

A preliminary study on urban malaria during the minor transmission season: The case of Adama City, Oromia, Ethiopia

Temesgen File, Hunduma Dinka *

Department of Applied Biology, School of Applied Natural Science, Adama Science and Technology University, P.O.Box. 1888, Adama, Ethiopia

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The distribution of malaria shows considerable spatial heterogeneity globally, regionally and locally. For the design of effective malaria control and elimination, and for its implementation in Ethiopia, urban malaria should be given due attention. Therefore, the present study was aimed to examine the status of urban malaria during the minor transmission season in Adama city. A total of 2590 febrile patients were screened using the gold standard microscopy-based blood test for malaria diagnosis from seven purposively selected health facilities found in Adama City from April to July 2018. Socio-demographic data were collected from malaria positive patients to correlate predisposing factors; like previous malaria history, settlement, travel history, age, and other associated risk factors with malaria incidence. Climatological data, such as temperature and relative humidity, recorded during the study period were also collected from the data base of Adama meteorology center for analysis. The microscopic data indicated that from a total of 2590 febrile patients screened for malaria during the study period 3.7% (97/2590) of them were confirmed malaria positive. Adolescents and adults (≥ 15 years of age) were found to be most affected by *Plasmodium vivax* (66%) and *Plasmodium falciparum* (20.5%), and mixed (6%). Analysis of the climatological data revealed a rise in environmental temperature and relative humidity during the study that coincides with the increase of malaria cases, since it creates favorable mosquito breeding for malaria transmission in the city. *P. vivax* was found as a predominant species in causing malaria burden indicating its public health problem in Adama city affecting the productive age group of the community, adolescents and adults, during the minor transmission season of malaria. In addition to its public health importance by causing morbidity and mortality such kind of scenario may also exacerbates poverty.

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1. Introduction

Malaria is caused by infection with protozoan parasites of the Plasmodium species. *Plasmodium falciparum* is widespread in Africa, while *P. vivax*, *P. ovale*, and *P. malariae* infections are less common and geographically restricted (Howes et al., 2015; Roucher et al., 2014). The distribution of malaria shows considerable spatial heterogeneity globally (Haworth, 1988; Snow et al., 2005), regionally and locally (Gemperli et al., 2006; Kazembe et al., 2006; Omumbo et al., 2005). Only fifteen countries mainly in sub-Saharan Africa (SSA) accounts for about 80% of the malaria cases (WHO and UNICEF, 2015) where African region

* Corresponding author.

E-mail address: hunduma.dinkaa@astu.edu.et (H. Dinka).

alone accounts for about 90% of the global malaria cases and 91% of the global malaria deaths (WHO, 2017). The problem of malaria is very severe in Ethiopia where it has been the major cause of illness and death for many years. According to records from the Ethiopian Federal Ministry of Health (EFMH), 75% of the country is malarious with about 68% of the total population living in malaria risk areas (FMOH, 1999).

The transmission of malaria in Ethiopia commonly depends on elevation of <2000 m above sea level and rainfall with a lag time varying from a few weeks before the beginning of the rainy season to more than a month after the end of the rainy season (FMOH, 1999). Ethiopia is unique in that *P. vivax* is co-endemic with *P. falciparum* accounting for about 60 and 40% of all malaria cases, respectively (Deressa et al., 2003). By 2035, the urban population of sub-Saharan Africa is expected to outnumber the rural one (Siri et al., 2008). As a world is becoming urban, malaria can no longer be considered as just a rural issue alone. Similarly, due to fast rate of urbanization in Ethiopia, there is frequent emergence of small and medium sized cities. However, there is a great mismatch between rate of urbanization and infrastructure development, favoring anopheles mosquito breeding and also, the adaptation of malaria vector in the changing urban ecosystem.

Ethiopian topography is characterized by mountainous terrain with variable winds, seasonal rains and ambient temperatures, which creates diverse micro-climate for highly seasonal malaria transmission in many communities, but constant pattern in others. The peak transmission occurs between September to December in most areas following rainy season from June to August, but some areas experience a second minor transmission period from April to June, after a short rainy season from February to March (FMOH, 1999). These bi-annual transmission peaks coincide with the planting and harvesting seasons, with the resultant economic problem (FMOH, 2018). Thus, malaria is not only negatively affecting the socioeconomic growth, but also it is the outcome of poverty. Malaria transmission occurs indoors, during the night time hours, but its transmission may also occur in outdoors during the night time work or other social activities in both rural and urban areas (Mendis et al., 2001).

