4%) [19, 20]. The malaria incidence variation between male and female is potentially due to a combination of both mosquito and human behaviors, such as males visiting forest areas

Table 4 Factors associated with participants' knowledge regarding mosquito breeding sites

Variable	Category	Knowledge		AOR[95%CI]	P-value	AOR[95%CI]	P-value
		Poor (%)	Good (%)				
HHs head sex	Male	368 (41)	534 (59)	1		1	
	Female	105 (45)	128 (55)	0.84[0.63–1.12]	0.23	0.85[0.63–1.16]	0.32
HHs head age (years)	18–28	71 (41)	102 (59)	1		1	
	29–39	121 (35)	224 (65)	1.29[0.89–1.87]	0.18	1.19[0.75–1.89]	0.46
	40–49	154 (46)	181 (54)	0.82[0.56–1.19]	0.28	0.61[0.37–1.02]	0.06
	50–59	71 (45)	87 (55)	0.85[0.55–1.32]	0.74	0.72[0.36–1.45]	0.36
	60–69	27 (40)	41 (60)	1.06[0.59–1.87]	0.84	1.00[0.43–2.35]	0.99
	≥70	29 (52)	27 (48)	0.64[0.35–1.19]	0.16	0.72[.28–1.86]	0.50
Respondents' age (year)	18–28	172 (44)	223 (56)	1		1	
	29–39	135 (36)	236 (64)	1.35[1.01–1.80]	0.04	1.44[1.00–2.08]	*0.04
	40–49	99 (44)	128 (56)	0.99[0.72–1.39]	0.98	1.45[0.95–2.21]	0.08
	50–59	36 (46)	42 (54)	0.89[0.55–1.47]	0.67	1.11[0.61–2.02]	0.72
	60–69	15 (43)	20 (57)	1.03[0.51–2.07]	0.93	0.94[0.37–2.39]	0.90
	≥70	16 (55)	13 (45)	0.62[0.29–1.34]	0.22	0.81[0.28–2.36]	0.69
Respondents' role	Father	234 (40)	356 (60)	1		1	
	Mother	57 (45)	69 (55)	0.79-[0.54–1.17]	0.24	1.25[0.67- 2.34]	0.47
	Daughter	170 (43)	227 (57)	0.88[0.67–1.14]	0.32	1.34[0.89–2.04]	0.16
	Son	12 (55)	10 (45)	0.54[0.23–1.29]	0.16	0.51[0.20–1.26]	0.14
HHs head education	Informal	364 (43)	489 (57)	1		1	
	Grade 1–12	89 (42)	121 (58)	1.01[0.75–1.37]	0.93	0.96[0.69- 1.33]	0.79
	≥College	20 (28)	52 (72)	1.94[1.14–3.29]	0.01	1.66[0.95–2.90]	0.07
Respondents' education	Informal	216 (45)	262 (55)	1		1	
	Grade 1–12	210 (42)	290 (58)	1.14[0.88–1.47]	0.31	1.05[0.80–1.38]	0.72
	College and above	47 (30)	110 (70)	1.92[1.31–2.84]	0.01	1.50[0.92–2.45]	0.10
HHs head occupation	Farmer	362 (45)	440 (55)	1		1	
	Labourer	12 (40)	18 (60)	1.23[0.59–2.59]	0.57	1.30[0.61–2.82]	0.49
	House wife	15 (43)	20 (57)	1.09[0.55–2.17]	0.79	1.16[0.57–2.39]	0.66
	Student	3 (23)	10 (77)	2.74[0.75–10.04]	0.12	2.40[0.63- 9.12]	0.19
	Merchant	29 (32)	61 (68)	1.73[1.08–2.75]	0.02	1.70[1.04–2.76]	* 0.03
	NGO	8 (44)	10 (56)	1.02[0.40–2.63]	0.95	0.97[0.37–2.56]	0.95
	GO	44 (30)	103 (70)	1.92[1.32–2.81]	0.01	1.59[0.98–2.58]	0.05
HHs' MMI (ETB)	≤5000	408 (42)	567 (58)	1		1	
	5001–10000	57 (43)	77 (57)	0.98[0.68–1.41]	0.91	0.82[0.55–1.22]	0.33
	≥10,001	8 (26)	23 (74)	2.09[0.92–4.71]	0.07	2.15[0.93–4.97]	

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; MMI: Mean monthly income; GO: Governmental organization; NGO: Non-governmental organization

* Significantly associated

more and not sleeping in ITNs, or when local mosquito vector species bite and rest outdoors [19, 21]. About 16.2% of the malaria cases were children, which was slightly higher than a study reported in Nigeria (11.7%) [19], and lower than a study in Arba Minch Zuria District, South Ethiopia (22.1%) [20]. Here, the possible differences might be awareness gaps in the proper use of ITNs and IRS together with supplementary malaria prevention methods such as chemical and biological larvicides [21].

