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Five Years Trend Prevalence of Malaria at Azezo Health Center, Northwest Ethiopia.

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Abstract

Background: Malaria is a febrile disease caused by a protozoan parasite. It is one of the most severe public health problems worldwide. Recent studies of malaria elsewhere in Ethiopia revealed a contrasting prevalence dictating continuous monitoring on the prevalence and burden of malaria in the country. Hence, this study aimed to determine the trend prevalence of malaria over the last five year.

Methods: A retrospective cross-sectional study was conducted at Azezo health center Northwest from January, 2019 to May, 2019. Study participants were those subjects who were requested for malaria diagnosis over the last five years before January 2019. Data was collected directly from the laboratory log book using tally sheet. The collected data was entered into MS-Excel and transferred into SPSS version 20.1. Cleared data were statistically analyzed using chi-square to measure statistical association between trend prevalence of malaria and independent variables.

Result: A total of 13507 blood films were requested for malaria diagnosis at Azezo health center from Jan 2014-Dec 2019. Of the examined blood films, 1784 (13.2%) were microscopically confirmed malaria cases. From a total malaria confirmed case male were more affected than female. With regard to age group above 15 years old were more affected. *Plasmodium falciparum* and *Plasmodium vivax* accounted for 1074 (60.13%) and 691 (38.69%) cases, respectively. From total positive cases, 21(1.18%) of cases were mixed infections.

Conclusion and recommendation: Malaria is still a major health problem and the species *Plasmodium falciparum* was most predominant followed by *Plasmodium vivax.* As a result, control activities should be continued in a strengthened manner in the study area.

Keywords: Trend of malaria; Gondar; North West Ethiopia.

Introduction

Malaria is a febrile disease caused by protozoan parasite and transmitted by the bite of female anopheles' mosquito (1). It is one of the leading causes of death and illness in the world. Five species of *Plasmodium* have long been recognized to infect humans in nature. Those are *Plasmodium falciparum* , *Plasmodium vivax*, *Plasmodium ovale*, *Plasmodium malariae*, and *Plasmodium knowlesi* (2).

According to WHO 2017 World malaria report, there were an estimated 216 million cases and 445000 death of malaria occurred in 2016 globally, as compared to 2015, 211 million number of case and 446000 death occur (3). Most malaria case and death occur in Africa region and East Asia with an estimation of 91% and 6% of death occurred respectively. About 99% of cases in sub Saharan Africa majorly caused by *P. falciparum* in 2016, but *P. vivax* high in American region which account about 64% of malaria cases (4).

In areas with high transmission of malaria, children under 5 are particularly susceptible to infection, illness and death; more than two thirds (70%) of all malaria deaths occur in this age group. The number of under 5 malaria deaths has declined from 440,000 in 2010 to 285,000 in 2016. However, malaria remains a major killer of children under five years old, taking the life of a child every two minutes (4).

Malaria can also affect people who have little or no immunity to malaria especially during seasons which favors transmission of malaria. For this reason, most malaria deaths in Africa occur in young children, whereas in areas with less transmission and low immunity, all age groups are at risk (5).

The transmission of malaria is depends on the relationship between the host, the parasite and the environment where the malaria vectors breeds, and climatic condition and seasonal variation. Since, the anopheles mosquito needs water body especially stagnant water, so the transmission is high during rainy season and after that. Most importantly life span of the anopheles vector affects the transmission of malaria. Likewise, the long lifespan and strong human-biting habit of the African vector species is the main reason why nearly 90% of the world's malaria cases are in Africa (6).

In Ethiopia the spread of malaria is also affected by population growth and migration, urbanization and improper use of malaria prevention and control methods. Urban areas are not traditionally included in spray operation and bed net distribution program because of a perception of good access of urban dwell to health institution. On the other hand, population attitude towards malaria also affects the transmission of malaria (7). In general, the epidemiological distribution of malaria in Ethiopia covers about 66% of the landmass and an estimated 60% of the population is believed to be at risk of the disease (8).

Although malaria is causing a huge number of cases and deaths worldwide, it is preventable. Among the common prevention and control methods of malaria include insecticide-treated mosquito nets (ITN), indoor spraying with residual insecticides (IRS) and early diagnosis and treatment (9). However, now a day the malaria transmitting vectors are developing resistance to most of the indoor spray chemicals and *plasmodium species* is also getting resistance to anti-malaria drugs mainly that *P. falciparum,* contributing to sustained transmission of the disease mainly in developing countries (10).

