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Prevalence and associated factors of malaria among febrile children in Ethiopia: A cross-sectional health facility-based study

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ABSTRACT

Malaria is one of the most important public health problems in Ethiopia. The objective of this study was to identify the prevalence and associated factors of malaria among children who presented for investigation. A cross-sectional health facility-based study was conducted between October and November 2012 in East Shewa Zone of Oromia Regional Sate in Ethiopia. Blood samples by finger pricks were collected for microscopic diagnosis of malaria from children under the age of 16 years with symptoms suggestive of malaria attending five health centers. An interview was conducted with the parents/guardians of the children using a pre-tested structured questionnaire. Bivariate and multivariate logistic regression was employed to study associations between malaria infection and associated factors. Of 830 children who provided blood samples, 170/830 (20.5%) were microscopically confirmed for malaria parasites. The predominant *Plasmodium* species were *Plasmodium vivax* (11.7%) and *Plasmodium falciparum* (8.4%), whilst mixed infections of both species were identified in 0.4% of patients (relative proportion: 57.1%, 41.2%, and 1.8%, respectively). Household's ownership of insecticide treated nets (ITNs) was significantly associated with decreased odds of malaria infection (adjusted odds ratio [aOR]: 0.69, 95% confidence interval [CI]: 0.56–0.85). However, an increased odds of malaria infection was observed among children between 10 and 15 years old (aOR: 2.19, 95% CI: 1.25–3.83) compared to children under the age of 2 years. The strong association reported here between household's ownership of ITNs and malaria infection among children in this part of Ethiopia call for continued efforts of net distribution and use to control malaria, which in turn might improve children's health and development.

1. Introduction

Globally there were an estimated 198 million cases and 584,000 deaths due to malaria in 2013, of which approximately 80% of the cases and 90% of deaths were from the sub-Saharan Africa (WHO, 2014). By 2010 the targets for the Global Malaria Action Plan of the Roll Back Malaria were set to achieve universal coverage for all populations at risk of malaria using appropriate interventions for prevention and case management, and to reduce malaria burden by at least 50% compared to the levels in the year 2000 (Nafo-Traoríe, 2005). However, the estimated incidence of malaria globally has reduced only by 17% between 2000 and 2010 (WHO, 2011). These rates of decline were lower than internationally agreed targets of 50% reductions for 2010 but, nonetheless, they represent a major achievement.

In Ethiopia, malaria is one of the most important public health problems with about two-thirds of the population (more than 55 million people) living in areas at risk of malaria infection (Ghebreyesus et al., 2006). *Plasmodium falciparum* (about 60%) and *Plasmodium vivax* (about 40%) are the two most important malaria parasites in the country. In line with the recent reduction in global malaria morbidity and mortality particularly in the African Region (WHO, 2013), Ethiopia made a remarkable achievement in reducing malaria cases and deaths at least by half between 2006 and 2011 (Otten et al., 2009; WHO, 2013). These reductions in the burden of malaria both among children and adults were observed in all malaria transmission areas in the country and were associated with the major scaling up of the universal coverage with effective interventions (Aregawi et al., 2014).

Despite the significant decline in the burden of malaria in Ethiopia, yet the disease is a major public health problem with

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approximately five million cases being reported annually (MOH, 2012, 2014a). In 2012, the World Health Organization (WHO) estimated that Ethiopia had approximately 5% of malaria cases in the African Region (WHO, 2013). According to the 2012/2013 health and health related indicators of the Ministry of Health (MOH), malaria was the first of the 10 leading causes of morbidity (12%) and a total of 2.85 million laboratory confirmed malaria cases were reported from different parts of the country (MOH, 2014b). In the Oromia Regional State of Ethiopia, the burden of malaria is also high with 65% of the population in the Region being at risk of infection (Deressa et al., 2004). Currently, diagnosis of malaria using microscopy or rapid diagnostic tests (RDTs) and treatment with artemisinin-based combination therapies (ACTs), promotion of long lasting insecticidal nets (LLINs) ownership and use by the community, and application of indoor residual spraying (IRS) with insecticides are being scaled up to improve access and equity to preventive as well as curative health services (MOH, 2012, 2014a).

