

Resurgence of malaria case buildup pertain to the parasites, epidemiological and entomological indices in Addis Ababa

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Abstract

Introduction: For almost 20 years, Ethiopia has successfully managed its malaria problem by largely using LLINs, IRS, and efficient anti-malarial medication. Nevertheless, the recent recurrence of malaria in Ethiopia was mostly caused by reasons such as climatic change, excessive population mobility, urbanisation, new construction, irrigation system development, and others. October 2022 fever cases were recorded by Addis Ababa City Public Health Institute.

Methods: Medical records were examined, blood samples were obtained to check for the presence of Plasmodium, and we looked into the case to determine the cause and origin of the malaria outbreak. Consequently, vector surveillance was done in the impacted areas. Analysis was done using descriptive data.

Result: There were 903 cases of malaria in all, with the majority of cases recorded being in the 15–34 age range (35%). Of the cases, 69 were male and 31 were female. Seventy-one percent of the cases had a travel history, while the remaining 29 percent do not. In addition, there were 118 daily labourers, 137 government employers, 278 unemployed people, and 370 private employees in relation to occupation. According to the lab results, 37% of the parasites were *Plasmodium falciparum*, 55% were *Plasmodium vivax*, and the remaining 8% were mixed. After a few days of research, 88% of the mosquitoes that had been collected were discovered to be *Culex*, and the remaining 12% to be *An. gambiae sl.*

Conclusion: This surveillance looked into *An. gambiae sl.* in the research areas, which is unusual even if malaria cases are not new in the area. We discovered that the main vector source was artificial breeding sites. To halt the ongoing outbreak and guarantee future prevention, appropriate treatment and vector control with LLINs should be implemented.

Key words: Ethiopia, malaria, resurgence, *An.gambiae sl.*, outbreak

Introduction

It will be necessary to take immediate action to treat malaria and to undertake ongoing surveillance in order to prevent the disease from spreading again in order for the countries of Africa to achieve the pre-elimination phases (WHO 2012). Variations in the climate that encourage the reintroduction of malaria cases to Gondar's highland areas are a serious concern for nearly all Ethiopian places that are susceptible to the disease (Lemma 2020; 2021).

The complex epidemiology of malaria in Ethiopia is thought to be related to a number of interacting socio-environmental risk factors, including population movement, gender, education level, topography, altitude, presence of water bodies, livelihood style, and climatic variability (Ayele et al. 2012; Irish et al., 2008; MoH 2020). However, altitude and rainfall are the main factors that relate to malaria transmission. Prior to 2003–2004, the Ethiopian highlands saw periodic outbreaks of malaria (Hay et al. 2000; Gerbere-Mariam et al. 1988; Negash et al. 2005). Even though El-Nino/La-Nina episodes have caused several cyclic catastrophic malaria epidemics in highland Ethiopia, the processes of transmission remain

unclear. The previous explanation of the dynamics of malaria transmission was not updated to take into account local or regional variations in the disease. All malaria transmission was seen as seasonal, and highland regions over 2000 meters were thought to be malaria-free (EPHI 2015; MoH 2020). Cases of malaria discovered above 2000 meters were therefore regarded as imported cases from the nearby endemic lowlands.

Siraj et al. (2014) found that a different study did not support the theory that malaria is spreading geographically as a result of global warming and is the cause of highland malaria transmission in Ethiopia above 2000 meters. First, based on the description provided by Fontaine and colleagues (1958), there may have been highland malaria epidemics in Ethiopia for at least the last 60 years in locations over 2600 m. The splenomegaly study carried out on children in various parts of Ethiopia in the 1950s (Covell 1957) and the fact that malaria is seasonal and only transmits during specific months of the year could be the second reason why 2000 m altitude used to be the upper limit of malaria transmission in the past (EPHI 2015).

Weldeyohannes and colleagues (2018) indicated that in the Debark district of northern Ethiopia, 2800 m altitude was predicted to be the upper limit for the existence of malaria transmission. However, the household-level study on human settlements in highland areas of Ethiopia revealed the existence of malaria transmission in all altitude ranges with a gradual decline in transmission (3.2%) in people living at 2500–3000 m altitude range.