In general, malaria is a major health problem and major contributing factor for morbidity and mortality throughout the world, especially in sub-Saharan Africa regions (11). Ethiopia, as a part of sub-Saharan region, shares high burden of malaria and as malaria is thought to be distributed nationwide. Therefore, based on previous literatures we have found that malaria is severing and it is still the major public health problem (12). As a result, this study will be beneficial in many aspects. It provides information on the prevalence and trend of malaria based on demography in the study area. Therefore, it could provide baseline information for those who are interested to conduct further study about malaria aiming to point out bottle necks in the use of prevention and control methods of malaria to help policy makers in the effort of malaria elimination program. Therefore, the current study assessed the trend prevalence of malaria over the last five year.

Method and materials

Study Area

The study was conducted at Azezo health center. Azezo health center is located in Central Gondar Zone, Amhara Regional State and 726m away from Addis Ababa the capital city of Ethiopia. The health center provides health service for about 25,000 inhabitants of the town and surrounding rural areas. The town has an attitude of 1400 meters above sea level which provides a warm and temperate climate condition to the town. The town has an average temperature of 19.2°C which however would be high in March, and be low in August. In addition, the town has an average rainfall of 1146 mm.

Study design, period, and population

A retrospective cross-sectional study was conducted at Azezo health center from February, 2019 to May, 2019. Patients who were attended at Azezo health center and requested for malaria diagnosis were our study population.

Eligibility criteria

Inclusion criteria

Patient who has completed data such as; sex, age, and *Plasmodium species* were included into the study.

Exclusion criteria

Patient who has duplicated record was excluded from the study.

Sample size and sampling technique

Since our study was a five years retrospective cross sectional study, all full recorded data of those subjects who were requested for suspect of malaria were enrolled. Since, the source of data was secondary data (laboratory log book), the study participants were recruited based on inclusion and exclusion criterion.

Data collection

Patients who visited Azezo health center from January 2009 to January 2019 and diagnosed for malaria was considered during data collection. Data was retrieved directly from the laboratory log book and collected using tally sheet with variables including sex, age, *plasmodium* species

identified, year and months data were retrieved directly from registration log book using prepared data extraction sheet .data was collected by prepared information sheet.

Quality control

The prepared data extraction sheet which contains information including: age, sex, type of *Plasmodium* species identified, and date of reporting was used to collect data from the laboratory log book. Cleared data were entered into MS-Excel and was transferred into SPSS version 20.1 after checking data completeness. Data in the SPSS version was cross-check independently by three data collectors. To maintain data originality and completeness, the original data extraction sheet was referred.

Data analysis

Data was analyzed statistically using SPSS version 20.1 to measure association between the outcomes and the independent variables. Chi-square were used to measure statistical significance association between variables and a p-value of <0.5 were considered statistical significance. Final result was expressed with frequency and percentage, and presented using tables and graphs.

Result

Prevalence of *plasmodium* specious with sex age among study participant

Within five years (January 2014-december 2019) a total of 13507 blood films were requested for malaria diagnosis in Azezo health center, from those male were frequently requested than female which accounts 7796 (57.7 %) and 5711(42.3%), respectively. Also from a total malaria confirmed cases male were more affected than female with prevalence rate of 1407 (78.9 %) and 377 (21.1 %), respectively. Malaria also reported in all age group in the study area, but the age group of above 15 years old were more affected with prevalence rate of 1540 (86.3 %) followed by the age group 5-15 and below 5 years old with prevalence rate of 176 (9.9 %) and 68 (3.8 %), respectively.

In relation to *plasmodium* species and sex in the study area *P. falciparum* was predominant in male with prevalence rate of 864 (80.4 %), followed by *P. vivax* and mixed with prevalence of 529 (76.6 %) and 15 (71.4 %), respectively. In contrast female was predominantly infected with mixed infection which accounts about 6 (28.6 %) and least affected by *P. falciparum* with 210 (19.6%). *Plasmodium* species also have relation with age in the study area. *Plasmodium falciparum* was dominant parasite in age group above 15 years old which accounts about 950 (88.5 %), but have least prevalence rate 32 (3 %) at age group below 5 years. But *P. vivax* and mixed infection were dominant below 5 year with prevalence of 37 (5.4 %) and 5-15 year with prevalence rate of 5 (23.8 %), respectively (**Table 1**).

