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Changes in Malaria Indices in an Ethiopian Health Centre: A Five Year Retrospective Analysis

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A B S T R A C T

Background*:* Malaria affects the health and wealth of individuals, as well as nations. In Ethiopia, malaria is identified as both a disease of poverty and a cause of poverty.
Objectives: A retrospective analysis was conducted to investigate the changes in malaria indices at the Serbo Health Center, Ethiopia.
Materials and Methods: Based on existing blood smear examination data. The original case records were carefully reviewed, analyzed and interpreted.
Results: Among the total of 51610 blood smear examinations, 26602 were found to be positive and contributed to 51.5% of the diagnostic yield. All of the 51610 cases were treated at the Serbo Health Center. Males constituted a total of 56.1% participants in this study (14934/26602 cases) and they were found to be more prone to having a positive malaria smear. Chi-square analysis showed a statistically significant association between male patients and the incidence of malaria ($P = 0.0001$; $\chi^2 = 212.5$; $df = 4$). Plasmodium falciparum contributes to about 62.4% of malaria cases followed by P vivax (37.3%).
Conclusions: There is an urgent need for active health education campaigns and the administration of front-line vector control interventions such as the consistent deployment of insecticide-treated bed-nets and indoor residual spraying to interrupt disease transmission and an eventual reduction in the number of malaria cases.

Implication for health policy/practice/research/medical education:
The present communication discusses the five year retrospective analysis about the changes in malaria indices in a typical Ethiopian health center. Reading this article recommended to active health education campaigns and the administration of front-line vector control interventions to interrupt disease transmission and an eventual reduction in the number of malaria cases.

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1. Background

Insect-borne disease imposesan enormous burden on the world's population in terms of loss of life (millions of death per year) and morbidity. These diseases are also responsible for huge economic losses, both in terms of health-care costs and lost productivity, mostly in countries that can least afford them (1). The rural population in Africa is often regarded as poor, uneducated, or unaware of the risks, with an inadequate social infrastructure, all of which makes them more prone to malaria (2). Despite currently available interventions, malaria remains a major public health problem worldwide. It has been reported that approximately half of the world's population is at risk of malaria with nearly one million deaths every

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year (3), and a global burden of malaria which exceeds 40 million disability adjusted life years (DALY)(4). People living in the poorest countries are comparatively the most vulnerable (5).

Malaria is ranked as the leading communicable disease in Ethiopia, accounting for about 30% of the overall DALY lost. Approximately 68% of the total populations of 78 million people live in areas at risk of malaria. According to Ethiopia's Federal Ministry of Health (FMOH), in 2008/2009, malaria was the leading cause of outpatient visits, health facility admissions and inpatient deaths, accounting for 12% of reported outpatient visits and nearly 10% of admissions. As a large proportion of the population does not have access to health care services, these figures are probably an underestimate of the true burden of malaria in the country (6). Ethiopia's varying topographical and climatic features contributes to the seasonal and unstable malaria transmission pattern which is usually characterized by frequent focal and cyclic, widespread epidemics (6, 7). The Ministry of Health in Ethiopia has summarized the impact of malaria in Ethiopia as follows; The socioeconomic burden resulting from malaria is immense; 1) the high morbidity and mortality rate in the adult population has significantly reduced production activities; 2) the prevalence of malaria in many productive parts of the country prevents the movement and settlement of people in resource-rich low-lying river valleys; on the flip side, the concentration of the population in non-malaria risk highland areas has resulted in massive environmental and ecological degradation and loss of productivity, exposing a large proportion of the country's population to repeated droughts, famine and overall abject poverty; 3) increased school absenteeism during malaria epidemics significantly reduces the learning capacity of students; 4) coping with malaria epidemics overwhelms the capacity of the Ethiopian health services and thus substantially increases public health expenditure'(8). In Ethiopia, despite the availability of effective interventions, malaria remains as one of the most important causes of maternal and child morbidity and mortality (9). At the moment, the battle against vector-borne disease has become a serious challenge, this is partly due to; insecticide resistance of vectors, drug resistance of parasites, lack of effective reliable vaccines and insecticide-treated nets (ITNs) (10). From this perspective, malaria cases which are routinely recorded provide useful information on malaria transmission and these are used by the health services to target appropriate malaria interventions and to allocate resources in a timely manner to control outbreaks of malaria epidemics (11). Therefore, health facility records are important sources of malaria data, as they are readily available and they can provide useful indicators on the situation of malaria at a lower cost. They are not only useful for planning malaria control and evaluating the impact of health services, but they can also provide valuable information for epidemiological surveillance. If properly utilized, this information will urge decision makers to act in time to intensify malaria control interventions effectively and efficiently (12).