Despite the frequent recurrence of malaria in Addis Ababa, there is a paucity of research and documentation on the disease. When the 1998 outbreak occurred in Addis Ababa, Akaki Town, and the neighbouring areas, however, the information showed that the epidemic was quite concerning, affecting a significant portion of Akaki and the adjacent areas, with a total of 622 cases (Adugna and Ali 2004). Thus, for the ongoing malaria elimination programme in Ethiopia, this study will provide valuable insight into the dynamics of highland malaria transmission. The objective of this study were: to implement Control measures and reduce the spread; to identify the source of malaria infection in Addis Ababa (indigenous/ Imported); to assess possible risk factors in Addis Ababa.

Material and method

Study Area and periods: This study was carried out in the subcities of Bole, Nifassilk Lafto, and Akaki Kalit in Addis Ababa City. From October to December 2023, we conducted surveillance in certain places and collected blood films and mosquitoes from breeding sites during the investigation period.

Parasite surveillance: All patients with febrile illnesses who visited health facilities had their medical records examined, and blood films were created; tests were performed using the fast diagnostic test and the letter was validated using the golden test of microscopy for malaria parasites at the health facilities.

Entomological surveillance: We chose five villages for our entomological inquiry, collecting both adult and larvae mosquitoes from each of the five chosen villages in light of the high number of malaria patients with laboratory certified testing. In order to gather adult mosquitoes indoors, mouth and Prokopack aspirators were used in a few homes where artificial and natural mosquito breeding places were examined for the presence of larvae or pupae abroad. Every female mosquito that was collected was brought to the entomology laboratory at EPHI for species identification using morphological methods based on keys Verrone 1962a, b; Gillies and Coetzee 1987. The female mosquitoes were examined under a stereo dissecting microscope with a 20x magnification power (WHO 2013).

Data Analysis: Using Microsoft Office Excel sheets, descriptive data analysis was carried out. The attack rates specific to age and sex were also computed by multiplying by 100 after dividing the total number of cases within each age or sex category. Mosquitoes also made use of percentage.

Ethical Considerations: This investigation was not classified as research because it was a public health emergency response, and informed consent was not necessary. In order to determine the most effective means of controlling the outbreak, mosquitoes (both adult and larval) and blood samples were obtained with the sole purpose of examining the underlying causal agent. The government agency, EPHI, which is fully authorised to carry out epidemiological research and handle any public health emergency, issued the directive.

Conflict of interest

The authors declare that they have no competing interests.

Result

On October 1, 2022, an outbreak of malaria was discovered in Addis Ababa; at least one case was documented in each of the 107 woredas included in the subcity. There have been 903 confirmed cases of malaria (so far), with the majority of cases reported falling within the 15–34 age range (35%). The percentage of cases by sex is 69 for men and 31 for women (Table 1). The three main regions impacted by the disease were Akaki-Kalit, Nifassilk Lafto, and Bole subcities.

Table 1: Percentage of malaria cases by age in Addis Ababa 2022

Percentage of malaria cases by age	
Age category	percentages of malaria cases
< 5	2.7
5-14	5.7
15-24	35.1
25-34	30.7
35-44	14.5
45-60	9.7
>60	1.9

Of the 903 cases, 71% have travelled, whilst 29% have not; 69% of the cases' participants are female, and the remaining 31% are male. Aside from that, there were 118 daily labourers, 137 government employers, 278 unemployed people, and 370 private workers among the 903 malaria cases. By percentage, 37% of the parasites were *Plasmodium falciparum*, 55% were *Plasmodium vivax*, and the remaining 8% were mixed. Table 2 below displays the Addis Ababa Ethiopian Public Health Institute's records about the occurrence of malaria build-up. In 2020, 2021, and 2022, there were 1706, 2031, and 4022 instances, respectively.