Table 1. Prevalence of *plasmodium* species with sex and age among study participants attended Azezo health center for prevalence of malaria, Northwest Ethiopia, 2019.

		Age			**Sex**		**Total**
		<5	5-15	>15	Male	Female	
Malaria status	Pos	68(3.8%)	176(9.9%)	1540(86.3%)	1407(78.9%)	377(21.1%)	1784(100.0%)
	Neg	2168(18.5%)	1909(16.3%)	7646(65.2%)	6389(54.5%)	5334(45.5%)	11723(100.0%)
	Total	2236(16.6%)	2085(15.4%)	9186(68.0%)	7796(57.7%)	5711(42.3%)	13507(100.0%)

		Age			Sex		Total
		<5	5-15	>15	Male	Female	
P.species	Pf	32(3%)	92(8.6%)	950(88.5%)	864(80.4%)	210(19.6%)	1074(100%)
	Pv	37(5.4%)	80(11.6%)	574(83.1%)	529(76.6%)	162(23.4%)	691(100%)
	Mix	0(0.0%)	5(23.8%)	16(76.2%)	15(71.4%)	6(28.6%)	21(100%)
	None	2167(18.5%)	1908(16.3%)	7646(65.2%)	6388(54.5%)	5333(45.5%)	11721(100%)
	Total	2236(16.6%)	2085(15.4%)	9186(68%)	7796(57.7%)	5711(42.3%)	13507(100%)

Abbreviation:

Pf: *Plasmodium falciparum;* **Pv:** *Plasmodium vivax,* P. species; *Plasmodium* species

Mix*: P. falciparum* and *P. vivax*

Annual trend prevalence of *plasmodium* species of study participant

Prevalence of malaria also assessed with year in study area. there was decreasing of prevalence malaria in the last five years (2014-2019) except in 2016 to 2017 year show increment which accounts about 440 (24.6%) whereas least prevalence was recorded in 2018 to 2019 with prevalence rate of 117(6.6%). With highest general prevalence of *P. falciparum* which accounts 1074(8%) whereas mixed infection has least prevalence for last five years with general prevalence of 21(0.2%) from the overall requested patient (**Table 2**).

Table 2. Annual trend prevalence of *plasmodium* species of study participant attended at Azezo health center, Northwest Ethiopia, 2019**.**

	***Plasmodium* species**			
Year of diagnosis	Pf	Pv	Mix	Total
2014-2015	429(13)	210(14)	1(4.76%)	640(35.8%)
2015-2016	226(21.04%)	116(16.8%)	11(52.38%)	353(19.8%)
2016-2017	221(20.57%)	213(30.8%)	6(28.57%)	440(24.6%)
2017-2018	131(12.19%)	104(15.1%)	1(4.76%)	234(13.2%)
2018-2019	67(6.2%)	48(6.9%)	2(9.53%)	117(6.6%)
Total	1074(100%)	691(100%)	21(100%)	1784(100%)
	(60.13%) of the total positive	(38.69%) of the total positive	(1.18%) of the total positive	

Abbreviation:

Pf: *Plasmodium falciparum;* Pv**:** *Plasmodium vivax, Plasmodium* species

Mix*: P. falciparum* and *P. vivax*

Prevalence of *plasmodium* species in season

Although malaria occurred in all month, the monthly distribution of prevalence of malaria exhibited different pattern for the last four seasons. Over all, two major peak seasons were recorded in the study area the first peak occurred from October to December and the second peak occurred from July to September. The highest peaks of confirmed malaria cases were observed from October up to December and the lowest number of malaria cases were observed from January to March. As compared to *P.vivax* the occurrence of *P.falciparum* were almost double during the two peak seasons throughout the last five years (2014-2019). But in other seasons like from January to March the occurrence of *p. vivax* was higher than *P. falciparum* whereas the distribution of mixed infection has constant distribution throughout the season (**Table 3**).

Table 3. The distribution of *Plasmodium* in different seasons in Azezo health center from 2014-2019.