Even though, it was presumed that urban development reduces vector breeding and malaria transmission; socio-economic disparity of the urban community to afford protection against malaria, and sometimes misdiagnosis and treatment due to the difficulty to clinically distinguish malaria from other febrile illness significantly contribute to the urban malaria. Consequently, as it is revealed in some African cities' malaria transmission persists in urban areas and in some cases at even higher levels than in surrounding rural area (De Silva and Marshall, 2012). Therefore, for the design of effective malaria control and elimination, and for its implementation in Ethiopia, urban malaria should be given due attention. So far, there are limited studies on the urban malaria in Ethiopia. The aim of this study was therefore, to examine the situation of urban malaria in Adama City during the minor transmission season (April to July 2018). The knowledge on the situation of malaria during this minor transmission season enables us to infer the bigger picture of malaria during the major transmission season. And the finding this study will augment the local, regional and national malaria control and elimination effort in Ethiopia.

2. Materials and methods

2.1. Description of the study area

The study was conducted in Adama City located at about 99 Km south east of Addis Ababa. The geographical coordinate of Adama City is 8.54°N and 39.27°E at an average elevation of 1712 m above sea level. This altitudinal location is locally categorized as a climatic zone of Woyna Daga (*badda daree*) (1500-2400 m) above sea level (Alemu et al., 2011).

The City is located between the base of an escarpment to the west, and the Great Rift Valley to the east (File et al., 2019) (Fig. 1). It is a rapidly growing major city next to Addis Ababa in central Ethiopia having the total population of 500,000 in 2018. Due to its elevation, <2000 m above sea level and various factors that would favor mosquito breeding, Adama is a well-known malarious city in Ethiopia. The city is surrounded by hills in north, east and west, and commonly affected by over flooding during rainy seasons. The rainfall pattern is heavy from mid-June to mid-September and shorter rainy season in March. Most of the seasons are having the environmental temperature of 16–32°C that is favorable for the breeding of *Anopheles arabiensis* (a predominant malaria vector in the region) (Golassa and White, 2017). In addition, plenty of bushy gorges, ditches, shanty and slum dwelling, poor tidiness, vegetation covered residential areas are some of the common epidemiological factors that favor mosquito breeding in Adama City (File et al., 2019).

The health facilities in Adama City include government owned teaching hospital, private hospitals, government owned health centers, non-government organization-based health center run by St. Francisco Catholic Mission, one government owned malaria diagnostic center and several clinics providing specific services to their customers (File et al., 2019).

2.2. Study design and data collection

A total of 2590 febrile patients were screened using the gold standard microscopy-based blood test for malaria diagnosis following WHO protocol (WHO, 2015), from seven purposively selected health facilities found in Adama City from April to July 2018. Socio-demographic data were collected by the laboratory technicians during diagnosis from malaria positive patients using standardized questionnaire to get information like previous malaria history, settlement area and travel history, age, sex and others to identify associated risk factor for the occurrence of malaria cases. The general climatological data recorded were collected from the data base of Adama Meteorology Center to check its correlation with malaria incidence during the study period.

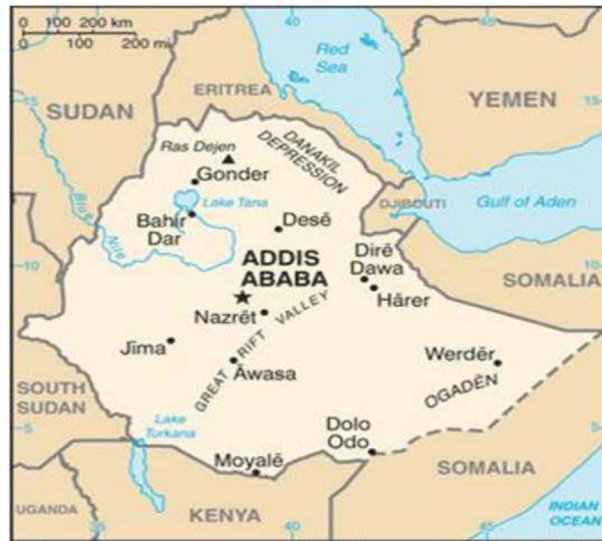


Fig. 1. Physical location of Adama/Nazareth City.