Several methods were used to determine malaria prevalence and identify risk factors associated with malaria infection including health facility and community-based cross-sectional surveys. Previous studies done in Africa and Asia on factors associated with malaria prevalence identified sex, age, number of bed nets in the household, presence of forest cover, altitude, household density and mud wall as the main determinant factors (Haque et al., 2011; Sintasath et al., 2005; Winskill et al., 2011). Similarly, in Ethiopia, insecticide treated net (ITN) utilization, age, gender, wealth index, presence of stagnant water in the locality, distance from health facility and material used for roofing were identified as risk factors for malaria infection (Alemu et al., 2011; Chala and Petros, 2011; Ferede et al., 2013; Graves et al., 2009; Woyessa et al., 2012). We conducted a cross-sectional health facility-based study among children under the age of 16 years in East Shewa Zone of Oromia Region in Ethiopia, using data that was originally collected to explore the associations between parental concerns about human immunodeficiency virus (HIV) infection in children with suspected malaria (Haji et al., 2014). Our aim was to determine the prevalence of malaria infection and its associated factors among children with suspected malaria who presented to five health centers.

2. Methods

2.1. Study area and population

This study was carried out in East Shewa Zone of Oromia Regional State in Ethiopia. The total population of the Zone in 2010/2011, as projected based on the 2007 census, was 1,519,103 inhabitants (CSA, 2008). The Zone has three hospitals, 18 health centers and 296 health posts. Based on the 2011/2012 annual reports of the District Health Offices (DHO) in the study area, malaria was the third cause of outpatient department attendants. A total of 25,999 microscopically confirmed and 72,565 clinically diagnosed malaria cases were reported from the health facilities in the zone during the year (unpublished results).

Data were collected from five health centers between October and November 2012, during a peak malaria transmission following cessation of the major rainy season. The health centers were Mojo, Meki, Batu, Bulbula, and Shashemene. These health centers were purposively selected based on high patient flow and malaria burden in the areas. In these health centers, diagnosis of malaria is based on clinical assessment and microscopic examination of blood films that guide subsequent treatment using national malaria treatment guidelines (MOH, 2012). The study population consisted of all children under the age of 16 years who presented with symptoms consistent with malaria (fever, headache, chills, thirsty, etc.) and gave blood for blood film examination under a microscopy at the health centers. A history of fever was sufficient for inclusion in the study populations; we did not use a threshold temperature at presentation as a criterion for inclusion in the study. Critically sick children and those presented to the health center without being accompanied by their parents/caretakers were excluded.

2.2. Study design and data collection

A health facility-based cross-sectional design was used to address the study objectives. The study principally employed quantitative techniques based on structured questionnaire that was administered to the parent/guardian of the children. These data were originally collected for a study of malaria and concern about HIV testing (Haji et al., 2014) on 836 children under the age of 16 years. Hence, there is no formal power calculation as this is a secondary analysis of these data.

A pre-tested structured questionnaire was initially developed in English and then translated into local language (*Afan* Oromo) for data collection on socio-demographic characteristics, knowledge of malaria diagnosis and treatment, treatment-seeking behavior for febrile children and results of blood film examination under microscopy. A laboratory technician (data collector) and one supervisor from each health center were trained for two days on the data collection instrument, interview techniques and recruitment of the study participants.

Malaria diagnosis was done with light microscopy using blood films prepared from finger-prick blood samples collected from children with suspected malaria. Experienced laboratory technicians prepared thick and thin blood films that were labeled and air-dried horizontally in a slide tray. Thin films were fixed with methanol for about 30 s, and both thick and thin films were stained with 3% Giemsa for 20–30 min at each health center using the standard malaria laboratory procedures (WHO, 2000). The thick films were used for detecting the malaria parasites while the thin films were used for label as well as for species confirmation. The blood slides were read and then classified qualitatively as either negative, *P. falciparum* positive, *P. vivax* positive, or mixed infection. Children with microscopically confirmed malaria infection were treated at the health centers according to the national malaria diagnosis and treatment guidelines (MOH, 2012).

2.3. Data analysis

All completed data collection forms were examined for completeness and consistency during data management, storage and analysis. Any errors during data entry were corrected timely and data editing and cleaning were given due attention. Data entry, data cleaning and coding were performed using the Epi info software (Centers for Disease Control and Prevention, Atlanta, GA, USA) and then exported to SPSS version 16 (SPSS, Chicago, IL, USA) for analysis. Respondents' knowledge of the causes of malaria was constructed based on their correct responses to the question about how malaria is transmitted or what causes malaria (measured by correct mentioning of mosquito bite and not citing other misconceptions such as hunger, eating maize stalk, and exposure to dirty).

Associations between dependent and independent variables were assessed using bivariate and multivariate logistic regression. Differences in proportions were compared for significance using X^2 test, and $p < 0.05$ was considered statistically significant. Multiple logistic regression models were built to assess the effect of each independent variable on malaria infection, adjusting for confounding. Variables which entered into the final logistic regression model include place of residence, household wealth index, household's ownership of ITNs, parents'/guardians' knowledge about the cause of malaria, advice sought before visiting the health center, age and sex of child, and duration between illness onset and current

Table 1
Characteristics of the febrile children and prevalence of malaria infection.