		***Plasmodium* species**			
		Pf	Pv	Mix	Total
Season	Jan- Mar	107(9.96%)	127(18.4%)	4(19.01%)	236(13.3%)
	Apr-Jun	128(11.9)	119(17.2%)	3(14.29%)	250(14%)
	July-sep	370(34.47)	205(29.7%)	5(23.8%)	580(32.5%)
	Oct-Dec	469(43.67)	240(34.7%)	9(42.9%)	718(40.2%)
	TOTAL	1074(60.13%)	691(38.69%)	21(1.18%)	1784(100%)

Pf: *Plasmodium falciparum;* Pv**:** *Plasmodium vivax,*

Mix*: P. falciparum* and *P. vivax*

Discussion

This health center based retrospective study assessed five years period distribution of malaria among individuals by sex, age, time and composition of indicated that *Plasmodium* species based on the available data of Azezo health center. The present study showed that, the number of laboratory confirmed malaria cases were 1784 with total positivity rate of (13.2%) and the dominant *plasmodium* species was *P. falciparum* which accounts about 1074(60.13%). This finding strongly agreed with study conducted in south omo zone (15) but lower than study conducted in North Gondar town, Kola deba (16), and woreta health center (17). This difference may be due to the type of study period, climatological differences, altitude variation, malaria diagnosis technique variation, skill of the laboratory personnel to detect and identify malaria parasit species, even sample size also possible cause of the above difference to be occurred (18).

The results of our study revealed that during the last five years, decreasing trend prevalence of malaria cases was observed in the study area except an increment in the number of malaria cases occurred from 2016–2017 with a minimum number of malaria cases were recorded from (2018-2019). In every year studied the remarkable decrement of total malaria cases was mainly due to decrease of *P. falciparum* with little fluctuating of *P. vivax* and some fluctuating of mixed infection, which indicates that the use of preventive mechanism of *plasmodium* species, especially for *P. falciparum* is common in the study area.

The reduction of total malaria cases throughout the year may be due to the increased availability of the new effective drug Coartem for the treatment of *P. falciparum* malaria at national and local levels (19). Other possible reasons for malaria reduction during the study period might be due to the increased attention to malaria control and preventive activities by different responsible bodies, increased awareness of the community on use of ITNs, increment of budget for malaria control and prevention activities (20). However, the increment of total confirmed malaria cases from (2016 -2017) may be due to intervention concerning *P. vivax* and mixed infection is less compared to *P. falciparum* and study participants who were attended at Azezo health center come from remote area like metama (21).

Plasmodium falciparum was the predominant species in the study area and accounted for 60.13% of malaria morbidity. This finding coincides with the malaria parasite distribution in Ethiopia, which indicates that *P. falciparum* and *P. vivax* are the two predominant malaria parasites,

distributed all over the country and accounting for 60% and 40% of malaria cases, respectively (22).

This study also shows that since 2016 *P. falciparum* is decreasing but *P. vivax* is slightly increasing, which indicates a trend shift. This trend shift is similar to other recent study reports in Ethiopia carried out in kola deba. The possible reason for this trend shift from *P. falciparum* to *P. vivax* might be due to the public health importance of *P. vivax* that is frequently overlooked and blamed by high prevalence of *P. falciparum* this results less concern to *P. vivax* prevention and treatment. In addition, the prevention and control activities of as guided by the National Strategic Plan (2006–2010) mainly focus on *P. falciparum* because it is assumed more prevalent and fatal malaria in the country Ethiopia (23).

Regarding the age groups, above 15 year old (86.3%) were highly affected age groups followed by 5–15 year old (9.9%) and below 5 year old (3.8%). *Plasmodium falciparum* was more prevalent in above 15-age group which accounts about (88.5%) but the age group from 5-15 were more affected by *P. vivax* whereas below 5 years old were affected with mixed infection. This finding is higher than the study which conducted in kola deba (16). The reason might be due to the way of classifying the age group in our study was more general to that of kola deba. The prevalence of malaria parasites among males (78.9%) was higher than females (21.1%). This finding is similar with the study conducted in Mali (24). The reason why malaria affected productive age groups above 15 year and more males because the study participant attended in the study area come from rural area and mostly work on agriculture and his might be due to prioritizing females in the use of ITNS as of their responsibility to care children, which is in accordance with a previous report. The area is hot so staying outside the home and sleeping under trees is common during the nighttime. Due to these and other different reasons, the age groups and males are more affected (25).

