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Magnitude of urban malaria and its associated risk factors: the case of Batu town, Oromia Regional State, Ethiopia

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Abstract

Objective: This study aimed to assess the magnitude of malaria and its associated risk factors in urban, Batu town, Oromia Regional State, Ethiopia.

Methods: This health-facility based prospective cross-sectional study enrolled 356 febrile malaria patients to assess risk factors associated with malaria infection.

Results: An overall positivity rate of 17.13% (61/356) for malaria infection was observed. Among the malaria-positive patients, 50.8% (31/61) of them were positive for *Plasmodium vivax*, 45.90% (28/61) were positive for *Plasmodium falciparum*, and 3.3% (2/61) had mixed infections of *P. falciparum* and *P. vivax*. Logistic regression analysis revealed that individuals who possessed insecticide-treated net (Odds ratio [OR] = 0.38, 95% confidence interval [CI] [0.194, 0.743]) and whose houses were sprayed with insecticides (OR = 0.18, 95% CI [0.097, 0.34]) were significantly less likely to have a malaria infection. Individuals living closer to stagnant water had a significantly greater chance of malaria infection than those who lived a distance from stagnant water (OR = 0.34, 95% CI [0.19, 0.59]).

Conclusion: The present study revealed that malaria remains a public health problem in the urban area of Batu town, which suggests that the same might be true for other urban areas in the country.

Keywords

Batu town, magnitude of malaria, plasmodium falciparum, plasmodium vivax, risk factor, urban.

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Introduction

Malaria is a life-threatening protozoan disease caused by one of the five *Plasmodium* parasites: *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae*, and *P. knowlesi*, and it is transmitted by the bite of female *Anopheles* (*An.*) mosquitoes. *P. falciparum* is the deadliest parasite in terms of its morbidity and mortality, and it is the most prevalent malaria parasite in sub-Saharan Africa (SSA), accounting for 99% of malaria cases in 2016, while *P. vivax* is the most prevalent in Asia and South America.[1] An estimated 219 million cases of malaria occurred worldwide in 2017, which is a slightly higher trend compared with 216 million cases of infection in 2016 in 91 countries; globally, there were 435,000 malaria deaths in 2017 compared with 451,000 estimated deaths in 2016.[1] Malaria deaths mainly occur (90%) in SSA, where children under 5 years of age account for 78% of all malaria deaths.[2]

Ethiopia is the SSA country that is most affected by malaria, and malaria ranks at the top of the communicable infectious diseases in the country.[3] It is a leading cause of morbidity and mortality in Ethiopia.[4] Approximately 68% of Ethiopia's population is at risk of malaria infection,[5] and nearly three-fourths of the Ethiopia landmass is considered to be malarious, with malaria mainly being associated with rainfall and altitude.[6] Malaria transmission occurs from September to December, while minor transmission occurs after short rainfalls from April to May.[7] In Ethiopia, *P. falciparum* and *P. vivax* are the two dominant species, accounting for 60% and 40%, respectively, of malaria cases reported in the country.[7,8] However, this proportion varies by location and season.[7] For example, recent studies showed a trend in the shift of dominance from *P. falciparum* to *P. vivax*.[9–11] Since 2004, artemether-lumefantrine (AL) (Coartem®) and chloroquine (CQ) have been used as first-line drug treatments for *P. falciparum* and *P. vivax*, respectively, in Ethiopia.[7] *An. arabiensis*, a member of the *An. gambiae* species complex, is the main malaria vector, while *An. pharoensis*, *An. funestus*, and *An. nili* are secondary vectors in some areas.[12,13] Recently, a new malaria vector, *An. stephensi*, was detected in Ethiopia using molecular and morphological methods.[14]

Compared with rural areas, urban areas are considered to have a low risk for malaria because of the improved housing, socioeconomic status, expanded personal protection, effective diagnosis and treatment, and limited breeding sites for *Anopheles* mosquitoes.[15,16] However, urban malaria cases were shown to account for 6% to 28% of the estimated global malaria incidence,[15] and therefore, in the era of malaria elimination, attention should be paid to urban malaria. Urban agricultural practices and small irrigations surrounding towns in African cities might create a conducive environment for *Anopheles* mosquito breeding.[11,16] Additionally, most African cities including Ethiopia are characterized by poor housing conditions, a lack of proper sanitation, and poor water drainage systems, which likely increase human and malaria vector contacts and thereby facilitate urban malaria transmission.[17] There is a paucity of information about the magnitude of malaria in Ethiopian towns located in malarious areas including Batu town. Therefore, the aim of the current study was to assess the magnitude of *P. falciparum* and *P. vivax* and the associated risk factors in Batu town, East Shoa, Oromia Regional State, Ethiopia.