Table 2: Trend of malaria cases in Addis Ababa from 2020-2022 using WHO EPI week

Week No	2020	2021	2022
1	52	61	25
2	54	64	31
3	50	63	38
4	57	96	54
5	75	77	39
6	50	29	64
7	60	39	40
8	56	46	35
9	45	42	50
10	60	39	68
11	91	38	92
12	39	59	66
13	53	41	78
14	40	47	86
15	47	26	91
16	29	23	67
17	27	41	58
18	37	33	81
19	15	26	69
20	29	27	73
21	14	35	81
22	19	31	84
23	19	35	94
24	16	30	76
25	22	38	93
26	18	36	111
27	25	33	125
28	27	27	87
29	36	34	87
30	30	47	85
31	35	53	78
32	18	52	105
33	16	36	96
34	33	35	67
35	24	44	93
36	17	46	83
37	15	50	105
38	26	27	91
39	24	33	115
40	23	38	105
41	32	66	110
42	49	53	151
43	53	71	160
45	60	58	173
46	31	53	195
47	58	53	167
Total	1706	2031	4022

**Figure 6: Image of morphological identification of *An. gambiae* sl, collected from investigation areas of Addis Ababa 2022**

Within a few days of investigation out of the collected 145 mosquitoes 88% were *Culex* whereas the rest 12% were found *An. gambiae* sl.

Discussion

As a result of our surveillance, 903 cases of malaria were found. In line with the 1998 epidemic report and publication (Adugna and Ali 2004) indicating the occurrence of an epidemic in the current research areas, this does not imply that the country's actions were ineffective in preventing or reducing malaria morbidity or mortality. The use of interventions such as IRS, LLINs, and treatments, particularly in high malaria transmission years, plays a significant role in reducing the impact of malaria-related mortality and morbidity in a country like Ethiopia where climate variability produced unpredicted malaria incidence (Irish et al. 2008).

Malaria in highland locations will result from the influence of climate variability, which produces rainfall and temperature dynamics. Because of the influence of climate conditions on malaria transmission, patterns of seven to ten years have been observed in recent decades; however, more recently, these patterns have shrunk to fewer than three years, with EL-Nino/La-Nina years in Ethiopia being particularly affected.

There were 4022 cases of malaria in the research areas in 2022 compared to 1706 occurrences in 2020. Nonetheless, the increase—a 2.36-fold increase—was extremely large. The reported malaria account 2031 for 2021 was higher than the 2020 report in the studied locations. The evidence we have shown that highland malaria transmission was constant at very high elevations. There is a tight relationship between temperature and altitude.

Naturally, there will be a drop in temperature in proportion to an increase in altitude. Hay et al. (2000) anticipated that there would be a 0.5 °C drop in temperature for every 100 m increase in altitude. Revision of the real temperature in the areas should take into account global warming, even though it may be challenging to pinpoint the precise cause of the recent increase in malaria cases in the research areas.

Out of 903 cases 71% have travel history but 29% were not traveled; and 69% were female and the rest 31% male. Lack or low level of immunity in the human population makes epidemics more likely since, they are highland dwellers (WHO, 2013). Antimalarial immunity develops slowly and is generally low in small children, even in areas with high transmission. Pregnant women lose some of their antimalarial immunity during a pregnancy. Hence, both population groups are particularly vulnerable to malaria. In line with this, several years have passed since the last Addis Ababa malaria epidemic occurred in 1998, then antimalarial immunity will have decreased, therefore greater proportion of the population susceptible to infection and, hence, at risk of malaria (Adugna and Ali 2004).

A total of 903 malaria cases identified and listed (so far), most of reported cases were among age group of 15-34yrs (35%). Similarly, a report during the outbreak of 1998 in Addis Ababa, Akaki Town and its surroundings, the information revealed that the epidemic was very worrying affecting a substantial part of Akaki and the surrounding areas, with the total number of cases amounting to 622 (Adugna and Ali 2004). As a result this study will give a good insight about highland malaria transmission dynamics for the ongoing malaria elimination program in Ethiopia.

The inclination or decline of mean malaria incidence was clearly observed with the implications of temperature variants, playing major role in highland malaria transmission dynamics associated with sporogonic cycle. As shown in the study (Lemma 2021), in highland area where the temperature ranged from 10 to 30 °C, there may not be temperature-related death of the immature stages in the aquatic habitats and malaria parasites death in the gut of the parous female mosquito vectors in human dwellings or in other shelters. The impact of temperature is, therefore, related to slowing down transmission during low temperature.