Variables	Health center					
	Mojo, *n* (%)	Meki, *n* (%)	Batu, *n* (%)	Bulbula, *n* (%)	Shashemene, *n* (%)	Total, *n* (%)
Sex of sick child						
Female	55 (55.6)	83 (43)	88 (49.2)	81 (50.6)	100 (49.7)	423 (51)
Male	44 (44.4)	110 (57)	91 (50.8)	79 (49.4)	99 (50.3)	407 (49)
Age of sick child						
<2 years	15 (15.2)	27 (14)	25 (14)	5 (3.1)	27 (13.6)	99 (12)
2–4 years	22 (22.2)	74 (38.3)	69 (38.5)	36 (22.5)	49 (24.6)	250 (30)
5–9 years	38 (38.4)	58 (30.1)	44 (24.6)	80 (50)	71 (35.7)	291 (35)
10–15 years	24 (24.2)	34 (17.6)	41 (22.9)	39 (24.4)	52 (26.1)	190 (23)
Duration of current illness before treatment						
<2 days	49 (49)	114 (59)	94 (52)	98 (61)	75 (38)	430 (52)
≥2days	50 (50)	79 (41)	85 (47)	62 (39)	124 (62)	400 (48)
Microscopic test result of the sick child						
Positive	12 (12.1)	65 (33.7)	33 (18.4)	24 (15)	36 (18.1)	170 (20.5)
Negative	87 (87.9)	128 (66.3)	146 (81.6)	136 (85)	163 (81.9)	660 (79.5)
Plasmodium species (*n* = 170)						
P. falciparum	5 (41.7)	37 (56.9)	18 (54.5)	6 (25)	4 (11.1)	70 (41.2)
P. vivax	7 (58.3)	28 (43.1)	13 (39.4)	18 (75)	31 (86.1)	97 (57.1)
Mix of both species	0 (0)	0 (0)	2 (6.1)	0 (0)	1 (2.8)	3 (1.8)
Sick child prescribed any medication by the health facility						
Yes	92 (92.9)	190 (98.4)	80 (44.7)	153 (95.6)	195 (98)	710 (85.5)
No	7 (7.1)	3 (1.6)	99 (55.3)	7 (4.4)	4 (2)	120 (14.5)
Child being prescribed anti-malarial drug (*n* = 710)						
Yes	12 (13)	65 (34.2)	33 (41.2)	24 (15.7)	36 (18.5)	170 (23.9)
No	79 (86)	125 (65.8)	46 (57.5)	129 (84.3)	159 (81.5)	538 (75.8)
Don't know	1 (1)	0 (0)	1 (1.2)	0 (0)	0 (0)	2 (0.3)
Type of antimalarial drug prescribed (*n* = 176)						
Coartem	2 (16.7)	35 (53.8)	19 (57.6)	6 (25)	5 (14)	67 (39.4)
Chloroquine	8 (66.7)	29 (44.6)	15 (45.5)	18 (75)	32 (86)	102 (60)
Quinine	2 (16.7)	1 (1.5)	1 (3)	0 (0)	0 (0)	4 (2.4)

treatment. The point estimates and their 95% confidence intervals (CI) were calculated using the SURVEY (SVY) command in STATA to account for the clustered nature of the data with health center as a primary sampling unit. Adjusted odds ratios (aORs) and their 95% CIs were reported.

2.4. Ethical considerations

Ethical approval for the study was obtained from the School of Public Health at the College of Health Sciences of Addis Ababa University, Ethiopia. Permission for the study was obtained from Oromia Regional Health Bureau, East Shewa Zonel Health Department and DHO. An information sheet in the local language was read to parents/guardians in the presence of their children. The study participants were given detailed explanations about the objectives, procedures and potential risks and benefits of the study. For children, assent was obtained from their parents/guardians. Participation was voluntary, and hence, it was in line with the ethical principle of "autonomy" by including statements that give participants the right to withdraw from the study anytime without further obligations. The interview of each study participant took place in a separate room after the children gave blood samples for microscopic investigation.

3. Results

3.1. Characteristics of the febrile children and prevalence of malaria infection

In this study, 836 children with symptoms suggestive of malaria were eligible for the study and 830 (99%) provided data. The children were from five health centers: Mojo (12%), Meki (23%), Batu (22%), Bulbula (19%) and Shashemene (24%). Descriptive characteristics of the study children are presented in Table 1. There were 423 (51%) girls and 407 (49%) boys. In terms of age, 349 (42%) of the children were below five years, whilst the remaining 481 (58%) were older, up to 15 years. The mean and median age of the children was almost equal, 6 years and 6.1 years, respectively. Of the total studied febrile children, the majority (86%) did not seek advice or treatment from any source before coming to the current health centers. About 52% of the children visited the current health centers within two days of illness onset.