Materials and methods

Description of study area

Batu town, which was formerly Zeway town, is located in the central part of

Ethiopia, 165 km south of Addis Ababa, which is the capital of Ethiopia, in the middle of the Ethiopian Rift Valley (Figure 1).[11] Briefly, the town's geographical coordinates are 7°56′03″ N latitude and 38°42′56″ E longitude. Batu town is located at an average altitude of 1657 m above sea level. Batu town has a total population of 78,784 (40,180 men and 38,604 women) in two *kebeles* (government administrative entities below the district level). Batu town has two hospitals (one government and one private), two government health centers, and eight private medium clinics (unpublished data from the Batu town Health Office, 2018). Lake Batu (Zeway) is located near the town, and this lake covers an area of about 434 km^2 and has an average depth of 4 m.[18] The lake is used for fishing, recreation, and irrigating small farms. The lake area maintains malaria transmission even during the dry season by creating conducive breeding ground for *Anopheles* mosquitoes on the lake's shoreline.[19] The area receives between 700 and 800 mm of annual rainfall, with the heavy rains from June to September and short rains in April and May. The mean temperature for 4 months (April–July) was 22°C, with a mean maximum and minimum temperatures of 29°C and 15°C, respectively (unpublished information from the South Ethiopia District Meteorological Agency, 2018). Malaria transmission in the Batu area is generally

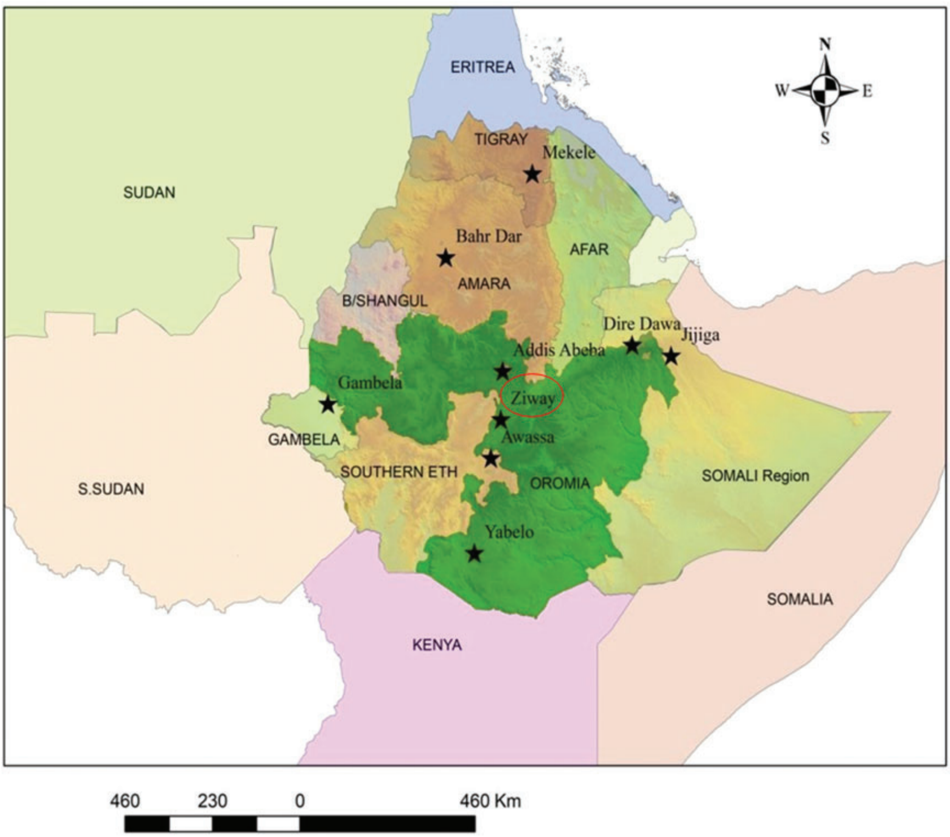

Figure 1. Map of the study area. Batu town was formerly known as Zeway town.