At the individual level, the highest malaria incidence rate was observed in the Dawuro (35.6%) and Konta (34.5%) zones, respectively. It is in line with studies reported in Nigeria and Eastern Rwanda, 35.3% and 22.8%, respectively [19, 22]. However, it is lower than a study in Zambezia, Mozambique (47.8%)[23], and higher than the studies reported in the East Shewa Zone, Ethiopia, and Eastern Rwanda (25% and 5.1%, respectively) [22, 24], and Adami Tulu, Central Ethiopia (8.6%) [25]. The possible differences may be attributed to the

Table 5 Factors associated with participants' knowledge regarding malaria prevention methods

Variable	Category	Knowledge		COR[95%CI]	p-value	AOR[95%CI]	P-value
		Poor (%)	Good (%)				
HHs head age (year)	18–28	101 (59)	71 (41)	1		1	
	29–39	253 (66)	132 (34)	0.74[0.51- 1.07]	0.11	0.79[0.53–1.17]	0.24
	40–49	257 (69)	118 (31)	0.65[0.45–0.95]	0.02	0.69[0.44–1.11]	0.13
	50–59	122 (71)	51 (29)	0.59[0.38–0.93]	0.02	0.63[0.33–1.22]	0.16
	60–69	50 (72)	19 (28)	0.54[0.29–0.99]	0.04	0.61[0.28–1.29]	0.19
	≥70	41 (69)	18 (31)	0.62[0.33–1.17]	0.14	0.65[0.29–1.43]	0.28
HHs heads' marital status	Single	23 (59)	16 (41)	1		1	
	Married	699 (67)	350 (33)	0.72[0.38–1.38]	0.32	0.98[0.47–2.06]	0.96
	Widowed	70 (73)	26 (27)	0.53[0.24–1.17]	0.11	0.65[0.27–1.57]	0.33
	Divorced	32 (65)	17 (35)	0.76[0.32–1.82]	0.54	0.81[0.32–2.10]	0.67
Respondents' role	Father	412 (64)	229 (36)	1		1	
	Mother	93 (71)	38 (29)	0.74[0.49–1.11]	0.14	1.00[0.53–1.90]	0.98
	Daughter	298 (69)	137 (31)	0.83[0.64–1.07]	0.15	1.03[0.68–1.58]	0.86
	Son	21 (81)	5 (19)	0.43[0.16–1.15]	0.09	0.44[0.16–1.22]	0.11
HHs heads' Education	Informal	634 (68)	305 (32)	1		1	
	Formal (Grade 1–12)	139 (63)	81 (37)	1.21[0.89–1.65]	0.22	1.13[0.81–1.56]	0.46
	≥College	51 (80)	23 (20)	0.94[0.56–1.56]	0.80	0.89[0.53–1.52]	0.67
HHs heads' occupation	Farmer	600 (67)	289 (33)	1		1	
	Labourer	19 (56)	15 (44)	1.64[0.82–3.27]	0.16	1.25[0.48–3.22]	0.64
	House wife	25 (66)	13 (34)	1.08[0.54–2.14]	0.82	1.89[0.84–4.23]	0.12
	Student	10 (83)	2 (17)	0.42[0.09–1.91]	0.25	0.28[.06–1.40]	0.12
	Merchant	35 (37)	59 (63)	1.23[0.79–1.91]	0.35	1.97[1.03–3.76]	*0.04
	NGO	11 (79)	3 (21)	0.57[0.16–2.05]	0.38	0.82[0.13–5.01]	0.82
	GO	100 (66)	52 (34)	1.01[0.75–1.55]	0.68	1.29[0.73–2.29]	0.37
Respondents' occupation	Farmer	359 (64)	202 (36)	1		1	
	House wife	16 (52)	15 (48)	1.67[0.80–3.44]	0.16	1.41[0.52–3.79]	0.49
	Student	236 (75)	80 (25)	0.60[0.44–0.82]	0.01	0.52[0.36–0.74]	0.01
	Merchant	95 (65)	51 (35)	0.95[0.65–1.39]	0.80	0.99[0.65–1.50]	0.94
	NGO	24 (31)	53(69)	080[0.48–1.34]	0.40	0.45[0.21- 0.96]	*0.03
	GO	7 (78)	2 (22)	0.51[0.10–2.47]	0.40	0.69[0.07–6.45]	0.74
	Other	58 (62)	35 (38)	1.07[0.68–1.69]	0.76	0.87[0.42–1.75]	0.69
HHs MMI (ETB)	≤5000	697 (66)	363 (34)	1		1	
	5001–10000	36(25)	108 (75)	0.64[0.43–0.95]	0.02	0.61[0.40–0.94]	*0.02
	≥10,001	19 (66)	10 (34)	1.01[0.47–2.19]	0.97	0.91[0.41–0.40]	0.82

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; MMI: Mean monthly income; HH: Households; GO: Governmental organization; NGO: Non-governmental organization

* Significantly associated

utilization of malaria prevention measures [26]. At HH's level, the highest malaria incidence rate was found in Konta (73.6%), West Omo (71.7%), and Bench Sheko (70.8%) zones. This finding was comparable with a study conducted in Northwest Ethiopia [27]. The sources and risks of malaria transmission may vary by location, time, and implementation status of malaria prevention methods [21].