Among 830 children microscopically tested for malaria, the slide positivity rate was 20.5% (*n* = 170) (Table 1). Almost all tests were done with microscopy using blood slides except two tests in which RDTs were used. There was a considerable variation with the slide positivity rate between the health centers ranging from 12.1% at Mojo to 33.7% at Meki. *P. vivax* accounted for 57.1% (*n* = 97) of confirmed cases of malaria infection, followed by *P. falciparum* (41.2%, *n* = 70) and three cases (1.8%) mixed infections of both species. About 40% and 60% of the children with malaria infection were treated with Coartem (artemether–lumefantrine) for *P. falciparum* and chloroquine for *P. vivax*, respectively.

3.2. Socio-demographic characteristics of parents/guardians

Table 2 shows the descriptive characteristics of the parents/guardians of the studied children. Briefly, about two-third (68%) of the respondents were females and more than half (56%) were from urban areas. Mothers and fathers of the surveyed children constituted about 61% and 26% of the respondents, respectively. About one-third (34%) of the respondents were unable to read/write, and 74% lived in houses with corrugated iron roofs. Nearly half (46%) of the respondents were Muslims and 35.8% were

Table 2
Socio-demographic characteristics of parents/guardians.

Variables	Health center					
	Mojo, *n* (%)	Meki, *n* (%)	Batu, *n* (%)	Bulbula, *n* (%)	Shashemene, *n* (%)	Total, *n* (%)
Residence						
Urban	67 (68)	115 (60)	115 (64)	22 (14)	150 (75)	469 (56)
Rural	32 (32)	78 (40)	64 (36)	138 (86)	49 (25)	361 (43)
Sex						
Female	73 (73)	133 (69)	115 (64)	106 (66)	140 (70)	567 (68)
Male	26 (26)	60 (31)	64 (36)	54 (34)	59 (30)	263 (32)
Age category						
16–24 years	20 (20)	37 (19)	35 (20)	21 (13)	44 (2)	157 (19)
25–34 years	45 (45)	96 (50)	92 (51)	75 (47)	74 (37)	382 (46)
35–44 years	22 (22)	51 (26)	45 (25)	58 (36)	55 (28)	231 (28)
>45 years	12 (12)	9 (5)	7 (4)	6 (4)	26 (13)	60 (7)
Relationship to the sick child						
Mother	63 (64)	119 (62)	101 (56)	99 (62)	121 (61)	503 (61)
Father	17 (17)	48 (25)	50 (28)	45 (28)	53 (27)	213 (26)
Brother	3 (3)	10 (5)	12 (7)	7 (4)	8 (4)	40 (5)
Sister	3 (3.0)	12 (6)	9 (5)	6 (4)	8 (4)	38 (5)
Others	13 (13)	4 (2)	7 (4)	3 (2)	9 (4)	36 (4)
Highest level of education						
Unable to read/write	34 (34)	64 (33)	51 (28)	91 (57)	44 (22)	284 (34)
Can read/write only	10 (10)	24 (12)	8 (4)	11 (7)	16 (8)	69 (8)
Primary Cycle 1	8 (8)	31 (16)	40 (22)	19 (12)	35 (18)	133 (16)
Primary Cycle 2	17 (17)	33 (17)	46 (26)	27 (17)	46 (23)	169 (20)
Secondary school and above	30 (30)	41 (21)	34 (19)	12 (7)	58 (29)	175 (21)
Roof material of household						
Corrugated iron	83 (83)	127 (66)	134 (75)	90 (56)	180 (90)	614 (74)
Thatched	16 (16)	66 (34)	45 (25)	70 (44)	19 (9)	216 (26)

Orthodox Christians. The majority (70.5%) of the respondents were from Oromo ethnic group, followed by Amhara (10.8%), Guraghie (6.9%), Hadiya (3.5%) and Kambata (2.3%).

3.3. Knowledge and perception about malaria among parents/guardians

About 87% of the respondents associated causes of malaria with mosquito bite, while 28% cited hunger/empty stomach, and 19% cited eating maize stalk (Table 3). The commonly mentioned symptoms of malaria were fever (92%), headache (73%), feeling cold (68%) and being thirsty (67%). With regard to the method how to protect oneself against malaria, 89% of respondents cited sleeping under mosquito nets/ITNs, 55% mentioned draining of mosquito breeding sites, 47% said to keep house surroundings clean, 44% cited spray house with insecticide. Whereas, misconceptions like eating garlic, drinking alcohol, and avoiding drinking dirty water were cited by some groups of respondents.