unstable (seasonal), with peak transmission occurring between September and November, and another transmission period falls between April and May in the short rainy season. The major malaria vector in this area is *An. Arabiensis*, while *An. pharoensis* plays secondary role.[18]

Study design

A health institution-based prospective cross-sectional study was conducted among patients from Batu town who attended governmental and private health facilities from April to July 2018. Understanding the magnitude of the malaria situation and risk factors during the minor transmission season enables us to deduce the larger picture of malaria during the major transmission season (September–December). Patients from the outpatient departments of the health facilities who were suspected of having malaria were included in the study. Patients who were suspected of having malaria who left the town and patients with severe malaria were excluded. We used the STROBE cross-sectional checklist when writing our report.[20]

Sample size and sampling techniques

The sample size was estimated using a single-population proportion formula[21] and the 95% confidence interval (CI) (Z (1−(1−α/2) = 1.96), a 0.05 margin of error, and a 15% non-responder rate. The slide positivity rate was assumed to be 28.1%, which was previously reported at Chichu and Wonago health centers, South Ethiopia.[22] On the basis of the above assumptions, the sample size was calculated as follows:

$$n = \frac{(Z - \alpha/2)^2 \, P(1 - P)}{(d)^2}$$

$$n = \frac{(1.96)^2 \, (0.281)(1 - 0.281)}{(0.05)^2}$$

$$n = 310 + 15\%(46) = 356$$

Thus, 356 individuals were included in the study. At all 12 health facilities (two hospitals, two health centers, and eight medium private clinics) in the town, patients who were suspected of having malaria were selected randomly to undergo a parasitological examination.

Blood collection and processing

Blood collection was performed in accordance with the standard operating procedure developed by the World Health Organization.[23] Briefly, before blood collection, the tip of the finger was cleaned using a cotton pad that was moistened with alcohol. Using a disposable blood lancet, two drops of blood was placed onto the slide. Thick and thin blood smears were prepared on the same slide side by side. After the slides were air-dried in a horizontal position, the thin blood smears were fixed with methanol for about 30 s. The thick blood smears were stained with 10% Giemsa solution for 20 minutes. Blood slides were observed under oil emersion objectives by experienced laboratory technologists. Parasite positivity was detected using the thick blood smears, while *Plasmodium* species identification was performed using the thin smears. The blood slides were observed by two technicians at each health facility for quality control. Slides were considered to be negative after 100 fields were carefully examined.

Questionnaire survey

A structured questionnaire including socio-demographic information and commonly known risk factors such as age, sex, occupation, education status, use of insecticide-treated nets, indoor residual spray, and stagnant water for mosquito breeding were included in our study. The questionnaire was translated from English into the local language (*Afan Oromo*) by an

Afan Oromo expert. At each health facility, the fluent-speaking *Afan Oromo* laboratory technicians received an orientation on how to collect the data. After the purpose of the study was explained to the study participants or the children's parents, the questionnaire was completed by data collectors before collecting the blood film. The principal investigator and a malaria expert from the Batu town health office supervised and doubled-checked the questionnaire responses for completeness.

Data analysis

Collected data were entered into a Microsoft Excel (Microsoft, Redmond, WA, USA) spreadsheet. The data were analyzed using SPSS version 25 (IBM Corp., Armonk, NY, USA). The Chi-square test was used to determine the association between malaria and age, sex, and season. Descriptive statistics were used to calculate the frequencies and percentages. Tables and graphs were also used to present the results. The association of different risk factors with malaria infection was analyzed using logistic regression analysis together with their corresponding 95% CI and odds ratio (OR). A P-value <0.05 was considered to be statistically significant.

