



Assessment on the prevalence of malaria and its associated risk factors in individuals visiting the health centers in the wetlands of Bahir Dar Zuria District, Northwestern Ethiopia

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ABSTRACT

Objectives: This study aimed to assess the prevalence and risk factors of malaria in individuals visiting health centers in the wetlands of Bahir Dar Zuria District, Northwest Ethiopia.

Methods: A cross-sectional study design was used on 422 study participants from three selected health centers from February to March 2020. Plasmodium parasite detection was examined using thick and thin blood smears, with a rapid diagnostic test. The chi-square (χ^2) test was used to analyze the association between the prevalence of malaria and categorical variables, whereas binary logistic regression was used to identify potential risk factors using SPSS Version 25. For all types of tests, *P*-values below 0.05 were considered significant.

Results: The overall prevalence of malaria observed at the selected health centers around the wetlands of Bahir Dar Zuria District was 23.90% (95% confidence interval: 20.30–27.70%). There was a higher prevalence of malaria in males (39.78%) than in females (11.44%). The younger age group (16–30 years) was the most affected (47.76%), compared with the remaining 0–2 (19.23%), 3–15 (8.64%), 36–45 (37.25%), and above 45 years age groups (13.01%). Individuals with bed net–using habit decreased the risk of malaria infection by 99.70% compared with their counterparts (adjusted odds ratio: 0.003, 95% confidence interval: 0.001–0.011).

Conclusions: In this study, the wetlands of Bahir Dar Zuria District were found conducive to the survival and reproduction of mosquitoes, and the occurrence of malaria prevalence was very high. Therefore, wetland management practices and community mobilizations that might decrease vector abundance and malaria transmission should be strengthened in the study area.

Introduction

In search of natural resources, the human population requires intimacy with wetlands for survival throughout the world. However, wetlands do not only supply resources, they also serve as a source of mosquito-borne parasitic diseases [1]. Because tropical wetlands are important hydrological features, they can also serve as mosquito breeding habitats. The egg and larval stages of mosquitoes require water, so there is a coincidence of wetlands and malaria at the global and local scales.

Worldwide, malaria is common in tropical and subtropical regions [2] and poses a significant challenge in endemic areas of tropical countries, including Ethiopia. In Ethiopia, due to the agroecological variations, the transmission of malaria is quite different [3]. Malaria is a known killer disease caused by the protozoan, which belongs to the genus *Plasmodium* species, which enters into the bloodstreams of hu-

mans during the bite of an infected female *Anopheles* mosquito. Of the different types of *Plasmodium* parasites that infect humans, *P. falciparum* and *P. vivax* are the most prevalent and *P. falciparum* is the most dangerous species [4–6].

Malaria affects more children aged below 5 years and pregnant women in tropical countries [7,8]. The transmission of the disease is perennial and seasonal, occurs as an epidemic, depending on the geographical location [9], and is still a main public health challenge in Ethiopia [6]. In the Amhara National Regional State, malaria appears in almost all districts, with more than 8 million (60%) of the inhabitants at risk, and the disease ranks first regarding morbidity and mortality [9,10]. Malaria remains a major challenge in the West Gojjam Zone of Amhara. Above all, the Bahir Dar Zuria District, which is surrounded by the wetlands of Lake Tana, is a hotspot area for malaria, where communities experience intense malaria transmission. All Kebeles are at risk of malaria, especially Andasa, Yinesa, and Kinbaba, which are found

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proximal to the wetlands of Lake Tana and the most vulnerable areas. Therefore, the study aimed to assess the prevalence of malaria and its associated risk factors around the Wetlands of the Bahir Dar Zuria District.

Methodology

Study design, area, and methods

From February to April 2020, an institution-based cross-sectional study was conducted to assess the prevalence of malaria and its associated risk factors in three selected health centers around the wetlands of Bahir Dar Zuria District during the peak periods (February to April) of malaria transmission. Bahir Dar Zuria District is located at 560 km from Addis Ababa, the capital of Ethiopia. The district surrounding Bahir Dar Town, the capital of the Region, and its elevation varies from 1700 to 2300 m above sea level. The district is also located around Lake Tana, one of the highland lakes in Ethiopia. The average annual rainfall of the district is 1035 mm, with a minimum and maximum temperature of 10°C and 32°C, respectively [11]. The district has nine health centers and 36 health posts, which offer diagnostic and treatment services to the community.