2.3. Data analysis

Collected data were managed and analyzed using statistical software for social science (SPSS) version 21.0. Simple descriptive statistics and chi-square tests were used to assess different variables. P -value < 0.05 was considered as statistically significant result.

3. Results

Out of 2590 febrile patients screened for malaria during the study period 3.7% (97/2590) of them were confirmed malaria positive. However, the test positivity was much greater in some health facilities (Table 1) showing spatial heterogeneity in a mosquito vector breeding sites in the city, and the degree of the patient case load in those health facilities. Out of the total 97 malaria cases, socio-demographic data were successfully collected from 83 patients from the selected health facilities during the study period. A statistically significant [$\chi^2 (2) = 8.87, P = 0.012$] result was obtained from the cross tabulation of socio-demographic data (Table 2) collected from malaria patients as a function of previous malaria history. This shows a significant relation between patients having previous malaria history to malaria cases diagnosed during the study period. Similarly, patients having more frequent malaria history were found to be significantly related [$\chi^2 (6) = 14.29, P = 0.03$] with malaria cases identified during the study period.

During our study we learned that health facilities were offering health services not only for residents of Adama city or specific catchment area of the sub-city but also, for those patients coming from anywhere in the city, even including patients coming from outside of the city (peri-urban or rural area). Hence, we revealed that 65% of the diagnosed malaria cases were from the Adama city residents whereas the remaining from the nearby rural area who visited those health facilities for malaria treatment (Table 2).

Analysis of the climatological data during the study period shows the minimum average temperature of 15.7 °C in July and the maximum average temperature of 31.2 °C in May (Fig. 2).

Table 1

Malaria cases among febrile patients in selected health facilities in Adama City from April to July 2018.

Health Facilities	Total number of febrile patients	Total cases of malaria positive	Prevalence (%)	*Pv	*Pf	Mixed infections
Adama Hospital Medical College	951	25	2.6	8	17	0
Adama Health Center	249	9	3.6	6	3	0
Anole Health Center	52	6	11.5	4	1	1
Denbela Health Center	57	6	10.5	5	1	0
St. Fransisco Health Center	642	4	0.6	1	3	
Biftu Health Center	234	5	2.1	3	1	1
Adama Malaria Control Center	405	42	10.4	29	9	4
Total	2590	97	3.7	56	35	6

Table 2

Socio-demographic data from patients diagnosed for malaria in selected health facilities in Adama City from April to July 2018.

Socio-demographic variables	Characteristics	Plasmodium species			Prevalence (%)	Statistical test	
		Pv*	Pf*	Mixed		χ^2	P-value
Settlement	In Adama	43	16	4	2.4	0.72	0.69
	Outside Adama	12	6	2	0.8		
Sex	Female	19	7	4	1.1	2.61	0.27
	Male	37	14	2	2.0		
Age (in years)	0–4	0	1	0	0.004	8.68	0.07
	5–14	1	3	1	0.1		
	≥15	55	17	5	2.9		
Travel history	No	47	17	3	2.5	4.01	0.13
	Yes	9	4	3	0.6		
Previous malaria history	No	16	12	0	1.0	8.87	0.012*
	Yes	40	9	6	2.1		
Frequency of Malaria history	No	16	12	0	1.0	14.29	0.03*
	Once	6	4	0	0.4		
	Twice	19	3	4	1.0		
	More than two	15	2	2	0.7		

* P-value <0.05; Pv - *P. vivax*, Pf - *P. falciparum*.

The daily average relative humidity slowly rose from April to July; the minimum relative humidity was noted as 31% at 18:00 GMT in May, whereas the maximum was 86% in July and April at 6:00 GMT (Fig. 3).

In line with the climatologic data, analysis for the monthly trend of malaria cases during the study period in Adama City, we revealed a relatively stable transmission of *P. vivax* contrary to *P. falciparum* that tends to rise after April (Fig. 4).

Our analysis also attempted to correlate the climatological data with malaria cases diagnosed during the study period and revealed an increase in malaria cases coinciding with a rise in environmental temperature and humidity after the rainy season (Figs. 2, 3 and 4) indicating higher temperature and humidity favors the breeding of anopheles mosquito and hence the transmission of malaria.