Among 481 patients reported as having malaria in the previous 28 days, 44% were diagnosed by clinical signs and symptoms without laboratory confirmation, which was contrary to a study in Tumbi Referral Hospital, Tanzania, which reported that 72.2% of malaria cases were confirmed by laboratory [28]. These factors might be attributed to a lack of supportive supervision and laboratory reagent provisions for public health facilities [29]. Of the total (56%) malaria cases, the laboratory confirmation showed that the majority (58%) was *P. falciparum*, followed by *P. vivax* (30%) and mixed (12%). This finding was contrary to a study in the East Shewa Zone

Table 6 Factors associated with participants' attitude regarding malaria diseases prevention methods

Variable	Category	Attitude		COR[95%CI]	P-value	AOR[95%CI]	P-value
		Unfavorable (%)	Favorable (%)				
Respondents' age (in year)	18–28	311 (56)	242 (44)	1		1	
	29–39	303 (60)	200 (40)	0.85[0.66–1.08]	0.18	0.82[0.63–1.04]	0.11
	40–49	167 (55)	136 (45)	1.05[0.79–1.39]	0.75	1.14[0.84–1.53]	0.39
	50–59	63 (61)	41 (39)	0.84[0.55–1.28]	0.41	0.94[0.58–1.48]	0.77
	60–69	28 (55)	23 (45)	1.56[0.88–2.78]	0.12	1.85[1.01–3.37]	*0.04
	≥70	21 (55)	17 (45)	1.04[0.54–2.02]	0.90	1.27[0.63–2.50]	0.49
Respondents' role	Father	462 (56)	358 (44)	1		1	
	Mother	90 (54)	76 (46)	1.08[0.78–1.52]	0.61	0.94[0.64–1.37]	0.74
	Daughter	321 (60)	213 (40)	0.86[0.69–1.07]	0.17	0.74[0.57- 0.96]	*0.02
	Son	15 (47)	17 (53)	1.46[0.72–2.97]	0.29	1.38[0.67–2.81]	0.38
HHs MMI (ETB)	≤5,000	785 (58)	570 (42)	1		1	
	5,001–10,000	85 (52)	80 (48)	1.16[0.92–1.49]	0.20	1.30[.93- 1.81]	0.11
	≥10,001	18 (56)	14 (44)	0.62[0.46–0.84]	0.02	1.11[0.54–2.27]	0.76

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; MMI: Mean monthly income; HH: Households

* Significantly associated

of Oromia that reported the dominant species of malaria was *P. vivax* (54%), followed by *P. falciparum* (45%) [24], and aligned with a study in Adami Tullu, Ethiopia, where 55.1% were *P. falciparum* and 25.3% were *P. vivax* [29], but unlike a study conducted in India, which displayed *P. vivax* as the dominant malaria species [26]. The possible reasons for similarities and differences in terms of dominant malaria species might be due to climate and environmental effects [27].

Knowledge of malaria symptoms

In this study, participants had higher knowledge toward malaria despite their lower practice of prevention methods, which was comparable with a study conducted in Myanmar [18], and Areka, South Ethiopia [30]. However, there were variations in terms of malaria symptoms, mode of transmission, mosquito breeding sites, and residents among six zones of the SWEPRS. This finding was in line with a study in the East Shewa zone of the Oromia Region, Ethiopia, and the west Belessa district, northwest Ethiopia [16, 24]. The main source for this information might be health professionals [16]. However, a considerable number of participants held misconceptions about malaria transmission, such as sleeping with malaria cases, contact with the sweat of malaria patients, poor personal hygiene, hunger, and other insect bites. This finding was in line with a study conducted in Kenya, Eastern Rwanda, and the Belessa district, Northwest Ethiopia [16, 22, 31]. The main contributing factor for these misconceptions or misunderstandings might be socio-economic backgrounds, cultural beliefs, and socio-economic factors [17].

Attitudes regarding malaria prevention

About three-fourths of respondents agreed that IRS effectively prevented malaria vectors from entering their homes despite inaccessibility, which was in line with a study conducted in central-western Senegal [14], but contrary to the study conducted in western Ghana [32]. Above two-thirds of household heads in all six zones of SWEPRS negatively perceived environmental management as a primarily malaria prevention method. For instance, a considerable number of participants replied that they were uncertain to accept mosquitoes as malaria vectors and believed that evil spirits, hygiene problems, poor nutrition, and other insect bites also shared in the disease's occurrences. These misconceptions are possibly associated with their educational status and socio-cultural backgrounds [17].