3.4. Mosquito nets/ITNs possession and utilization by households

Concerning self-reported households' current possession of ITNs, 51% had mosquito nets/ITNs. Among the net-owning households, 34.7% had one net, 48.5% two and the rest 17% had three or more nets (Table 4). Of the respondents possessed ITN, 58% of the adults reported that they slept under ITNs every night in the last 15 days and 76% slept under ITNs on the preceding night. The percentage of febrile children sleeping under ITNs every night in the last 15 days was 62% and 75% of them reported that they slept under ITNs the night preceding the survey.

3.5. Factors associated with malaria infection among febrile children

In the final adjusted model, children from households who owned an ITN had a decreased odds of malaria infection with adjusted odds ratio (aOR) of 0.69 (95% confidence interval [CI]: 0.56–0.85) (Table 5). An increased odds of malaria infection was observed among children between 10 and 15 years old (aOR = 2.19, 95% CI: 1.25–3.83) compared to younger children under the age of 2 years. However, sex of the children, household wealth index, seeking advice before visiting the current health facility, duration between illness onset and treatment, and knowledge of the causes of malaria, as defined by incorrect response of the parents/guardians to question about cause of malaria, were not statistically associated with malaria infection in the surveyed children.

4. Discussion

This cross-sectional study of a population of children presenting to health facilities with suspected malaria showed that 20% of those with symptoms had confirmed infection. Risk factor analysis for infection with malaria in this population demonstrated that absence of ITN in the households and older age were associated with positive diagnosis of malaria infection. In contrast, sex of the child, wealth index, advice before seeking treatment, duration between illness onset and seeking treatment, and knowledge of the parents/guardians on the causes of malaria were not statistically associated with malaria infection in this population.

The strengths of these data include the high response rate (99%) from eligible individuals. The use of a population with suspected malaria with subsequent confirmation of malaria infection status permits investigation of possible risk factors that may modify malaria infection in this population. However, these data might have the limitation that any findings observed could be culturally and geographically specific to the study population, and hence not necessarily generalizable to other communities. Other limitations include the cross-sectional nature of the study, and hence it is unable to demonstrate causal associations while the use of participants' self-report could possibly lead to the introduction of misclassification bias and recall bias.

Table 3
Knowledge of the parents/guardians about causes, symptoms and prevention mechanisms of malaria.

Variables	Health center					
	Mojo, *n* (%)	Meki, *n* (%)	Batu, *n* (%)	Bulbula, *n* (%)	Shashemene, *n* (%)	Total, *n* (%)
Causes of malaria[a]						
Mosquito bite	88 (89)	179 (93)	169 (94)	150 (94)	134 (67)	720 (87)
Hunger/empty stomach	12 (12)	78 (40)	59 (33)	22 (14)	61 (31)	232 (28)
Eating maize stalk	4 (4)	60 (31)	26 (14.5)	57 (36)	8 (4)	155 (19)
Exposure to dirt/swamp	13 (13)	18 (9)	22 (12)	9 (6)	71 (36)	133 (16)
Drinking dirty water	10 (10)	20 (10)	30 (17)	27 (17)	26 (13)	113 (14)
Eating immature sugarcane	7 (7)	45 (23)	21 (12)	16 (10)	6 (3)	95 (11)
Cold/changing weather	9 (9)	27 (14)	11 (6)	7 (4)	17 (8.5)	71 (9)
Others	8 (8)	3 (1.5)	8 (4)	1(0.6)	5 (2.5)	25 (3)
Symptoms of malaria[a]						
Fever	86 (86.9)	184 (95.3)	175 (97.8)	155 (96.9)	166 (83.4)	766 (92.3)
Headache	70 (70.7)	134 (69.4)	145 (81)	143 (89.4)	113 (56.8)	605 (73)
Feeling cold	76 (76.8)	140 (72.5)	106 (59.2)	126 (78.8)	113 (56.8)	561 (68)
Thirsty	56 (56.6)	114 (59)	126 (70.4)	131 (82)	130 (65)	557 (67)
Loss of appetite	69 (70)	99 (51)	82 (46)	93 (58)	46 (23)	389 (47)
Vomiting	54 (54.5)	134 (69.4)	82 (46)	30 (19)	74 (37)	374 (45)
Sweating	46 (46.5)	132 (68.4)	27 (15)	12 (7.5)	60 (30.2)	277 (33)
Bitterness in mouth	41 (41.4)	50 (26)	41 (23)	72 (45)	67 (33.7)	271 (33.7)
Nausea	42 (42.4)	92 (47.7)	32 (18)	14 (9)	79 (40)	259 (31)
Body weakness	43 (43.4)	40 (20.7)	36 (20)	24 (15)	23 (11.6)	166 (20)
Body ache/joint pain	37 (37.4)	28 (14.5)	21 (12)	4 (2.5)	44 (22)	134 (16)
Others	6 (6)	2 (1)	12 (6.7)	4 (2.4)	8 (4)	32 (4)
Protection against malaria[a]						
Sleep under ITNs	87 (88)	183 (95)	163 (91)	152 (95)	154 (74)	739 (89)
Drain mosquito breeding sites	48 (48.5)	111 (57.5)	140 (78)	91 (57)	68 (34)	458 (55)
Keep house surroundings clean	53 (53.5)	77 (40)	124 (69)	51 (32)	82 (41)	387 (47)
Indoor residual spraying/IRS	25 (25)	153 (79)	73 (41)	100 (62.5)	11 (5.5)	362 (44)
Avoid mosquito bite	11 (11)	118 (61)	27 (15)	13 (8)	25 (13)	194 (23)
Eat garlic	9 (6)	71 (47)	49 (32)	11 (7)	11 (7)	151 (18)
Smoking in the house	2 (2)	44 (23)	64 (36)	21 (13)	18 (9)	149 (18)
Don't drink dirty water	9 (9)	20 (10)	27 (15)	21 (13)	11 (5.5)	88 (11)
Others	7 (7)	31 (16)	31 (17)	16 (1)	25 (11)	110 (13)