4. Discussion

There is a great mismatch in the unprecedented urbanization rate and infrastructure development in sub-Saharan Africa (SSA). This condition not only favor mosquito breeding but also, the adaptation of malaria vector in the changing urban ecosystem. Even though there is malaria control and elimination effort at national, regional and local level in Ethiopia, malaria is still one of the major public health problems causing morbidity and mortality. *P. falciparum* and *P. vivax* co-exists accounting for 60 and 40% of all malaria cases, respectively (Deressa et al., 2003). In Adama City, contrary to this previous report, the result of the present study has shown 66.2% *P. vivax*, 26.5% *P. falciparum* and 7.2% mixed infection cases. Similarly, a recent retrospective data analysis (from 2013 to 2018) on the transmission of falciparum and vivax in Adama City (File et al., 2019) has also shown that, the relative burden of *P. vivax* (61%) over *P. falciparum* (39%), which is gradually increasing from year to year, calling for tailored intervention strategies particularly on the liver stage of the *P. vivax* parasite. This finding is also consistent with the report of Ethiopian Federal Ministry of Health, which states that *P. vivax* is the main causative agent of malaria in Oromia regional state of Ethiopia (FMOH, 2015).

Statistical analysis of the socio-demographic factors on the variation in malaria cases as a function of respondents' previous malaria history was found to be significantly related ($P = 0.012$). This is because of the possibility of relapse of *P. vivax*

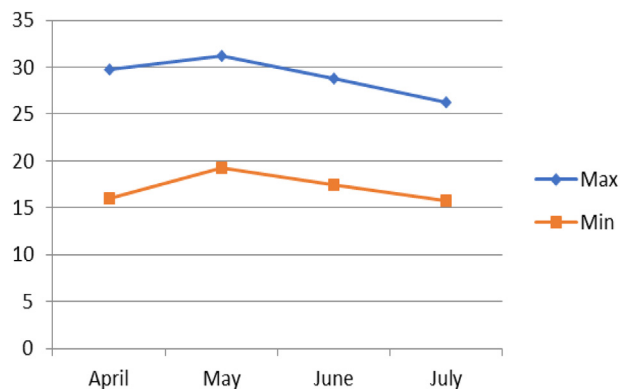


Fig. 2. Average monthly temperature in degree celsius from April to July 2018.

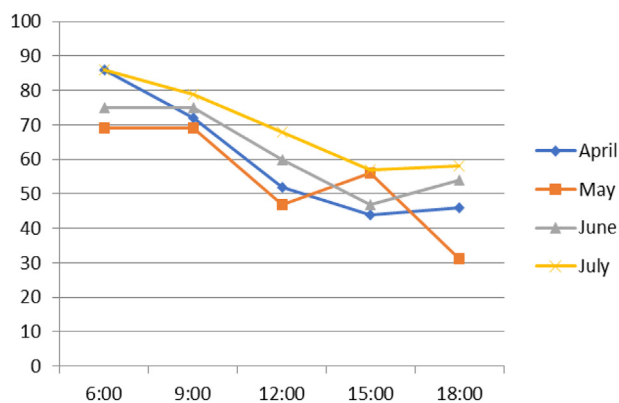


Fig. 3. Average monthly relative humidity (%) from 6:00 am to 18:00 pm from April to July 2018.

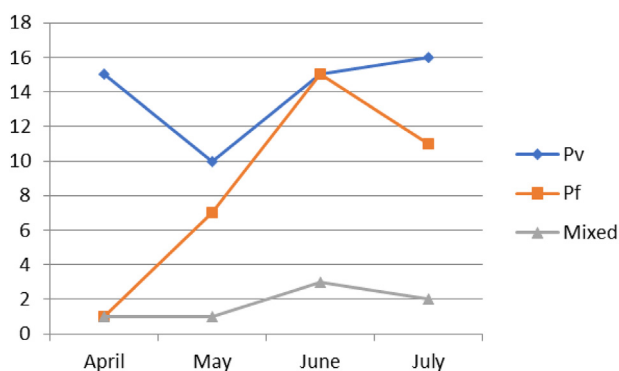


Fig. 4. Monthly trends of malaria cases in selected health facilities in Adama City from April to July 2018.