Ethics approval and consent to participate

Ethics approval for this research was obtained from Adama Science and Technology University Research September 2019, Adama, Ethiopia. The aims, risks, and benefits of the study were explained to the study participants. Written informed consent was provided by the study participants, but for children less than 18 years of age, consent was provided by their parents. Confidentiality of participant information was maintained using a code number instead of their name to protect the participants' identity. Patients with positive *P. falciparum* and mixed infection test results were treated with AL, while those infected with *P. vivax* were treated with CQ, in accordance with the national malaria treatment guideline.[24]

Results

Socio-demographic characteristics of the study participants

All 356 individuals who were included in the study provided responses to the questionnaire. Among study participants, 216 (60.7%) were male, and most of the participants were over 14 years of age (46.90%). Educational status for most of the study respondents (24.72%) were above grade 12, and most of them (41.57%) were private workers (day laborers) (Table 1).

Table 1. Socio-demographic characteristics of the study participants (N = 356).

Variables	Frequency	Percentage
Sex		
Male	216	60.7
Female	140	39.3
Age (years)		
0–4	86	24.16
5–14	103	28.93
>14	167	46.91
Education status		
Illiterate	41	11.52
Grade 1–4	53	14.89
Grade 5–8	71	19.94
Grade 9–10	55	15.45
Grade 11–2	48	13.48
>Grade 12	88	24.72
Occupation*		
Merchant	95	26.69
Government employer	62	17.42
Farmer	51	14.32
Private (day laborers)	148	41.57

*For children less than 18 years of age, their parents occupation was considered.

Magnitude of malaria and its associated risk factors

The overall slide positivity rate in the study area was 17.13%, and *P. vivax* accounted for 50.8% of infections while *P. falciparum* and mixed (both *P. falciparum* and *P. vivax*) infections accounted for 45.9% and 3.3% of infections, respectively. We observed mixed infections only in female. For malaria infections distributed by sex, among the 17.13% of positive slides, we observed 9% and 8.13% of cases in male and female, respectively (Table 2). Sex had no significant association with malaria infection ($\chi^2 = 2.026$). Malaria infection occurred among all age groups. We observed a higher association with malaria infection in older (>14 years) age groups followed by an association in the 5- to 14-year-old age group (Table 2).

Table 2. Magnitude of malaria related to study participant sex and age groups.

Risk factors	Number examined	Number infected	Percentage*	P-value
Sex				
Male	216	32	9	
Female	140	29	8.1	0.156
Total	356	61	17.1	
Age groups				
0–4 years	86	9	2.5	0.001
5–14 years	103	10	2.8	
>14 years	167	42	11.8	
Total	356	61	17.1	

*The percentage is out of the total population (N = 356).

The average monthly trend of malaria infection was 16.9%. However, the number of patients visiting health facilities fluctuated during the months when the study was conducted. A greater number of malaria cases (36; 59.0%) were treated during June and July (wet season) while fewer malaria cases (25; 41.0%) were treated during April and May (dry season) (Figure 2). However, there was no statistically significant difference in malaria cases between seasons ($\chi^2 = 3.118$) (Table 3). Among patients treated for malaria at health facilities, 82% of them were treated at private health facilities while 18% were treated at a government health facilities.

Logistic regression analysis showed that individuals who use insecticide-treated nets were less likely to become infected with malaria (OR = 0.38, 95% CI [0.194, 0.743], P = 0.005). Individuals who lived closer to stagnant water were more likely

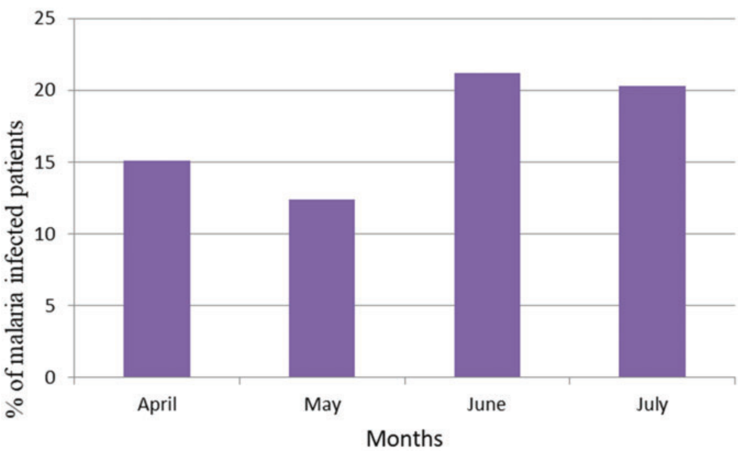

Figure 2. Malaria infection positivity rate in the infected population at Batu town health facilities from April to July 2018.