Practices of malaria prevention

There was an inadequate proportion of IRS utilization across households in the six zones of SWEPRS. However, the WHO recommends access to effective vector control using both ITNs and IRS at optimal coverage levels for all populations at risk of malaria in most epidemiological and ecological settings with ongoing malaria transmission [21]. Household heads' poor knowledge, unfavorable attitude toward malaria holistic prevention methods, and inaccessible chemical supply were playing the major role in poor utilization of IRS (Figs. 7 and 9). Furthermore, among houses sprayed with IRS, the incidence rate of malaria prevalence was 74.7%, but in houses not sprayed with IRS, it was a nearly similar 71.1%. This finding was inconsistent with the study conducted in Tanzania, which

Table 7 Factors associated with participants' attitude regarding malaria prevention methods

Variable	Category	Attitude		COR[95%CI]	P-value	AOR[95%CI]	P-value
		Unfavorable (%)	Favorable (%)				
Respondents' sex	Male	431 (65)	231 (35)	1		1	
	Female	614 (69)	276 (31)	0.84[0.68–1.04]	0.10	1.17[0.48–2.85]	0.72
HHs head age (year)	18–28	162 (74)	58 (26)	1		1	
	29–39	324 (67)	159 (33)	1.37[0.96–1.95]	0.08	1.41[0.95–2.08]	0.08
	40–49	323 (67)	157 (33)	1.36[0.95–1.94]	0.09	1.31[0.82–2.09]	0.25
	50–59	127 (62)	77 (38)	1.69[1.12–2.56]	0.01	1.36[0.72–2.57]	0.34
	60–69	54 (59)	38 (41)	1.96[1.18–3.28]	0.01	1.66[0.82–3.33]	0.15
	≥70	55 (75)	18 (25)	0.91[0.49–1.68]	0.77	0.78[0.36–1.69]	0.53
Respondent s' role	Father	563 (69)	257 (31)	1		1	
	Mother	98 (59)	68 (41)	1.52[1.08–2.14]	0.01	1.61[0.66–3.97]	0.29
	Daughter	360 (67)	174 (33)	1.06[0.84–1.34]	0.63	1.20[0.54–2.68]	0.65
	Son	24 (75)	8 (25)	0.73[0.32–1.65]	0.44	0.72[0.31–1.63]	0.42
Respondents' education	Informal	459 (66)	232 (34)	1		1	
	Grade 1–12	457 (67)	229 (33)	0.99[0.79–1.24]	0.94	1.05[0.83–1.35]	0.63
	≥College	129 (74)	46 (26)	0.71[0.49–1.02]	0.06	0.73[0.46–1.17]	0.18
HHs heads occupation	Farmer	772 (67)	384 (33)	1		1	
	Labourer	30 (68)	14 (32)	0.94[0.49–1.79]	0.84	1.01[0.44–2.34]	0.96
	House wife	28 (58)	20 (42)	1.44[0.79–2.58]	0.22	1.69[0.89–3.15]	0.14
	Student	12 (71)	5 (29)	0.84[0.29–2.39]	0.74	0.88[0.28–2.74]	0.82
	Merchant	78 (74)	28 (26)	0.72[0.46–1.13]	0.15	0.88[0.48–1.62]	0.68
	NGO	16 (73)	6 (27)	0.75[0.29–1.94]	0.55	0.83[0.18–3.59]	0.79
	GO	109 (69)	50 (31)	0.92[0.65–1.32]	0.65	1.44[0.82- 2.53]	0.20
Respondents' occupation	Farmer	478 (65)	252 (35)	1		1	
	Housewife	24 (65)	13 (35)	1.02[0.51–2.05]	0.93	1.13[0.46–2.76]	0.79
	Student	274 (70)	119 (30)	0.82[.63–1.07]	0.15	0.75[0.56–1.01]	0.05
	Merchant	123 (64)	68 (36)	1.05[0.75–1.46]	0.78	0.99[0.69–1.44]	0.99
	NGO	64 (74)	23 (26)	0.68[0.41–1.12]	0.13	0.76[0.39–1.49]	0.42
	GO	11 (73)	4 (27)	0.69[0.21–2.19]	0.52	0.68[0.11–4.05]	0.65
	Other	71 (72)	28 (28)	0.74[0.47–1.19]	0.21	0.64[0.33–1.24]	0.18
HHs MMI (ETB)	≤5000	915 (68)	440 (32)	1		1	
	5001–10000	111 (67)	54 (33)	1.01[0.71–1.43]	0.94	1.11[0.77–1.59]	0.56
	≥10,001	19 (59)	13 (41)	1.41[0.69–2.91]	0.33	1.44[0.69–3.04]	0.33

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; HH: Households; MMI: mean monthly income

displayed that malaria re-infection was reduced among IRS users [33]. The possible explanation for poor efficacy of spray might be due to substandard spray by untrained operators and rough wall surface types [14, 33, 34], and the level of community awareness, sensitization, mobilization, monitoring, and supervision before, during, and after the campaign [2, 10]. Three-fourths of participants reported that they were utilizing ITNs; however, ITNs were improperly hanged, had holes and tears for the entrance of mosquitoes, and used for other domestic purposes instead of its ultimate aim. All of the ITN users obtained ITNs from a government distribution campaign, which was contrary to a study conducted in Tumbi Referral Hospital, Tanzania (40%)[28]. The majority (> 70%) of respondents did not properly utilize ITNs due to either disliking sleeping under them or, less frequently, personal behaviour and/or lack of information on whether ITNs are reusable after washing, sewing, and immersing in chemicals [28, 35]. Ineffective communication, including unclear and aesthetically not pleasing messages, and language barriers possibly contributed to the incorrect use of ITNs [36]. Due to inappropriate use of ITNs and unresolved misconceptions, the incidence rate of malaria cases and mortality is not yet minimized as expected, with insignificant differences between households that have ITNs and those that do