Sample size and sampling technique

The required sample size (n) for this study was estimated using a single population proportion formula.

$$n = \frac{(z^2 p(1 - p))}{d^2}$$

Because the prevalence of malaria in the study area was unknown to students, a *P*-value of 50% is used. A 95% confidence interval (CI) (*z*) and a 5% margin of error (*d*) were applied; therefore, a sample size of 384 participants was obtained. However, to minimize errors in the study, 10% of the calculated sample size (384), which is 38 study participants, was added to 384. Finally, the estimated sample size became 422. A purposive sampling technique was applied based on their proximity to the wetlands of Lake Tana to select three health centers, which include Andasa (serving six Kebeles), Yinesa (serving five Kebeles), and Kinbaba (serving five Kebeles). A simple random sampling technique was used to select the study participants from the three health centers, and participants were selected with a quota system based on the population size of the three health centers. Therefore, a population of 136 participants (63 females and 73 males) of 37,274 residents from Andasa, 162 participants (106 females and 56 males) of 44,340 residents from Yinesa, and 124 participants (67 females and 57 males) of 33,891 residents were selected.

Laboratory investigations

Plasmodium parasite detection and identification

Microscopic blood film examination was used to diagnose *Plasmodium* based on the standard guidelines [12,13]. Before collecting blood samples, orientation was given to all patients visiting the selected health centers around the wetlands of the district. Based on the orientation, alcohol-moistened cotton was used to clean the finger, dried with dry cotton, and pricked by using a sterile disposable blood needle. Thick and thin blood smears were prepared on the same slide per individual. The smears were air-dried, and the thin smear was fixed with 100% methanol and attained with 10% Giemsa for 30 minutes and stained; blood film examinations were performed by following the standard protocol of the Federal Ministry of Health, Ethiopia [9]. Positive results were detected from thick blood smears, and species identification was applied from thin blood smears. Positive dry slides were appropriately kept in the slide box. An additional rapid diagnostic test was also performed within about 15 minutes.

Questionnaire administration

A questionnaire was first prepared in English and then converted into Amharic (the local language of the community) to obtain socio-demographic data and known potential risk factors for malaria. For the study participants having difficulty in reading and responding to the questionnaires, a face-to-face interview was made. Interviews were also conducted to sample people, including training health workers and laboratory technicians. Focal group discussions were conducted with 18 individuals on the selected three Kebeles. A preliminary test was carried out in a neighboring district 2 weeks before the actual data collection to avoid confusion from repeated questions.

Statistical analysis

Data were recorded and analyzed using SPSS Version 24. The prevalence of malaria was reported in proportions. A chi-square (χ^2) test was used to assess the association between the prevalence of malaria and categorical variables. For the identification of risk factors with the prevalence of malaria, univariate and multivariate binary logistic regression analyses were applied. Finally, the strength of the association between malaria infection and associated risk factors was measured using a crude odds ratio, and an adjusted odds ratio (AOR) with a 95% CI. Statistical significance was considered when *P*-values were less than 0.05.