Table 3. Seasonal pattern of malaria by *Plasmodium* species in Batu town health facilities.

Season	Month	No. examined	Slide positive n, (%)	*Pf*, n	*Pv*, n	Mixed, n	P-value
Dry season	April	93	14 (15.05)	7	7	0	
	May	89	11 (12.36)	6	4	1	
Wet season	June	99	21 (21.21)	7	14	0	0.077
	July	75	15 (20.27)	8	6	1	
	Total	356	61 (17.13)	28	31	2	

Table 4. Logistic regression analysis for the association of other risk factors with malaria infections.

		Total population examined (N= 356)			
Variable	Category	Malaria cases (n = 61)	Malaria negative results (n = 294)	OR (95% CI)	P-value
Sex	Male	32	184	1.49 (0.86, 2.60)	0.156
	Female	29	111		
ITN use	Yes	16	38	0.38 (0.194, 0.743)	0.005
	No	45	257		
Presence of stagnant water	Yes	38	106	0.34 (0.19, 0.59)	<0.001
	No	23	189		
Insecticide spray	Yes	26	39	0.18 (0.097, 0.34)	<0.001
	No	35	256		

OR, odds ratio; CI, confidence interval; ITN, insecticide-treated net.

to become infected with malaria than those who lived a greater distance from reservoir water (OR = 0.34, 95% CI [0.19, 0.59], P < 0.001). Similarly, individuals with a house where insecticides were sprayed were approximately 0.2-times less likely to become infected with malaria compared with those with a house that was not sprayed with insecticides (OR = 0.18, 95% CI [0.097, 0.34], P < 0.001) (Table 4).

Discussion

The findings of this current 4-month study (April–July 2018) revealed that 61 participants (17.13%) had malaria infection. This positivity rate (17.13%) is greater than that reported in other parts of Ethiopia such as Butajira,[25] Arba Minch hospital,[5] and Arsi Negele,[26] which had a positivity rate of 0.93%, 7%, and 11.45%, respectively. However, our study positivity rate was less than that of patients attending Wonago health centers (28.1%),[22] Hadiya (25.8%),[27] Kersa Woreda (43.8%),[28] and Hallaba (82.8%).[9] The observed differences might result from altitude, seasonal, or other climate variations that contribute to *Anopheles* mosquito breeding as well as the malaria control measures implemented in the study areas.[25]

For *Plasmodium* species, *P. vivax* accounted for most of the cases. This finding is in agreement with the study conducted at the Hallaba health center, with 70.41% of infections caused by *P. vivax* and 23.08% caused by *P. falciparum*, while the rest (6.51%) were mixed infections.[9] Our results are also similar to the study conducted at Aleta Wondo that showed 66% *P. vivax* and 34% *P. falciparum* infections.[29] The results of the study conducted at health centers in Dilla town[6] also showed that *P. vivax* accounted for 62.5% of infections, followed by *P. falciparum* at 26.8%, and mixed infections with both *P. vivax* and *P. falciparum* at 10.7%, which is in agreement with the present findings. An 85% prevalence of *P. vivax* was also reported in the area surrounding Dilla town.[30] A study conducted by Ketema et al.[31] on the therapeutic efficacy of CQ treatment for *P. vivax* showed a two-fold increase in the prevalence of CQ-resistant *P. vivax* in South Ethiopia. This dominance of *P. vivax* in the area may require implementation of unique interventions to control vivax malaria in addition to conventional control measures such as insecticide-treated nets and indoor residual spraying.

In the present study, male showed a higher prevalence of malaria infection compared with female, but the difference was not statistically significant; this is in agreement with the results of a retrospective study that was conducted at Batu town health facilities.[11] This result is also in agreement with the findings of Regasa[9] at Arba Minch hospital and Alemu et al.[17] from Jimma town who reported higher malaria infection rates among male compared with female. The higher positivity rate of malaria among male might be because male engage in outdoor activities and recreation at night outside the home, which makes them more likely to be near *Anopheles* mosquitoes breeding sites.