In Ethiopia, only a few retrospective studies have been carried out to assess changes in malaria indices in Ethiopia and therefore, the present investigation becomes more significant and pertinent. Indeed, studying malaria trends is considered to be one of the most important aspects of employing effective control strategies in malaria-prone settings. In Ethiopia, primary health centers are the basic elements of the healthcare system which play a vital role in minimizing the malaria burden among the rural poor residing in remote areas of the country. Indeed, examining health facility records is one of the easiest, most cost-effective and effectual modes to assess the prevalence and trends of malaria in particular vicinity. In this context, the present retrospective study has greater relevance and significance.

2. Objectives

The outcome of this study should provide some baseline information for policy-makers and researchers to help them design more appropriate and sustainable malaria control strategies and new initiatives which better suit the local conditions in the near future.

3. Materials and Methods

3.1. Study Area

The setting is the Serbo Health Centre located in Serbo Town in the Kersa Woreda, a malaria-endemic area in Ethiopia. Kersa is one of 180 woredas in the Oromia Region of Ethiopia. (A woreda is an administrative division of Ethiopia, managed by a local government, which is equivalent to a district.) The altitude of this woreda ranges from 1740 to 2660 meters above sea level. Kersa Woredaconsists of 31 villages, which are the smallest unit of local government in Ethiopia. Kersa Woredahas an estimated total population of 329629, among whom 162690 are male and 166939 female (13). Malaria is a leading cause of morbidity and mortality in the Kersa Woreda. According to malaria stratification of the Kersa Woreda, 20 villages are at high risk of malaria transmission, three villages are at medium risk, six villages are at low risk and only two villages are free from malaria. Each village is divided into many tiny hamlets, each with 25 to 50 huts. Malaria transmission is quite unstable and usually occurs in epidemics associated with high morbidity and mortality rates. In general the males of this region move out to the cities for employment, education and other activities. However, women, children and the geriatric population remain in the villages. This results in a constant inflow and outflow of population leading to the spread of malaria in both directions. Kersa Woredahas one health center, three health stations, ten health posts and 24 villages covered by health extension workers. However, laboratory based medical treatment services are accessible only at the health center. The Serbo Health Center has four laboratory technicians to perform malaria diagnosis (14).

3.2. Study Procedures

Blood films were taken from all febrile patients presenting themselves with clinical features suggestive of malaria. Peripheral smear examination of all samples was conducted according to standard operating procedure in each health center throughout the country. In brief, before collection the finger is cleansed with an alcohol-moistened swab, dried with a piece of dry cotton and punctured with a disposable blood lancet. After wiping off the first drop of blood, thick and thin films were made on the same slide. After being air-dried in a horizontal position, the thin blood films were fixed in methanol for 30 seconds. Then the smears were stained with a 10% Giemsa solution for 20 minutes. Each slide was examined under an oil immersion microscopic objective by experienced laboratory technicians or technologists certified in malaria diagnosis and species identification by the Ethiopian Ministry of Health. The stained slides were examined under a light microscope using 100 × oil immersions by an experienced laboratory technician. One hundred fields were examined before a negative result was recorded. The thick smear was used to detect malaria parasites and parasite quantification. Then the thin smear was used to identify the Plasmodium species. Parasitemia was calculated per 200 white blood cells (WBC) assuming 8000 WBC/µl of blood (15). These microscopically confirmed malaria cases are reported monthly to the zonal health office which in turn reports to the Ethiopian Ministry of Health. Patients with positive peripheral blood smears are treated empirically for malaria. However, if the patient's did not have lab-confirmed malaria, the physician would refer the patient for diagnostic tests for other diseases excluding malaria or send them to higher referral health care facilities. However, due to the remoteness and economic constraints, many febrile cases are not even reported to the health center. These malaria cases that possibly receive treatment either from health extension workers or self-medication, and they are not included in the study, which greatly limits our investigation.