[a] Multiple responses are possible.

Table 4
Households' mosquito nets/ITNs possession and utilization.

Variables	Health center					
	Mojo, *n* (%)	Meki, *n* (%)	Batu, *n* (%)	Bulbula, *n* (%)	Shashemene, *n* (%)	Total, *n* (%)
Current ownership of any ITNs (*n* = 830)						
Yes	76 (77)	97 (50)	85 (47)	85 (53)	78 (39)	421 (51)
No	23 (23)	96 (50)	94 (52)	75 (50)	121 (61)	409 (49)
Number of ITNs owned by household (*n* = 421)						
One	25 (33)	49 (50.5)	39 (46)	8 (9.4)	25 (32.1)	146 (34.7)
Two	43 (56.6)	38 (39.2)	41 (48)	56 (66)	26 (33.3)	204 (48.5)
Three or more	8 (10.8)	10 (10.3)	5 (6)	21 (24.7)	27 (34.6)	71 (16.9)
Frequency of sleeping under ITNs in the last 15 days (*n* = 421)						
All nights	18 (24)	56 (58)	64 (75)	50 (59)	55 (70.5)	243 (58)
Almost all nights	22 (29)	1 (1)		17 (20)	1 (1)	50 (12)
Sometimes	17 (24)	30 (31)	9 (11)	14 (16.5)	13 (17)	80 (19)
Only few nights	0 (0)	2 (2)	6 (7)	2 (2)	4 (5)	8 (2)
None of the nights	19 (25)	8 (8)	0 (0) 6 (7)	2 (2)	5 (6)	40 (10)
Any adult slept under ITNs last night (*n* = 421)						
Yes	41 (54)	74 (76)	73 (86)	71 (83.5)	62 (79.5)	321(76)
No	35 (46)	23 (24)	12 (14)	14 (16.5)	16 (20.5)	100 (24)
Frequency of the sick child sleeping under ITNs in the last 15 days (*n* = 421)						
All nights	22 (29)	54 (56)	66 (78)	67 (79)	54 (69)	263 (62)
Almost all nights	9 (12)	1 (1)		2 (2)	1 (1)	17 (4)
Sometimes	20 (26)	31 (32)	4 (5)	12 (14)	13 (17)	82 (19)
Only few nights	2 (3)	3 (3)	6 (7)	2 (2)	4 (5)	12 (3)
None of the nights	23 (30)	8 (8)	1 (1)			
newline 8 (9)	2 (2)	6 (8)	47 (11)			
Child slept under ITNs last night (*n* = 421)						
Yes	43 (57)	70 (72)	65 (76)	74 (87)	62 (79)	314 (75)
No	33 (43)	27 (28)	20 (23)	11 (13)	16 (20)	107 (25)

Table 5
Univariate and multivariable logistic regression analyses of factors associated with malaria infection in children.