Results

There was a statistically significant ($\chi^2 = 16.203$; *P* < 0.05) variation in the prevalence of malaria in Bahir Dar Zuria District between males and females. The prevalence of malaria was higher (47.76%) in the 16-35 years age category than in the other age groups. The variation was statistically significant ($\chi^2 = 51.120$; *P* < 0.05) on the prevalence of malaria according to age categories. The prevalence of malaria was 23.80% in rural residents and 25.80% in urban residents. However, there was no statistically significant association ($\chi^2 = 0.062$; *P* > 0.05) between respondents' residence. The prevalence of malaria according to the educational status of respondents varied significantly ($\chi^2 = 21.158$; *P* < 0.05) across the educational categories of the respondents. Malaria prevalence was highest (32.10%) in illiterate individuals compared with preschoolers and respondents who completed primary and secondary education. The prevalence of malaria according to the respondents' occupations was the highest (33.70; *n* = 87) in farmers compared with infants, merchants, and civil servants. The association according to respondent's occupations was statistically significant ($\chi^2 = 36.898$; *P* < 0.05). The prevalence of malaria according to marital status was statistically significant ($\chi^2 = 13.280$; *P* < 0.05). It was higher (30.205) for married respondents than for the remaining single and under-marriage respondents. The prevalence of malaria according to health centers was different, ranging from 21.5% to 27.9% (*P* < 0.386). The highest prevalence was observed in Andasa (27.9%), followed by Yinesa (22.8%), and Kinbaba (21.5%). However, the association was statistically insignificant ($\chi^2 = 1.905$; *P* = 0.386) among health centers (Table 1).

Potential risk factors associated with the prevalence of malaria

Binary logistic regression analysis was used to select potential risk factors (Table 2). In the final model, only five risk factors with *P* < 0.05 emerged as independent explanatory variables for malaria in the participants in the study area. These risk factors had a statistically significant association (*P* < 0.05) with the prevalence of malaria. At the same time, the other variables such as residence, age, educational status, occupation, marital status, religion, and presence of bed nets did not show a significant (*P* > 0.05) association with the prevalence of malaria.

All variables that were significantly associated with malaria prevalence in the univariate binary logistic regression analysis were reassessed using multivariate analysis. After adjustment, sex and sex occupation interactions were not found to be significantly associated with

Table 1
The prevalence of malaria based on socio-demographic data in Bahir Dar Zuria District.

Sex	Total respondents	N, Prevalence (%)	χ^2	P-value
Male	186	74 (39.78%)	16.203	0.000
Female	236	27 (11.44%)		
Total	422	101 (23.93%)		
Age (years)	Total respondents	N, Prevalence (%)	χ^2	P-value
0-2	26	5 (19.23%)	51.120	0.000
3-15	81	7 (8.64%)		
16-35	67	32 (47.76%)		
36-45	102	38 (37.25%)		
>45	146	19 (13.01%)		
Total	422	101 (23.93%)		
Residence	Total respondents	N, Prevalence (%)	χ^2	P-value
Rural	391	93 (23.80%)	0.062	0.827
Urban	31	8 (25.80%)		
Total	422	101 (23.93%)		
Educational status	Total respondents	N, Prevalence (%)	χ^2	P-value
Preschooler	25	4 (16.60%)	21.158	0.000
Illiterate	243	78 (32.10%)		
Primary education	124	15 (12.10%)		
Secondary education	30	4 (13.30%)		
Total	422	101 (23.93%)		
Occupation	Total respondents	N, Prevalence (%)	χ^2	P-value
Infants	26	5 (19.20%)	36.898	0.000
Students	88	6 (6.80%)		
Merchants	36	2 (5.60%)		
Farmers	258	87 (33.70%)		
Civil servants	14	1 (7.10%)		
Total	422	101 (23.93%)		
Marital status	Total respondents	N, Prevalence (%)	χ^2	P-value
Single	137	35 (25.50%)	13.280	0.001
Married	179	54 (30.20%)		
Under marriage	106	12 (11.30%)		
Total	422	101 (23.93%)		

Table 2
Binary logistic regression analysis for factors potentially associated with malaria among respondents of Bahir Dar Zuria District.

Risk factors	Positive (%)	Negative (%)	Adjusted odds ratio (95% confidence interval)
Sex			
Male	74	112	0.395 (0.147-1.059)
Female	27	209	
Stagnant water			
No	169	19	0.019 ^a (0.005-0.079)
Yes	152	82	
The habit of using a bed net			
Yes	303	13	0.003 ^a (0.001-0.011)
No	18	88	
Spraying chemicals			
Yes	29	43	15.380 ^a (5.245-45.100)
No	292	58	

^a Significant association.

the prevalence of malaria ($P > 0.05$). The other variables became significantly associated with the prevalence of malaria, including the presence of stagnant water, the habit of using bed nets, and spraying anti-infective chemicals (Table 2).