contributing for a significant relationship between the malaria cases diagnosed and the patients' previous malaria history. Similarly, variation in malaria cases as a function of frequency of respondents' previous malaria history was again found to be significantly related for the same reason. This strongly supports the previous study done in Adama City in 2015 by Golassa and White (2017), where they concluded 70% of *P. vivax* infections are suggested to have arisen from relapse during February to April, and 40% from August to October 2015. The epidemiological shift towards *P. vivax* dominance in the city could be partly due to relapse cases, the emerging trend of the parasite clone to infect Duffy negative individuals (Mendis et al., 2001), and highest genetic diversity of *P. vivax* over *P. falciparum* that shows the relative evolutionary advantage of fitness to the environmental challenges. However, the issue needs further molecular study.

The results of the present study also revealed that 93% of malaria patients are the productive section of the community (≥ 15 years of age). This shows how malaria is negatively affecting the socio-economic development by exacerbating poverty, due to treatment cost and income loss by patients and their care givers (Amek et al., 2012). In agreement with this finding, the recent retrospective study conducted by File et al. (2019) from 2013 to 2018 also confirmed the same. The present study also revealed male individuals are proportionally more affected (64%) compared to female which agrees with the report of Golassa and White (2017), where they reported that, males are proportionally more affected by malaria in Adama City. This is due to sex related occupation in Ethiopian tradition, where males are commonly engaged in outdoor activities which when accompanied by warmer climate of the city that favors malaria transmission by increasing human vector contact (Golassa and White, 2017).

Health facility based clinical prevalence of malaria cases during the study period in Adama City was found to be 3.7%. But, according to WHO when the slide positivity rate of all febrile patients with suspected malaria is less than 5%, the country could be considered transitioning into pre-elimination (Roll Back Malaria Partnership, 2008). However, since this study was conducted during the minimum to minor malaria transmission season the test positivity of febrile patients at health facilities in the remaining seasons is expected to be much greater. Even during this study period, in some health facilities like Anole Health Center, Dambala Health Center, Adama Malaria Control Center there is still higher health facility-based malaria case, having percentage of 11.5%, 10.5% and 10.4%, respectively. Such local variation in malaria cases is due to the uneven distribution of vector breeding sites in the city observed during the study period and also the existing higher patient case load in those facilities.

In the present study maximum temperature was noted in May whereas the minimum in July. Similarly, the maximum relative humidity was in July whereas the minimum in May. It has been reported that temperature from approximately 21°–32°C and a

relative humidity of at least 60% are most conducive for maintenance of malaria transmission (Saugeon et al., 2009). A minimum ambient temperature of 15 °C for *P. vivax* and 20 °C for *P. falciparum* was reported (CDC, 2015). Likewise, malaria cases in selected health facilities during the present study in Adama City tend to rise from April to July. *P. vivax* showing relatively stable transmission, whereas *P. falciparum* is showing relatively seasonal transmission, due to narrower conducive temperature that favor the developmental cycle of plasmodia in female anopheles mosquito (Saugeon et al., 2009). In the present study, the rise in humidity and temperature following shorter rainy season from April to May, resulted in minor increase in malaria case positivity rate in the study area which is in agreement with our previous publication, a five-year retrospective analysis of the transmission of *P. falciparum* and *P. vivax* in the study area (File et al., 2019).

5. Conclusion

The major finding of this study is that, malaria cases mainly due to *P. vivax* are endemic to the city during the short transmission season. The epidemiological shift of *P. vivax* dominance over *P. falciparum* contributed to its highest malaria burden in the city where the productive group of the community, adolescent and adulthood above 15 years of age, are mostly affected that contributes to poverty. The data used for this research is mainly the microscopic data which was collected during the minor malaria transmission season in the city where a comprehensive year round microscopic and socio-demographic data, supplemented with advanced molecular research employing Polymerase Chain Reaction (PCR) is highly recommended to get the full picture of malaria in the city, which will be an input to design effective malaria control strategy in urban setting at local and national level in Ethiopia.

Declaration of Competing Interest

The authors have declared that there is no competing of interest.

Authors Contribution

TF, has designed, collected and analyzed the data and wrote the paper, HD, designed and, reviewed the paper, and finally read and approved the manuscript.

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