3.3. Data Extraction

In the light of data mining, monthly data between July 2003 and June 2008 were extracted by the researchers. Data on in-patient and out-patient malaria records, all-cause cases and deaths, data on laboratory confirmed out-patient malaria cases and all-cause attendances were collected. For all indicators, data were stratified into two age groups, < 5 years and > 5 years, as far as data was available. The socio-demographic data such as the sex of all study subjects were also collected from the database. The collected data were transcribed and cleaned by excluding illegible, unclear or illogical records, and completing missing data by comparing the ward-book and case records. Then the collected data were analyzed and interpreted.

3.4. Quality Control and Quality Assurance

Quality control procedures for this retrospective study included a random selection of data points with comparisons made between the paper case report form and the electronic database record of those same data. We have statistically examined the data with frequency distributions of outcome variables/endpoints to identify outliers or questionable data points that may represent data errors. In addition, the researchers observed scheduling practices, request processing, patient preparation processes, as well as results processing. These were observed from three different access points into the health center, namely; when the patient arrived as an inpatient, an outpatient, or an emergency patient. The researchers also identified key activities, materials and resources, as well as input and output parameters. To ensure accuracy, observations were conducted at different times (ie, morning, afternoon, and over an entire workday), observations were verified through staff interviews.

3.5. Statistical Analysis

Data was entered and analyzed using IBM SPSS Chicago, version 12, statistical software package. Range and mean were analysed and appropriate tables, graphs and percentage were displayed. A chi-square test was performed to determine the level of significance using 95% of confidence intervals and *P*-value.

4. Results

The five-year trend at the out-patient and in-patient departments at the Serbo Health Center for all cases and malaria cases are shown in *Table 1*, *Table 2* and *Table 3*. A total of 51610 blood smear examination were prepared, out of which 26602 were found to be positive for malaria (51.1%). However, all of the cases were treated at the Serbo Health Center. The vast majority [25903/26602 (97.3%)] of cases were treated as out-patients, with just 2.7% requiring in-hospital care and they were admitted. The highest 75.0% and lowest 26.2% of malarial cases were treated between July 2003-June 2004 and July 2007-June 2008, respectively (*Figure 1*). Overall, every year the highest prevalence was observed among males rather than females and a statistically significant association ($P = 0.0001$; $\chi2 = 212.5$; $df = 4$) was found between male cases and the incidence of malaria (*Table 1*). *Figure 1* and *Figure 2* clearly illustrate that

Table 1. Gender Numbers of Malaria Cases Treated Between July 2003 and June 2008

	Total Number of Blood Smear Examined	No. of Positive Malaria Smear, Frequency (%)	No. of Male Cases, Frequency (%)	No. of Female Cases, Frequency (%)	
2003-04	9383	7044 (75.1)	3649 (51.8)	3395 (48.2)	
2004-05	8374	3756 (44.9)	2073 (55.2)	1683 (44.8)	$\chi^2 = 212.5$
2005-06	12517	7047 (56.3)	4272 (60.6)	2775 (39.4)	$df = 4$
2006-07	9891	5746 (58.1)	3022 (52.5)	2724 (47.5)	$P = 0.0001$[a]
2007-08	11445	3009 (26.3)	1918 (63.7)	1091 (36.3)	
Total	51610	26602 (51.5)	14934 (56.1)	11668 (43.9)	

[a] $P = 0.05$ statistically significant

Table 2. Age Groups of Malaria Cases Treated Between July 2003 and June 2008

	Total Number of Blood Smears Examined	No. of Positive Malaria Smears	Number of Malaria Cases in Age Groups Frequency (%)		
			< 5 years	≥ 5 years	
2003-04	9383	7044	2817 (39.9)	4227 (60.1)	
2004-05	8374	3756	1491 (39.6)	2265 (60.4)	$\chi 2 = 851.1$
2005-06	12517	7047	1633 (23.1)	5414 (76.9)	$df = 4$
2006-07	9891	5746	1328 (23.1)	4418 (76.9)	$P = 0.0001$[a]
2007-08	11445	3009	1193 (39.6)	1816 (60.4)	
Total	51610	26602	8462 (31.8)	18140 (68.2)	