Table 8 Factors associated with participants' attitude regarding malaria treatments

Variable	Category	Attitude		COR[95%CI]	P-value	AOR[95%CI]	P-value
		Unfavorable (%)	Favorable (%)				
Respondents' sex	Male	487 (74)	175 (26)	1		1	
	Female	681 (77)	209 (23)	0.85[0.68–1.08]	0.18	1.35[0.53–3.38]	0.52
HHs head age (year)	18–28	159 (72)	61 (28)	1		1	
	29–39	376 (78)	107 (22)	0.74[0.51–1.07]	0.10	0.92[0.61–1.37]	0.67
	40–49	370 (77)	110 (23)	0.77[0.53–1.11]	0.17	0.93[0.56–1.53]	0.77
	50–59	156 (76)	48 (24)	0.80[0.52–1.24]	0.32	0.81[0.40–1.62]	0.54
	60–69	60 (65)	32 (35)	1.39[0.83–2.34]	0.21	1.50[0.71–3.14]	0.27
	≥70	47 (64)	26 (36)	1.44[0.82–2.53]	0.20	1.79[0.83–3.88]	0.13
HHs heads' marital status	Single	30 (61)	19 (39)	1		1	
	Married	1002 (76)	325 (24)	0.51[0.28–0.92]	0.02	0.60[0.30–1.19]	0.14
	Widowed	93 (77)	28 (23)	0.48[0.23-.97]	0.04	0.49[0.21–1.12]	0.09
	Divorced	43 (78)	12 (22)	0.44[0.19–1.04]	0.06	0.51[0.19–1.31]	0.16
Respondent s' role	Father	631 (77)	189 (23)	1		1	
	Mother	114 (69)	52 (31)	1.52[1.06–2.19]	0.02	2.13[0.85–5.34]	0.10
	Daughter	397 (74)	137 (26)	1.15[0.89–1.48]	0.27	1.42[0.63–3.18]	0.40
	Son	26 (81)	6 (19)	0.77[0.31–1.89]	0.57	0.77[0.31–1.91]	0.56
HHs head education	Informal	898 (76)	283 (24)	1		1	
	Grade 1–12	203 (71)	81 (29)	1.27[0.95–1.69]	0.11	1.32[0.97–1.78]	0.07
	≥ College	67 (77)	20 (23)	0.94[0.56–1.59]	0.83	1.07[0.62–1.81]	0.80
HHs heads occupation	Farmer	874 (76)	282 (24)	1		1	
	Labourer	28 (64)	16 (36)	1.77[0.94–3.32]	0.07	1.79[0.94- 3.42]	0.70
	House wife	36 (75)	12 (25)	1.03[0.53–2.01]	0.92	0.98[0.46–2.05]	0.95
	Student	12 (71)	5 (29)	1.29[0.45–3.69]	0.63	0.93[0.29–2.90]	0.90
	Merchant	76 (72)	30 (28)	1.22[0.79–1.91]	0.37	1.17[0.73–1.86]	0.51
	NGO	14 (64)	8 (36)	1.77[0.74–4.27]	0.20	1.69[0.69–4.12]	0.24
	GO	128 (81)	31 (19)	0.75[0.49–1.14]	0.17	0.79[0.52–1.21]	0.28

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; HH: Households

not [23]. Over half (55.2%) of respondents did not properly adhere to prescribed medications as per the national malaria treatment guidelines, which was contrary to a study reported in Areka, South Ethiopia (85.2%) [30]. The major contributing factors for this noncompliance were sharing drugs with others (29%), terminating the medications while feeling cured (23%), and the unaffordable cost of drugs (19%). This finding was unlike a study in Kenya [31]. Environmental management is among the measures taken against malaria vectors in their breeding site. However, this study finding displayed that the majority (> 80%) of household heads were not engaged in environmental management practices such as draining stagnant water, clearing vegetation besides irrigation canals, avoiding temporary water-holding containers, leaves with water drops, and others. This finding was conflicting with a study conducted in Areka, South Ethiopia (89.6%) [30]. The underlying possible causes for this poor status of malaria prevention practices might be lack of comprehensive and inclusive information communication, inadequate supply of IRS, lack of training and monitoring for community health workers, as well as household members'unfavourable attitudes toward malaria prevention methods [37, 38].

Factors associated with KAP toward malaria

Participants residing in rural areas were approximately two times less likely to exhibit good knowledge of malaria symptoms such as chills, fever, headache, and others ($p \leq 0.04$) compared to their counterpart urban residents. In terms of family member roles, mothers and daughters were 27% and 37% less likely to demonstrate good knowledge of malaria symptoms ($p \leq 0.01$) and ($p \leq 0.03$), respectively, compared to the fathers. Household heads aged between 40 and 49 years and 50 and 59 years old were 55% and 47% less likely to possess good knowledge ($p < 0.04$, $p < 0.05$) regarding malaria transmission routes, respectively, compared with participants in the age group of 18 to 28 years. This finding was in line with a study in Myanmar that reported age ($p < 0.022$) was significantly

Table 9 Factors associated with participants' practice regarding environmental management