Season also played a role in the transmission of malaria in the study area. The highest peak of malaria cases in almost all year groups was observed during (October and December). This seasonal occurrence indicates the real malaria transmission for the country Ethiopia. In Ethiopia, the major transmission of malaria follows the June to September rains and occurs between Septembers to December, while the minor transmission season occurs between Januarys to March following the April to Jun rains(26). This result agreed with most study but disagree with the study conducted in south omo zone (27). Many factors might be responsible for seasonal

changes, e.g., climatic variables, ecologic and environmental factors, host and vector characteristics, and social and economic determinants such as change in health care infrastructure (28, 29). Social, biological and economic factors such as mosquito control measures, population immunity, local ecological environment, governmental policy, availability of health facilitates and drug resistance have an impact on malaria prevalence(30). Although there were different malaria control activities in each year, such as insecticide spraying, elimination of mosquito breeding sites, health education about malaria, distribution of ITNs and some malaria drugs and other activities to decrease mortality and morbidity of malaria, the prevalence is still sustained(31).

Conclusion and recommendation

Relatively, after introduction of current malaria control strategies, the morbidity and mortality of malaria is decreasing, but malaria is still a major health problem and the species *P. falciparum* was most predominant. The highest peak of malaria cases in almost all year groups was observed from October to December. In this study there was a major problem such as low data recording habit of laboratory professionals which was clerical error related to name and residence of the patient. Therefore using different software should be better to improve data quality. Therefore, control activities should be continued in a strengthened manner in the study area considering both *P. falciparum* and *P. vivax* and the seasonal occurrence of malaria.

Abbreviation and Acronym

IRS Indoor Residual Spray

ITNS Insecticide Treated Nets

PCR Polymerase Chain Reaction

PF *Plasmodium falciparum*

PV *Plasmodium vivax*

QC Quality Control

WHO World Health Organization

Declarations

We declare that this manuscript is original and has not been submitted or published in other journal. Also, all methods were achieved based on appropriate guidelines and regulations.

Ethics approval and consent to participate

This study followed the ethical standards of the Declaration of Helsinki. Also, this study was conducted after ethical approval was obtained from the research and ethics committee of the School of Biomedical and Laboratory Sciences, College of Medicine and Health Sciences, University of Gondar. A support letter was obtained from the central Gondar Zonal Health bureau and presented to Azezo health center, from which permission was also be obtained to collect data of the study. The objective of the study was clarified to health personnel working at Azezo health center as required.

Consent for publication

Not applicable

Patients or the public involvement

Patients or the public were not involved in the design, conduct, reporting, or dissemination plans of our research.

Availability of data and material

We confirmed that all the data for this manuscript are available, if someone wants to request the data can contact Wagaw Abebe.

Clinical Trial

In this manuscript 'Clinical trial number: not applicable'**.**

Competing interests

The authors declare that they have no competing interests.

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Author contribution

A.M was conceived, designed the study, interpretation of the data, and wrote original draft of the manuscript. **W.A** was critically reviewed the manuscript.

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References

1. Arrow KJ, Panosian C, Gelband H. The parasite, the mosquito, and the disease. Saving Lives, Buying Time: Economics of Malaria Drugs in an Age of Resistance: National Academies Press (US); 2004.
2. cdc. about malaria biology. Malaria journal. 2018.
3. Gupta PAB, Maheshwari R. Malaria: Wolters kluwer india Pvt Ltd; 2019.
4. Organization WH. World malaria report 2017. Geneva: WHO; 2017. 2018.
5. Doolan DL, Dobaño C, Baird JK. Acquired immunity to malaria. Clinical microbiology reviews. 2009;22(1):13-36.
6. Organization WH. Malaria: fact sheet. World Health Organization. Regional Office for the Eastern Mediterranean, 2014.
7. Berhane Y, Mariam DH, Kloos H. Epidemiology and ecology of health and disease in Ethiopia: Shama books; 2006.
8. Animut A, Gebre-Michael T, Medhin G, Balkew M, Bashaye S, Seyoum A. Assessment of distribution, knowledge and utilisation of insecticide treated nets in selected malaria prone areas of Ethiopia. Ethiop J Health Dev. 2008;22(3).
9. Najera J. Prevention and control of malaria epidemics. Parassitologia. 1999;41(1-3):339-47.
10. Nájera JA, Zaim M, Organization WH. Malaria vector control: insecticides for indoor residual spraying. Geneva: World Health Organization, 2001.
11. Oladipo HJ, Tajudeen YA, Oladunjoye IO, Yusuff SI, Yusuf RO, Oluwaseyi EM, et al. Increasing challenges of malaria control in sub-Saharan Africa: Priorities for public health research and policymakers. Annals of Medicine and Surgery. 2022;81:104366.
12. Esayas E, Tufa A, Massebo F, Ahemed A, Ibrahim I, Dillu D, et al. Malaria epidemiology and stratification of incidence in the malaria elimination setting in Harari Region, Eastern Ethiopia. Infectious Diseases of Poverty. 2020;9:1-12.
13. Efficacy and safety of the RTS,S/AS01 malaria vaccine during 18 months after vaccination: a phase 3 randomized, controlled trial in children and young infants at 11 African sites. PLoS medicine. 2014;11(7):e1001685.
14. Dassah S, Adu B, Sirima SB, Mordmüller B, Ngoa UA, Atuguba F, et al. Extended follow-up of children in a phase2b trial of the GMZ2 malaria vaccine. Vaccine. 2021;39(31):4314-9.