[a] $P = 0.05$ statistically significant

Table 3. Incidence of Malaria Among Pregnant Women and Children Under 5 Years in Terms of in-Patient Admission and Deaths During July 2003-June 2008

	Malaria in-Patient Admission			Death Due to Malaria Illness		
	≥ 5 years	Pregnant Women	< 5 years	≥ 5 years	Pregnant Women	< 5 years
2003-04	165	35	25	4	8	3
2004-05	39	12	4	2	1	0
2005-06	112	38	16	2	9	1
2006-07	68	5	10	2	5	0
2007-08	117	26	27	0	5	0
Total	501	116	82	10	28	4

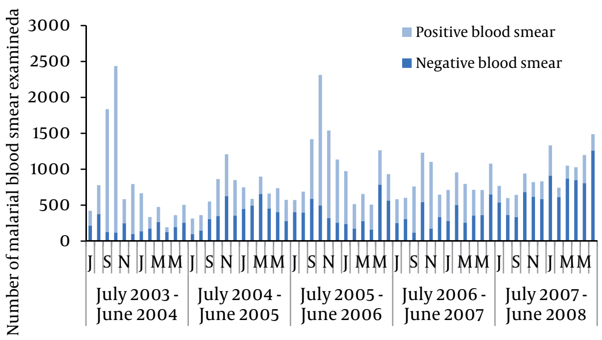

Figure 1. Monthly Numbers Proportions of Malaria Positive Slides in Outpatients at the Serbo Health Center, Ethiopia From July, 2003 to June, 2008

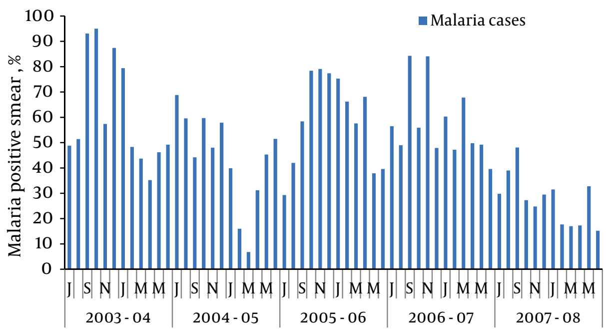

Figure 2. Monthly Percentage of Malaria Cases Treated at the Serbo Health Center, Ethiopia From July, 2003 to June, 2008

annually there was a continuous bimodal transmission episode between September-December and a short rise during May-July.

Overall, 31.8% and 68.2% of under five-year-old children and above five-year-old persons were treated for malaria at Serbo, respectively, and a statistically significant association ($P = 0.0001$; $\chi^2 = 851.1$; $df = 4$) was found between the age and incidence of malaria (*Table 2*). Among the all-female cases, 295 of who were pregnant during the study period, 61.7% (182/295) were found to be positive for malaria (*Table 3*). *Figure 3* indicates the number of positive and negative blood smear examinations among the pregnant women. Overall, 57404 blood films were checked to identify the malaria cases. Overall, only 51610 cases were treated at the Serbo Health Center, the remaining 5794 cases were referred to multispecialty hospitals for various further treatments. Two species of malaria were reported, of which *P. falciparum* constituted the majority [62.4% (16584/26602)] cases and *P. vivax* was confirmed in 37.3% (9913/26602 cases). Mixed infection with *P. falciparum* and *P. vivax* constituted 105 cases. However, during this study period, *P. ovale* and *P. malariae* were not diagnosed (*Figure 4*).

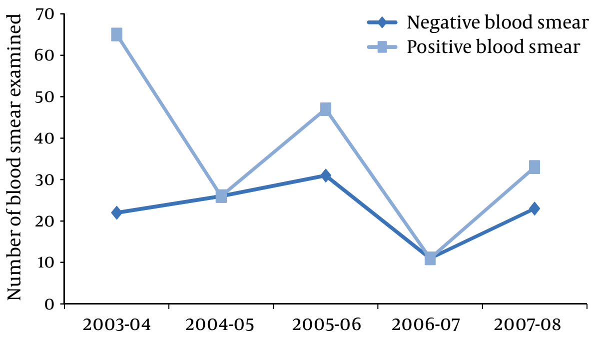

Figure 3. Number of Positive and Negative Blood Smear Examinations Among Pregnant Women at the Serbo Health Centre, Ethiopia From July, 2003 to June, 2008