Variable	Category	Practice		COR[95%CI]	P-value	AOR[95%CI]	P-value
		Poor (%)	Good (%)				
HHs head Sex	Male	1,020 (85)	187 (15)	1		1	
	Female	298 (86)	47 (14)	0.86[0.61- 1.21]	0.39	0.85[0.59–1.20]	0.35
Respondents' age (year)	18–28	468 (85)	85 (15)	1		1	
	29–39	429 (85)	74 (15)	0.95[0.68–1.33]	0.76	0.91[0.64–1.29]	0.60
	40–49	257 (85)	46 (15)	0.99[0.66–1.46]	0.94	0.98[0.65–1.48]	0.91
	50–59	83 (80)	21 (20)	1.39[0.82–2.37]	0.22	1.59[0.89–2.87]	0.12
	60–69	47 (92)	4 (8)	0.47[0.16–1.33]	0.15	0.47[0.16–1.37]	0.16
	≥70	34 (89)	4 (11)	0.65[0.22–1.87]	0.42	0.63[0.21–1.88]	0.40
Respondents' Family member	Father	701 (85)	119 (15)	1		1	
	Mother	149 (90)	17 (10)	0.67[0.39–1.15]	0.14	0.58[0.32–1.07]	0.08
	Daughter	446 (84)	88 (16)	1.16[0.86–1.57]	0.32	1.13[0.79–1.61]	0.48
	Son	10 (31)	22 (69)	2.68[1.24- 5.79]	0.01	2.64[1.21–5.76]	*0.01
HH heads education	Informal	999 (85)	182 (15)	1		1	
	Grade 1–12	241 (85)	43 (15)	0.98[0.68–1.40]	0.91	0.95[0.66–1.38]	0.78
	≥ College	78 (90)	9 (10)	0.63[0.31–1.29]	0.20	0.55[0.27–1.12]	0.09
HHs mean monthly income (ETB)	≤5000	1151 (85)	204 (15)	1		1	
	5001–10000	137 (83)	28 (17)	1.15[0.75–1.78]	0.51	1.09[0.71–1.70]	0.68
	≥10,001	30 (94)	2 (6)	0.38[0.09–1.59]	0.18	0.38[0.09–1.61]	0.19

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; HH: Households

* Significantly associated

associated with the knowledge level [18]. This finding implied that older individuals may have exposure to accumulated life experiences and potentially expose them to wide misconceptions and misbeliefs that prevent them from easily welcoming new information [18].

Respondents who had completed formal education (Grades 1–12) and those who had completed college or higher education were nearly twice as likely to demonstrate good knowledge of malaria transmission modes (each $p \leq 0.02$) compared with participants with informal educational backgrounds. This finding was comparable with a study conducted in Zambezia, Mozambique [22], and Areka, Ethiopia ($p < 0.001$) [30]. These findings highlighted that educational attainment plays a significant role in understanding malaria transmission modes [39]. Among household members, students were twice as likely to be knowledgeable about malaria transmission routes ($p \leq 0.01$) compared to daily labourers. This could be due to the fact that individuals attending schools have better information about malaria diseases [32, 40].

Among household members, daughters and housewives were twice and 30% less likely to demonstrate good knowledge of malaria transmission modes compared to their male counterparts, respectively ($p \leq 0.01$). This disparity may reflect differences in exposure to health information based on occupational role differences. Household heads who replied that their mean monthly income was between 5,001 and 10,000 ETB were twice as likely to demonstrate good knowledge of malaria transmission routes ($p \leq 0.02$) compared with households earning less than 5,000 ETB mean monthly income. This finding was in line with a study conducted in Myanmar [18], and West Belessa District, Ethiopia [16]. The possible explanations for similarities could be due to the fact that individuals from better educational statuses and wealth index households have better information options [32]. This suggests that individuals from higher wealth index households may have improved access to educational resources and information sources [16, 41].

Regarding mosquito breeding sites, respondents in the age range of 29 to 39 years old and household heads whose primary occupation is commerce (merchants) were approximately twice as knowledgeable regarding mosquito breeding sites compared to those in the age group of 18 to 28 years and those engaged in farming occupations, respectively ($p \leq 0.04$ and $p \leq 0.03$). This finding was in line with a study in Myanmar where age was associated with knowledge level regarding malaria ($p < 0.022$) [18]. The possible explanation for youths and merchants knowledge regarding mosquito breeding sites might be experiences in health talks, peer education, and information sharing trend differences [40, 41].