The study indicated that the absence of stagnant water in their residence area decreases the chance of malaria infection by 98.10% compared with respondents having stagnant water in their residence area (AOR: 0.019, CI: 95%: 0.0005-0.079).

With bed net-using habit, respondents decreased the risk of malaria infection by 99.70% compared with their counterparts (AOR: 0.003, CI: 95%: 0.001-0.011).

Respondents, who did not spray chemicals were 15.38 times more likely to acquire malaria infection than respondents who sprayed chemicals (AOR: 15.38, CI 95%: 5.245-45.100).

Plasmodium species identification

Of the total 101 individuals who tested positive for Plasmodium, the recorded infection rates with *P. vivax* and *P. falciparum* were 74.26% ($n = 75$) and 21.78% ($n = 22$), respectively, whereas mixed species was 3.96% ($n = 4$) (Figure 1).

Discussion

The relationship between the presence of wetlands and the propagation of malaria has been widely discussed in different parts of the world. This study was conducted in the wetlands of Bahir Dar Zuria District, comprising 422 study participants. The overall prevalence of malaria in this study was 23.93%. The finding of this study was higher

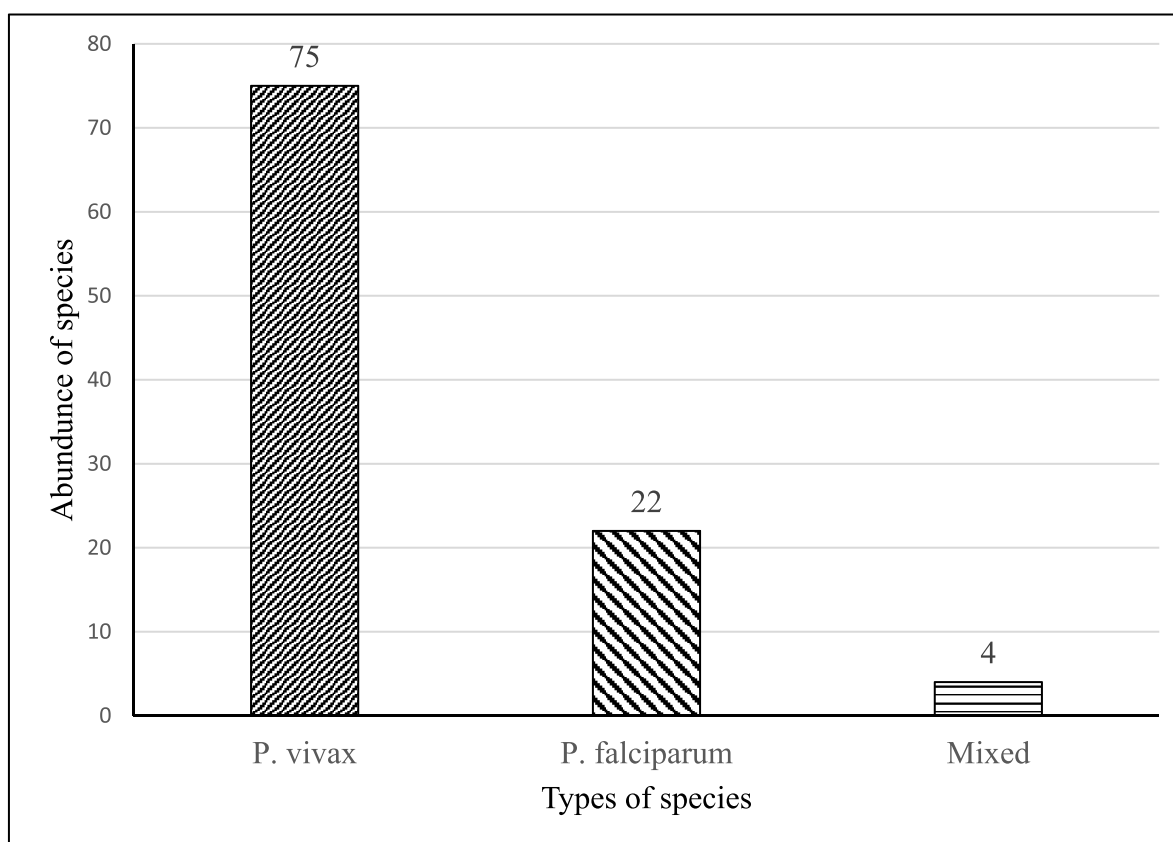


Figure 1. *Plasmodium* species identified in patients with malaria in Bahir Dar Zuria District.