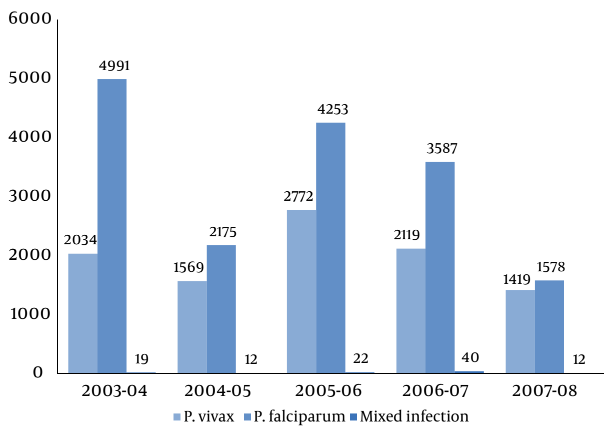

Figure 4. Distribution of Malaria by Species in the Number of Malaria Cases at the Serbo Health Center, Ethiopia From July, 2003 to June, 2008

5. Discussion

Malaria is a devastating vector-borne disease that primarily occurs in the developing world. Over two billion people are at risk of contracting malaria and in 2001 an estimated 1.2 million people died from malaria (4). African governments spend more than 1% of their gross domestic product to combat malaria and the estimated annual direct and indirect costs attributable to malaria in sub-Saharan Africa are in excess of US$12 billion (16). The highest prevalence was observed among males than females. This could be explained by the fact that males are more often in the outdoors in the early evening hours than females. The results are comparable with an earlier study, carried out by Jamaiah *et al.* (1998) (17) in Ethiopia. This can possibly be explained by the fact that in this part of the world the female population mostly stays back in the villages, thus their contact with malarial infection is minimized. During September to October, more malaria cases were reported at the Serbo Health Center and this could possibly be explained as due to the increased and prolonged wet seasons in the country. In Ethiopia, the epidemiological pattern of malaria transmission is quite seasonal and largely unstable. Previously malaria was known to occur, in areas below 2000 m, whereas now it has been documented to occur even in areas above 2400 m, such as Addis Ababa, Akaki, etc(18). In addition, malaria is generally epidemic, due to a short peak of transmission, in the months between September and December followed by summer rains with relatively low transmission levels during the dry season (January-May). This results in a low level of acquired immunity by the community (7, 19, 20). Unstable malaria occurs mainly in the highland fringes of the country where climatic conditions are conducive for transmission (21). In Ethiopia, certain areas also experience perennial malaria, as the environmental and climatological situations permit the continual breeding of vectors in permanent breeding sites.

Malaria in this country is not only a public health problem, but it is also a major obstacle for socioeconomic development, since the peak transmission season coincides with the major cultivating and harvesting seasons of the year. This severely affects the income of households and hence the economy of the country at large (14). Among a total of 51610 blood smears examined, 26602 were found to be positive. The finding of parasites in a blood smear does not necessarily mean that the patients' symptoms are due to malaria, as the presence of parasites is required to build up and maintain immunity, which is never complete. In recent years relatively accurate techniques have been developed to determine the impact of malaria within populations, and the level of parasitemia that is required in order to distinguish symptoms due to other diseases, from those responsible for malaria infections (22). However, in the present study all of the blood films were taken from febrile patients presenting themselves with clinical features suggestive of malaria.

Figure 1 and *Figure 2* clearly reveal that the pattern of malaria transmission in Serbo is quite unstable and often epidemic in nature. This is mainly due to climatic features that correlate with the Anopheles vector breeding cycles and increased transmission potential. The present study results are consistent with earlier reports, as malaria is seasonal and unstable in Ethiopia (7, 12, 20), causing frequent epidemics (7, 23-25). This is mainly due to the varying topographical and climatic features. In most parts of Ethiopia, a short transmission season followed by a long interval of very low or no transmission, results in little effective immunity acquired by the population. Unstable malaria affects children and adults in the productive age group, resulting in substantial economic loss due to compromised capacity and efficiency of the labor force (26). In addition, *Figure 1* and *Figure 2* clearly suggest a striking feature, with a radical decline in malaria cases and a large proportion of the malaria burden having been alleviated since 2006.This phenomenon could be explained by effective existing malaria prevention and control strategies such as; indoor residual spraying, free distribution of bed-nets and active malaria case management, as well as rapid healthcare infrastructure development in the catchment area. Insecticide-treated bed-nets, prompt and effective treatment of clinical cases of malaria, intermittent preventive treatment for pregnant women, and in some populations, indoor residual spraying is now being widely deployed across Africa, with increasing amounts of coverage achieved (27).