Regarding malaria prevention methods, household heads whose primary occupation is commerce

Table 10 Factors associated with participants' practice in ITNs utilization

Variable	Category	Practice		COR[95%CI]	P-value	AOR[95%CI]	P-value
		Poor (%)	Good (%)				
HHs head age (year)	18–28	113 (72)	45 (28)	1		1	
	29–39	252 (72)	98 (28)	0.98[0.64–1.48]	0.91	0.92[0.53–1.58]	0.75
	40–49	266 (77)	79 (23)	0.74[0.48–1.14]	0.17	0.78[0.42–1.46]	0.43
	50–59	112 (74)	39 (26)	0.87[0.53–1.44]	0.60	0.77[0.37–1.62]	0.48
	60–69	48 (76)	15 (24)	0.78[0.39–1.54]	0.48	0.69[0.27–1.78]	0.43
	≥70	40 (75)	13 (25)	0.81[0.39–1.67]	0.57	1.26[0.45–3.51]	0.66
Respondents' age (year)	18–28	295 (74)	103 (26)	1		1	
	29–39	262 (72)	104 (28)	1.13[0.83–1.56]	0.43	1.05[0.67–1.63]	0.84
	40–49	171 (80)	43 (20)	0.72[0.48–1.07]	0.11	0.79[0.44–1.41]	0.42
	50–59	59 (69)	27 (31)	1.31[0.79–2.17]	0.29	1.88[0.88- 4.01]	0.10
	60–69	23 (74)	8 (26)	0.99[0.43–2.29]	0.99	1.21[0.39–3.75]	0.74
	≥70	21 (84)	4 (16)	0.54[0.18–1.63]	0.27	0.51[0.12–2.19]	0.36
HHs heads marital status	Single	25 (69)	11 (31)	1		1	
	Married	698 (73)	262 (27)	0.85[0.41–1.76]	0.66	0.79[0.35- 1.81]	0.58
	Widowed	74 (85)	13 (15)	0.39[0.16–1.00]	0.05	0.40[0.14–1.13]	0.08
	Divorced	34 (92)	13 (8)	0.20[0.05–0.79]	0.02	0.24[0.06–1.00]	0.05
HHs heads education	Informal	618 (73)	232 (27)	1		1	
	Grade 1–12	156 (76)	50 (24)	0.85[0.60–1.21]	0.37	0.76[0.52–1.10]	0.14
	≥ College	7 (11)	57 (89)	0.33[0.15–0.73]	0.01	0.28[0.12-.63]	*0.001
Respondents' education	Informal	379 (77)	111 (23)	1		1	
	Grade 1–12	355 (71)	146 (29)	1.40[1.05–1.87]	0.02	1.33[0.98–1.82]	0.07
	≥ College	97 (75)	32 (25)	1.12[0.71–1.77]	0.60	1.16[0.65- 2.06]	0.62
HHs head occupation	Farmer	612 (73)	223 (27)	1		1	
	Labourer	25 (78)	7 (22)	0.77[0.32–1.80]	0.54	0.59[0.19–1.79]	0.35
	House wife	30 (94)	2 (16)	0.18[0.04–0.77]	0.02	0.24[0.05–1.17]	0.07
	Student	11 (85)	2 (15)	0.49[0.10–2.27]	0.36	0.53[0.10–2.78]	0.45
	Merchant	57 (71)	23 (29)	1.11[0.67–1.84]	0.69	0.89[0.44–1.83]	0.76
	NGO	8 (57)	6 (43)	2.05[0.71- 5.99]	0.15	0.62[0.10–3.77]	0.60
	GO	88 (77)	26 (23)	0.81[0.51–1.29]	0.37	0.53[0.23–1.21]	0.13
Respondents' occupation	Farmer	386 (75)	132 (25)	1		1	
	House wife	20 (77)	6 (23)	0.88[0.34–2.23]	0.78	1.32[0.38–4.52]	0.65
	Student	214 (73)	79 (27)	1.08[0.78–1.49]	0.64	1.25[0.86- 1.82]	0.23
	Merchant	108 (79)	28 (21)	0.76[0.48–1.20]	0.23	0.91[0.48–1.74]	0.78
	NGO	46 (72)	18 (28)	1.14[0.64–2.04]	0.64	1.27[0.56–2.89]	0.56
	GO	4 (44)	5 (56)	3.66[0.97–13.81]	0.05	6.65[0.77- 57.32]	0.08
	Other	53 (72)	21 (28)	1.16[0.67–1.99]	0.59	2.00[0.85–4.75]	0.11

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; HH: Households

* Significantly associated

(merchants) were twice as likely to show a good knowledge of malaria prevention methods ($p \leq 0.04$), and respondents who were involved in non-governmental organizations (NGOs), such as community-based organizations were 45% more likely to demonstrate good knowledge regarding malaria prevention methods ($p \leq 0.03$) compared to those with farmer occupations. Furthermore, HHs heads responded that they had a mean monthly income of between 5001 and 10,000 Ethiopian Birr (ETB) and were 61% more likely to be knowledgeable about malaria prevention methods ($p \leq 0.02$) compared to households earning less than 5,000 ETB monthly incomes. This finding was aligned with a study in Myanmar [18], and Boricha district, Sidama, Ethiopia [17]. The possible justification for this result might be that households with better mean monthly income had better

Table 11 Factors associated with participants' practice regarding IRS utilization