than the report from Wolkite Health Center [14], with a value of 7.7%. The possible reason for the higher prevalence around the wetlands of Bahir Dar Zuria District might be related to the occurrence of the wetlands of Lake Tana. In this study, males were more likely to be infected by malaria than females. This variation might be because males are engaged in outdoor activities such as irrigation and grass collection for their livestock, which makes them more prone to the bite of infected mosquitoes. In line with this study, comparable results were found from other parts of Ethiopia [15–17] and abroad by Winskill et al. [18] (north-east Tanzania) and Kimbi et al. [19] (southwest Cameroon).

In this study, 16–35 years age category was the most (47.76%) infected group by malaria compared with the remaining 0–2 (19.23%), 3–15 (8.64%), 36–45 (37.25%), and above 45 (13.01%) years age groups. The reason could be that, in the rural areas, these age groups are more vulnerable to different field farming works day and night, which predisposes them to be more vulnerable to mosquito bites. This result aligns with the study conducted in Woreta Town, Northwest Ethiopia [20]. On the contrary, the study conducted in Oromia, and Southern Nations, Nationalities and Peoples (SNNP) regions of Ethiopia reported that a greater effect was observed on the age group less than 5 years [21]. This could be because children may not protect themselves from mosquito bites properly and they may not have good awareness about the preventive mechanisms of malaria infection compared with adults due to their maturity difference.

In the current study, the prevalence of malaria was higher in rural (23.80%) residents than in urban (25.80%) residents. The difference in the prevalence of malaria between rural and urban residents might be due to the difference in their lifestyle because rural residents are more involved in outdoor activities such as irrigation and fishing on wetlands. These factors may aggravate the transmission of malaria and may negatively affect the prevention and control strategies of malaria. This result agrees with a study conducted in Jimma Town [22].

According to this study, illiterate individuals were more likely to be affected (32.10%) by malaria than preschoolers (16.60%) and those who completed primary (12.10%) and secondary education (13.30%). However, the current finding did not agree with a study done in the urban areas of Assosa Zone [23], in which the prevalence of malaria is higher in individuals who completed secondary education.

The prevalence of malaria according to the respondent's occupations was the highest (33.70%) in farmers compared with the remaining infants (19.20%), students (6.80%), merchants (5.60%), and civil servants (7.10%). This variation might be attributed to farmers often engaging in early night outdoor activities such as irrigation, which can increase the chance of exposure to the bite of malaria vector. This finding is in line with a study conducted in Tanzania [24].

The prevalence of malaria was found to be statistically significant across the categories of marital status of the respondents. It was higher (30.205) for married respondents than the remaining single and under-marriage respondents, with a value of 25.50% and 11.30%, respectively. The reason why married respondents were more infected by malaria could be due to their low educational status. Early marriage is common in Ethiopia and most of those who married before age 18 years had never gone to school. This finding aligns with a study done in urban areas of Assosa Zone [23].

The prevalence of malaria was relatively the highest (27.90%) in Andasa compared with Kinbaba (21.50%) and Yinesa (22.80%). However, the variation was statistically insignificant. These differences might be due to the baptistery service in Andasa Giyorgis Tsebel where many people (about 20,000–30,000) live temporarily without a house and sleep near the trees without a bed net. Thus, they are vulnerable to mosquito bites.