Variables	Malaria lab. result[a]		Univariate OR (95% CI)	Adjusted[b] OR (95% CI)
	Positive	Negative		
Place of residence				
Urban	83 (18)	386 (82)	1.00	1.00
Rural	87 (24)	274 (76)	1.48 (0.85–2.56)	1.49 (0.76–2.92)
Household wealth index				
Low	87 (21)	319 (79)	1.00	1.00
Medium	43 (25)	130 (75)	0.17 (0.06–0.45)	1.51 (0.51–4.45)
High	40 (16)	211 (84)	0.04 (0.01–0.28)	0.93 (0.35–2.45)
Households' ITN possession				
No	93 (23)	316 (77)	1.00	1.00
Yes	77 (18)	344 (82)	0.76 (0.53–1.09)	0.69 (0.56–0.85)[c]
Guardians knowledge about the cause of malaria				
Good	135 (19)	583(81)	1.00	1.00
Poor	35 (31)	77 (69)	1.96 (0.88–4.36)	1.99 (0.73–5.45)
Advice sought before visiting				
No	137 (19)	579 (81)	1.00	1.00
Yes	33 (29)	81 (71)	1.72 (0.82–3.63)	1.54 (0.73–3.23)
Age of sick child				
<2 years	11 (11)	88 (89)	1.00	1.00
2-4 years	55 (22)	195 (78)	2.26 (0.76–6.68)	2.11 (0.78–5.76)
5–9 years	60 (21)	231(79)	2.08 (0.69–6.29)	1.91 (0.51–7.10)
10–15 years	44 (23)	146 (77)	2.41 (1.64–3.53)[c]	2.19 (1.25–3.83)[c]
Sex of sick child				
Female	73 (18)	334 (82)	1.00	1.00
Male	97 (23)	326(77)	1.36 (0.76–2.44)	1.36 (0.74–2.52)
Duration of current illness before treatment				
Early (<2 days)	73 (17)	357 (83)	1.00	1.00
Delay (≥2 days)	97 (24)	303 (76)	1.56 (0.72–3.39)	1.46 (0.83–2.58)

[a] Numbers in parenthesis are percentages.
[b] Adjusted for age group, sex, wealth (3 levels), residence, ITN ownership, knowledge and duration of current illness.
[c] Statistically significant at $p < 0.05$; CI—confidence interval; ITN—insecticide treated net.

This study demonstrated a relatively lower slide positivity rate of 12.1–33.7% compared with the study in 2000 that showed 41–48% parasite rate among suspected malaria patients attending malaria control laboratories in East Shewa Zone of Oromia Regional State (Deressa et al., 2003a). However, this finding is almost similar to the recent study conducted in Metema Hospital, northwest Ethiopia, where about 17% slide positivity rate was reported (Ferede et al., 2013). The distribution of slide positivity observed was also remarkably varied among the health centers. In Ethiopia, malaria transmission is seasonal and varies from one place to another. There are areas in which *P. falciparum* infections predominate over *P. vivax* and vice versa (Lo et al., 2015). The current findings also demonstrated similar spatial variations in the proportion of *Plasmodium* species, with the predominant occurrence of *P. vivax* in Shashemene and Bulbula health facilities, while *P. falciparum* infections predominated over *P. vivax* in the remaining two study sites. This was most likely due to the wide ecological diversity within each area. The topography, ecological landscape, climatic factors and the available mosquito breeding sites in the study zone are diverse, even within the catchment areas of each health facility. This is similar with another community-based study conducted in Fincha'a, Ethiopia, where variation between villages with malaria infection was also observed (Chala and Petros, 2011). The role of Duffy antigens for the variations in the prevalence of *P. vivax* infections in the study area is unclear. A recent study in Ethiopia identified *P. vivax* infections among both Duffy-positive and Duffy-negative community samples, with more infections among Duffy-positive individuals (Lo et al., 2015).

The distribution of *P. falciparum* and *P. vivax* reported in the current study were found to be different from the previous reports in the study area. More than half (57%) of malaria infections detected was due to *P. vivax*. A longitudinal community-based study conducted in East Shewa Zone in 1994 demonstrated that *P. falciparum* constituted 66% of the total malaria infections (Abose et al., 1998). A study conducted among self-reported suspected malaria patients attending Batu malaria control laboratory in East Shewa Zone in 2000 showed that *P. falciparum* constituted 52.6% of the total malaria infections (Deressa et al., 2003a).