Variable	Category	Practice		COR[95%CI]	P-value	AOR[95%CI]	P-value
		Poor (%)	Good (%)				
HHs head age (year)	18–28	208 (95)	12 (5)	1		1	
	29–39	439 (91)	44 (9)	1.73[0.89–3.35]	0.10	1.76[0.89–3.48]	0.10
	40–49	451 (94)	29 (6)	1.11[0.55–2.22]	0.75	0.95[0.44–2.05]	0.88
	50–59	190 (93)	14 (7)	1.28[0.58–2.83]	0.54	1.04[0.36–2.97]	0.94
	60–69	88 (96)	4 (4)	0.79[0.25–2.51]	0.68	0.64[0.17–2.40]	0.51
Respondents' role	≥70	69 (95)	4 (5)	1.00[0.31–3.22]	0.99	0.74[0.20- 2.73]	0.65
	Father	762 (93)	58 (7)	1		1	
	Mother	156 (94)	10 (6)	0.84[0.42–1.68]	0.62	1.29[0.45–3.75]	0.44
	Daughter	500 (94)	34 (6)	0.89[0.57–1.38]	0.61	1.44[0.71- 2.91	0.13
	Son	27 (84)	5 (16)	2.43[0.90–6.55]	0.07	2.59[0.95–7.11]	0.06
Respondents' occupation	Farmer	672 (92)	58 (8)	1		1	
	House wife	35 (95)	2 (5)	0.66[0.16–2.82]	0.57	0.68[0.16–2.93]	0.60
	Student	565 (93)	28 (7)	0.89[0.56–1.42]	0.62	0.88[0.55–1.42]	0.61
	Merchant	182 (95)	9 (5)	0.57[0.28–1.18]	0.13	0.60[0.29–1.27]	0.18
	NGO	83 (95)	4 (5)	0.56[0.19–1.58]	0.27	0.58[0.21–1.66]	0.31
	GO	15 (100)	0 (0)	–		–	
	Other	93 (94)	6 (6)	0.74[0.31–1.78]	0.51	0.72[0.30–1.74]	0.46

AOR: Adjusted odds ratio; COR: Crude odds ratio; ETB: Ethiopian birr; HH: Households

Table 12 Malaria patients and treatment adherence in SWEPR

Variable	Category	Frequency	Percentile (%)
Health facility	Hospitals	14	28.6
	Health centers	125	29.6
Malaria patient sex	Male	926	54.99
	Female	758	45.01
Age category	≤5 years	272	16.15
	Adult	1412	83.85
OPD	Adult	1374	81.64
	under five	297	17.65
	pregnant	12	0.71
Malaria species	*P. falciparum*	982	58.31
	P.vivax	502	29.81
	Mixed	165	9.8
	Unspecified	35	2.08
Malaria complication status	Uncomplicated	1,508	89.55
	Complicated	176	10.45
Adherence to updated national malaria treatment guideline	NO	1,074	63.78
	Yes	610	36.22

OPD: Out Patient Departments

access to information toward malaria prevention with multiple media options [18].

Concerning attitudes towards malaria prevention methods, respondents aged within the age group of 60 to 69 years were twice as likely to demonstrate unfavourable attitudes regarding malaria disease prevention methods ($p \leq 0.04$) compared to younger age groups (18–28 years). Similarly, among family members, daughters were approximately 74% more likely to hold unfavourable attitudes regarding malaria disease prevention methods ($p \leq 0.02$) compared to fathers in the households. These results were conflicting with a study conducted in Areka, Southern Ethiopia [30]. These findings toward malaria prevention methods might be attached to cultural beliefs developed through life experiences and traditionally esteemed values instead of scientific evidence [30].

Regarding malaria prevention activities, sons were three times more likely to participate in environmental management practices to avoid malaria breeding sites ($p \leq 0.01$) when compared to father roles. Furthermore, household heads who had completed college and above were about 28% more likely to utilize ITNs while sleeping ($p \leq 0.01$) when compared to household heads who had no formal education. This result was in line with a study in Areka, Ethiopia [32]. These findings implied that sex, age, and educational status make a difference in the implementation of malaria prevention practices [18, 41].

Conclusion

In conclusion, these findings underscore the necessity for comprehensive malaria intervention strategies that consider communication language, media options, and the diverse socio-demographic factors such as gender, occupation, age, education level, and income.

Addressing these factors will be crucial for enhancing malaria prevention efforts in the region.

Limitation of the study and recommendation

Future research should prioritize a comprehensive evaluation of supplementary malaria prevention methods beyond ITNs and IRS, as well as an analysis of the drug sensitivity patterns of different malaria strains and vector control strategies.

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Author contributions

G.M. developed the concept, wrote the proposal, and carried out data analysis, interpretation, and manuscript preparation. The other authors—B.A., T.G., M.A., W.N., and E.N.—contributed to the conceptualization, proposal writing, data analysis, and interpretation. Finally, all authors reviewed and approved the final manuscript.

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Availability of data and materials

Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate

This study received approval from the SWEPRS Health Bureau Ethics Committee, as indicated by reference letter No. 12002/29/2016. Participants were thoroughly informed about the study's overall purpose, and their verbal consent was obtained before data collection, in accordance with international research ethics principles. In this study there no need of involving the use of any animal or human data or tissue. The heads of selected households or members whose age is greater than 18 years and living in the South Ethiopia Peoples Region State fully understand the objective of this study and weigh up the risks and benefits of participating. Then, they were informed about autonomy to withdraw or continue in this study and were assured that the data and sample collected from them were kept confidential. Finally, they orally confirmed their agreement.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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