The analysis of potential risk factors related to the prevalence of malaria was done using multivariate logistic regression. The result indicated that the presence of stagnant water, bed net–using habit, and

spraying anti-insect chemicals was significantly associated with malaria infection. The absence of stagnant water in their resident areas reduces the risk of acquiring malaria infection by 98.10% more than respondents living in closer proximity to stagnant water (AOR: 0.019, 95% CI: 0.005–0.079). This study agrees with the studies conducted in China [25] and Indonesia [26]. This might be because stagnant water acts as a breeding ground for mosquitoes, and residing close to bodies of water, such as rivers and streams, could be a significant factor affecting malaria transmission.

Individuals having bed net–using habits decrease the risk of malaria infection by 99.70% than those who do not have bed net–using habits (AOR: 0.003, 95% CI: 0.001–0.011). This agrees with a study conducted by Graves et al. [21] in the Amhara, Oromia, and SNNP regions of Ethiopia. Another study in Ghana also depicted that using bed nets is an effective strategy to prevent mosquito bites [27].

For respondents who did not spray chemicals, the likelihood of being infected by malaria was 15.38 times greater than for respondents who sprayed chemicals (AOR: 15.38, CI 95%: 5.245–45.100). A study conducted in other areas of the country depicted that people living in sprayed houses reduced the chance of malaria infection [5]. In line with this finding, a study conducted in Eritrea revealed that spraying chemicals was positively correlated with a reduction of malaria infection [28].

In this study concerning *Plasmodium* species, *P. vivax* was 3.4 times more common than *P. falciparum*. Of the total of 101 individuals who tested positive for malaria, infections with *P. vivax* and *P. falciparum* occurred with the prevalence of 74.26% ($n = 75$) and 21.78% ($n = 22$), respectively, whereas mixed species was 3.96% ($n = 4$). This result agreed with research done in Kola Diba Health Center, in which 75% were *P. vivax* cases and the remaining 25% were *P. falciparum* cases [8]. Another study performed in Assosa General Hospital reported that the prevalence of *P. vivax* was a little bit higher than *P. falciparum*, detected with a value of 55.02% and 44.98%, respectively [29]. The probable reason for the high *P. vivax* infection in the study area might be due to the suitability of the area for these species. *P. vivax* is more likely to be found in highland areas (>1500 m), where the temperature is relatively cooler than in lowlands. However, in contrast to this study, a study done in the country indicated that *P. falciparum* accounted for 60% and *P. vivax* accounted for 40% [30]. A study by Graves et al. [21] in Amhara, Oromia, and SNNP regions of Ethiopia, in which *P. falciparum* prevalence accounted for 56.5%, and another study conducted in Metema Hospital, Northwest Ethiopia reported that the prevalence of *P. falciparum* was quite large (90.7%) [16]. The result is contradicted by a study conducted in Woreta Town [20] in which the prevalence of *P. falciparum* was 69.7% and *P. vivax* was 26.5%. These variations might be associated with differences in geographical locations, climatic variations, altitudinal variations, vector species distribution, and migration patterns of the variety.

In conclusion, the study revealed that wetlands increase the prevalence of malaria by providing unique ecological conditions as breeding habitats for malaria vector species and creating frequent human-mosquito contact. Therefore, to alleviate these problems, integrated mosquito control measures that include wetland management, such as proper drainage of microhabitats and vegetation removal and conventional malaria control strategies should be applied in the study area.

Declarations of competing interest

The authors have no competing interests to declare.

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Ethics approval and consent to participate

Before data collection, a formal letter requesting cooperation was written from Debre Markos University, Department of Biology to the Research Ethical Review Committee of Amhara Regional Health Bureau and Amhara Regional Research Association Institute. Ethical approval was obtained from the Research Ethical Review Committee of Amhara Regional Health Bureau and Amhara Regional Research Association Institute. Based on the approval, permission was obtained from the Bahir Dar Zuria District Health Centers. Finally, appropriate treatment was given by local nurses to residents of Bahir Dar Zuria District who were found to be positive for malaria, as per the recommendations of medical doctors. All methods were performed following the relevant guidelines and regulations of the regional criteria and informed consent was obtained from all subjects.

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Author contributions

ASB, FA, and ANY have designed the data collection, data analysis, interpretation, and manuscript preparation.

Data availability

The data used and analyzed in this study are available from the corresponding author upon reasonable request.

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