Besides out of 903 malaria cases the numbers of daily laborers were 118, government employer 137, without occupation 278 and private workers 370 shows local transmission possibilities. Movements of people can contribute to malaria epidemics from Oromia and Djibouti (heavy tracks were seen the study areas). On

one hand, people with malaria moving into an area where malaria arose can be sources of acquiring *Plasmodium* gametocytes for local mosquitoes, which precipitating an outbreak/epidemic. In line with this, non-immune people from Addis Ababa moving to highly endemic areas may cause an apparent epidemic. Such movement could be migrant workers, refugees, resettlement, displacement and other travelers. Besides, non-effective drugs may cause a malaria epidemic, since *Plasmodium* infections are not properly cleared allowing persisting parasitemia, which in turn will increase infectiousness to the mosquito vector (Lemma 2021).

In terms of the parasite 55% were *Plasmodium vivax*, 37% *Plasmodium falciparum* and the rest 8% mixed this might shows the sporogonic cycle was not affected by the temperature in the vectors. One of the main challenges in the malaria elimination program in Ethiopia is, the unpredictable impact of climatic change variables which overstretch the formerly sensitive and unstable malaria situations in Ethiopia, where it comes to the highland malaria the consequence is sever. Similarly Weldeyohannes and his colleagues (2019) described climate change impacts on malaria distribution in Ethiopia. In line with this, they suggested, in the study conducted at the household level on human settlements in highland areas of Ethiopia showed the existence of malaria transmission in all altitude ranges with a gradual decline in transmission (3.2%) in people living at 2500–3000 m altitude range; thus, in Northern part of Ethiopia in the district of Debark, 2800 m altitude was predicted to be the upper limit for the existence of malaria transmission.

On the other hand, this study showed the presence of *Anophelines* within a few days of investigation, out of the collected 145 mosquitoes 88% were *Culex* whereas the rest 12% were found *An. gambiae* s.l. The sources were mainly associated with small irrigation practices, in containers shipped from Djibouti and man-made artificial breeding habitats. In addition, the existence of permanent vector breeding habitats created by poor management of water supported the survival of vector species. In the highland areas above 2000m a.s.l considerable numbers of *An. gambiae* s.l. were collected similar to our study (Kibretet al. 2010; Woyessa et al. 2011; Animut et al. 2012).

During our study both temporary and permanent breeding habitats were dominantly occupied by *Culex* although *An. gambiae* s.l. collected. The breeding habitats of *An. gambiae* s.l. in the study localities were created by human activities rather than natural causes. That is, the water accumulated from overflow of small irrigation, interrupted marshy areas and pipes remain

the most important breeding sites created by human activities. Similarly, studies conducted in Ethiopia and western Kenya, reported that marshes, irrigation canals and river pockets were served as breeding habitat for *An. gambiae* s.l. during months of low precipitation (Animut et al. 2012; Kenea et al. 2011, 2016; Imbahale et al. 2011; Kweka et al. 2015).

During this short period the result of adult *Anopheles* collection revealed few *An. gambiae* s.l., this is due to shortage of time and lack of efficient adult collection methods especially for outdoor resting mosquitoes were some of the limitation of the surveillance. In agreement with other studies, this species is incriminated as the principal vector of malaria in Ethiopia (Animut et al. 2012; Kibret et al. 2011) and elsewhere in East, West and South Africa (Kenea et al., 2011; Imbahale et al. 2011; Kweka et al. 2015). Although, few *An. gambiae* s.l. were collected, it is a break through evidences for the presence of potential vector which can transmit malaria in the study area. There might be other malaria vector important as *An. gambiae* s.l. thus, another further study in study areas required. The presence of this species in the study area during the study months is an indication for the malaria transmission. Understanding malaria epidemiology and entomology at least at Zonal administration level to establish local specific malaria control strategy would be necessary.

Conclusion and Recommendations

Potential malaria vectors which designated as the primary vector *An. gambiae* s.l. were found, rapid distribution of LLINs, larval control activities could be functional at least in small irrigations, and well known breeding habitats. Follow-up on meteorological report indicating normal or abnormal situations (rainfall, temperature) required. In line with this, health education, efforts to mobilize the community and partners in achieving the needed participation should be assessed. Furthermore, training on entomology for the health workers is necessary. Revising the national malaria control program above 2000m altitudes should be considered.

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