Evidence suggests that there has been a slight shift in the relative proportion of *Plasmodium* species causing malaria infections in Ethiopia since the last decade. Recent community-based studies carried out in south-central rural parts of the country showed the relative predominance of *P. vivax* malaria infections (Bekele et al., 2012; Woyessa et al., 2012). This is in line with the findings of a study conducted in urban area of south-west Ethiopia which revealed the predominating *P. vivax* (71%) infection (Alemu et al., 2011). An important reason for higher proportion of malaria infections due to *P. vivax* may be due to the relapsing feature of this species. Another important reason for the increase in the proportion of *P. vivax* compared with *P. falciparum* might be due to the reduced transmission rates of malaria and absence of major epidemics since last decade, which used to be caused mainly by *P. falciparum*. In areas with low malaria transmission rates and absence of epidemics, evidence indicates the predominance of *P. vivax* (Mendis et al., 2001). In addition, the lack of treatment with primaquine for *P. vivax* hynozoites may lead to the relapse of *P. vivax*, which may also contribute to increased *P. vivax* transmission.

However, the national health and health indicators in 2011–2012 (MOH, 2013) and 2012–2013 (MOH, 2014b) reported about 60% of *P. falciparum* infections, with the remainder being due to *P. vivax*. The national data still show that the predominant *Plasmodium* species during peak malaria transmission is *P.*

falciparum with a relative proportion of 60% (MOH, 2014a). The 2007 and 2011 national community-based malaria indicator surveys conducted during peak malaria transmission season reported the predominance of *P. falciparum,* 83% and 77%, respectively (MOH, 2008; EHNRI and Partners, 2012).

Of factors associated with malaria infection, ITN possession by households found to be protective against malaria as children whose guardians reported not to have ITN were about 1.5 times more likely to be infected with malaria than their counterparts which is supported by other similar studies (Alemu et al., 2011; Winskill et al., 2011). The protective effect of ITN use shown in our study adds to the vast body of facts supporting the efficacy and effectiveness of ITN for protection against malaria (Lengeler, 2004). It is obvious that proper utilization of ITN will prevent mosquito bite that in turn prevents malaria infection. However, this needs further elaboration, as ITN possession alone does not guarantee its utilization and lack of association of ITN utilization with malaria infection (Deressa et al., 2014).

Another important factor determining the odds of malaria infection is age. In this study, malaria was less prevalent among infants less than 2 years old compared to older children. This is consistent with other studies conducted in northern Ethiopia and Tanzania where older children were more commonly infected with malaria than younger ones (Graves et al., 2009; Winskill et al., 2011). However, the findings of this study contradicts other similar studies in western and south central Ethiopia in which older children had lower odds of malaria infection (Woyessa et al., 2012). It is obvious that children are the most susceptible group of the community in malaria endemic areas than adults in areas of high malaria transmission. However, in low transmission areas such as Ethiopia, risk of malaria is similar between children and adults.

The results indicated that knowledge about the symptoms of malaria was very high. Almost all of the study participants had knowledge of at least one of the classical symptoms. This is almost comparable with study done in Ethiopia on knowledge, attitude and practice (KAP) about malaria (Deressa et al., 2003b; Yewhalaw et al., 2010) and other KAP study done on malaria in Swaziland (Hlongwana et al., 2009). However, a better malaria knowledge observed in this study in comparison with a study done in Ghana (Adjei et al., 2008) reported only 66% and India (Matta et al., 2004) reported only 49% of one or two classical symptoms of malaria. The knowledge about malaria symptoms is commonly high in malaria endemic areas where the community is aware of the clinical presentation of the disease and also this may be associated with improved malaria prevention strategies and accessibility of the study sites to educational institutions.

Malaria prevention measures such as ITN use, draining mosquitoes breeding sites, keeping surroundings' clean and use of IRS were commonly mentioned in the study. This is higher than the findings of other studies reported elsewhere (Deressa et al., 2003b; Mota et al., 2009; Paulander et al., 2009). However, misconceptions like eating garlic, drinking alcohol, avoiding dirty food etc. were also identified. The higher knowledge on malaria prevention observed in the current study may be due to the fact that, all other studies were conducted about a decade back, while current strategies of house to house awareness of malaria prevention through deploying health extension workers are implemented in our study population.

5. Conclusions

Lack of ITN at households and age of the children are the main factors associated with malaria that requires due attention in preventing malaria. All concerned bodies should work on modifiable factors such as ITN distribution and utilization, knowledge of malaria cause and treatment seeking behaviors, and changing attitude through health education.

Conflict of interest

The authors declare that they have no actual or potential conflict of interest.

Authors' contributions

YH was involved in proposal writing, participated in field coordination, supervision and the overall implementation of the study, analyzed the data, drafted and finalized the manuscript. WD and AWF conceived, designed and developed the study, and participated in all stages of the study including analysis and revision of the manuscript together with YH. AWF obtained funding for the study. All authors read and approved the final submitted manuscript. YH and WD are guarantors of the paper.

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