15. Ergete S, Sorsa S, Loha E, Asnake S. Trend of malaria cases in Hana and Keyafer health centers, south Omo zone, southern Ethiopia. Ethiopian journal of health sciences. 2018;28(3):277-86.
16. Alemu A, Muluye D, Mihret M, Adugna M, Gebeyaw M. Ten year trend analysis of malaria prevalence in Kola Diba, North Gondar, Northwest Ethiopia. Parasites & vectors. 2012;5:1-6.
17. Amir Alelign AA, Zinaye Tekeste ZT, Beyene Petros BP. Prevalence of malaria in Woreta town, Amhara region, northwest Ethiopia over eight years. 2018.
18. Tegegne G. Comparative assessment of microscopy, malaria rapid diagnostic test and polymerase chain reaction as diagnostic test tools in Adama Woreda, East Shoa zone of Ethiopia: Addis Ababa University; 2017.
19. Nega D, Assefa A, Mohamed H, Solomon H, Woyessa A, Assefa Y, et al. Therapeutic efficacy of artemether-lumefantrine (Coartem®) in treating uncomplicated P. falciparum malaria in Metehara, Eastern Ethiopia: regulatory clinical study. Plos one. 2016;11(4):e0154618.
20. Tizifa TA, Kabaghe AN, McCann RS, van den Berg H, Van Vugt M, Phiri KS. Prevention efforts for malaria. Current tropical medicine reports. 2018;5:41-50.
21. Eperon G, Durieux-Paillard S, Mauris A, Chappuis F, Gysin N. Malaria cases in Switzerland from 2005 to 2015 and recent rise of imported Plasmodium vivax malaria. Swiss medical weekly. 2017;147(4142):w14510-w.
22. Mekonnen SK, Aseffa A, Medhin G, Berhe N, Velavan TP. Re-evaluation of microscopy confirmed Plasmodium falciparum and Plasmodium vivax malaria by nested PCR detection in southern Ethiopia. Malaria journal. 2014;13:1-8.
23. Habtamu K, Petros B, Yan G. Plasmodium vivax: the potential obstacles it presents to malaria elimination and eradication. Tropical Diseases, Travel Medicine and Vaccines. 2022;8(1):27.
24. Dao F, Dembele L, Diarra B, Sogore F, Marin-Menendez A, Goita S, et al. The prevalence of human Plasmodium species during peak transmission seasons from 2016 to 2021 in the rural commune of Ntjiba, Mali. Tropical Medicine and Infectious Disease. 2023;8(9):438.
25. Awasthi KR, Jancey J, Clements AC, Leavy JE. A qualitative study of knowledge, attitudes and perceptions towards malaria prevention among people living in rural upper river valleys of Nepal. PLoS One. 2022;17(3):e0265561.
26. Adugna A. Malaria in Ethiopia. Ethio Demography and Health org. 2011.

27. Solomon Ergete SE, Solomon Sorsa SS, Eskindir Loha EL, Solomon Asnake SA. Trend of malaria cases in Hana and Keyafer health centers, South Omo Zone, Southern Ethiopia. 2018.
28. Gage KL, Burkot TR, Eisen RJ, Hayes EB. Climate and vectorborne diseases. American journal of preventive medicine. 2008;35(5):436-50.
29. Sutherst RW. Global change and human vulnerability to vector-borne diseases. Clinical microbiology reviews. 2004;17(1):136-73.
30. Organization WH. A global strategy for malaria control: World Health Organization; 1993.
31. Gelband H, Panosian CB, Arrow KJ. Saving lives, buying time: economics of malaria drugs in an age of resistance. 2004.