Malaria infection also occurred among all age groups. However, the highest malaria infection occurred in participants who were older than 14 years, and the difference was statistically significant. This result is in agreement with the findings of Regessa[5] and Molla and Ayele.[6] The highest malaria positivity rate in this age group might be because these participants are away from home during the time when *Anopheles* mosquitoes bite. A study conducted by Kenea et al.[32] at Adami-Tulu Jido Kombolcha (which is close to our study area) showed that a greater proportion (76.6%) of human biting activity by the *Anopheles* mosquito occurs outdoors compared with indoors during the early part of the night. The peak biting time for *An. arabiensis* (the major vector in the area)[18] begins in the early evening.[33] Similarly, a study conducted on Bioko Island, Equatorial Guinea, showed that a high level of outdoor biting by *An. gambiae* (s.s) occurred throughout the night.[34] In the current study area, more malaria cases were detected during June and July compared with in April and May, but there was no statistically significant difference. This might be because in April and May, it was the dry season, but rain occurred during June and July, which might create a conducive breeding ground for *Anopheles* mosquitoes. Generally, seasonal variations in malaria transmission are a well-established feature of unstable malaria, where in Ethiopia,[35] 2.6% of malaria cases were reported in the dry season (April and May) and 5.8% of malaria cases were reported during the wet season (September–November).

In government health facilities (hospital and health centers), there was a tendency to treat patients who were clinically suspected of having malaria in addition to those patients with laboratory parasitology-confirmed cases. However, private health facilities have a strict policy not to treat patients with only clinically suspected malaria. They treat malaria patients only once the infection has been confirmed microscopically. This might be why the large difference in treatment frequency was observed between government and private health facilities. To eliminate malaria, involving the private health sector is essential for complete and timely reporting of malaria cases.[36] Investigating the role of private health facilities in the town in diagnosing and treating patients who are infected with malaria showed that more patients were attending these facilities. A survey study that was conducted by Jerene et al.[37] showed that 86% of private health facilities in Oromia Regional State in Ethiopia were providing malaria diagnostic and treatment services.

In the present study, living near stagnant water was identified as a risk factor for malaria infection. Among those infected with malaria, more cases occurred in patients who lived near stagnant water compared with those who did not live near stagnant water. This may be because stagnant water is a suitable breeding ground for *Anopheles* mosquitoes. Additionally, participants whose houses were not sprayed with insecticide were more likely to have a malaria infection than those whose houses were sprayed with insecticide. Participants who had and used insecticide-treated nets were less likely to become infected with malaria than those who did not have bed nets, which is in agreement the findings of Molla and Ayele[6] and Belete and Roro.[22]

Limitations

This study had some limitations. First, this study was facility-based, and it involved only symptomatic patients who were seeking treatment from a health facility. Asymptomatic malaria carriers from the community who do not visit a health facility and seek treatment were not enrolled due to a lack of logistics and financial constraints. Second, a malaria diagnosis was made only using the gold standard microscopy; some malaria-negative patients could have malaria parasites that can only be detected using robust molecular diagnostic techniques such as polymerase chain reaction and loop-mediated isothermal amplifications. This might underestimate the true magnitude of malaria during the study period.

Conclusion

The results of the present study suggest that both *P. falciparum* and *P. vivax* were the dominant species in the study area. However, the *P. vivax* positivity rate was higher than that of *P. falciparum*. There was also a strong association between several risk factors and the occurrence of malaria. Malaria remains a public health problem in Batu town, and this might be true for other towns located in malaria areas throughout the country. Therefore, appropriate control measures should be scaled-up to minimize malaria-related morbidity and mortality.

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Author contributions

JH and DH conceived and designed the study. JH performed data collection and statistical analysis, wrote the final draft, and reviewed and edited the final draft of the manuscript. DH supervised the study and edited and reviewed the final draft of the manuscript. Both authors read and approved the final version of the manuscript.

Consent for publication

The participants or their parents/legal guardians provided informed consent before participating in this study.

Declaration of conflicting interests

The authors declare that there are no conflicts of interest.

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