A sharp decline in malaria cases have also been observed by several researchers in many other African countries. In Eritrea, a major fall in morbidity and mortality due to malaria has been attributed to the application of indoor residual spraying together with the distribution of insecticide-treated bed-nets and strengthening of malaria case management in the community (28). A reduction in malaria on the island of Zanzibar has been produced by highly effective artemisinin-based combination therapy and this has been consolidated after an increased distribution of insecticide-treated bed-nets (29). In Kenya, the number of malaria admissions has fallen in the coastal areas(30), and the reduced risk has been attributed to an increase in the use of bed-nets as a result of social marketing and free distribution (31). Highly organized programs for indoor residual spraying have substantially reduced malaria rates in South Africa and in neighboring areas of Mozambique and Swaziland (32). *Table 3* shows the most vulnerable section of the population to malarial infection, who are children under the age of five and pregnant women. Children below five-years-of-age contributed to about 31.7% of the total confirmed malaria cases. Overall, 61.7% of pregnant women were reported to have malaria during the study period (*Figure 3*). *Table 3* and *Figure 3* confirm that pregnant women and children below five-years-of-age are extremely vulnerable to malarial infections. Malaria accounts for about 20% of mortality among children below five-years-of-age and 10% of the continent's total disease burden (33). Overall, 64.6% of in-patient's deaths were caused by malaria and pregnant women [28/42 (66.6%)] were the most affected faction. Pregnant women are particularly vulnerable to malaria; as pregnancy reduces a woman's immunity to malaria, making her more susceptible to malaria infection, increasing the risk of illness, severe anemia and death (34).

Figure 4 suggests that *P. falciparum* is the most predominant parasite contributing to about 62.4% of malaria cases followed by *P. vivax* (37.3%). This is comparable with earlier reports that infection with *P. falciparum* > 60% and P. vivax about 40% have been consistently observed in many parts of the country (7, 9, 13, 20). Other earlier studies have also documented the predominance of *P. falciparum* species in many places of Ethiopia (24, 35).The present study result is consistent with one other study which was carried out in the same study area revealing that the two most important causes of malaria are *P. falciparum* and *P. vivax*, comprising 51.5% and 32.3% of cases, respectively (12, 13). It is interesting to note that the dominant malaria in Africa is caused by P. falciparum, accounting for nearly 100% of malaria cases in most of the sub-Saharan countries. This phenomenon is currently explained by the lack of Duffy receptors on the erythrocytes of AfricanBantu races, which makes them resistant to infection by *P. vivax*, the most common species in the rest of the world (36). Ethiopia is an exception in this respect, since it is a meeting place between Semitic and African races, where 25-35% of malaria cases in Ethiopia are due to *P. vivax* (20, 37).

Malaria is one of the major obstacles to socio-economic development in the country as the main transmission periods coincide with peak agricultural and harvesting periods (14). The present study results demonstrate that the highest numbers of *P. falciparum* cases (70.8%) were treated during July 2003-June 2004. There was a major epidemic in Ethiopia during 2003-2004 and the high numbers of *P. falciparum* cases were attributed to the virulent and severe nature of the epidemic. The malaria epidemic was confirmed locally by a sharp increase in *P. falciparum* positive results among children treated in the Médecins Sans Frontières feeding centers (38). Poor knowledge about malaria was a significant factor for the number of deaths from this disease among the Sudanese population (39). Thus, there is an urgent call for updated information on key socio-cultural, socio-economic indicators and understanding about malaria to effectively implement appropriate control strategies (40). The devastating nature of malaria in sub-Saharan Africa, particularly in a country like Ethiopia, is indubitably distressing(41).

Vector control remains a corner stone in malaria control campaigns due to a lack of reliable vaccine (42). However, decisions on which vector control intervention to select should be made on the basis of an integrated vector management approach (43). In almost all malaria-endemic areas, ITNs, in particular Long Lasting Insecticide Nets (LLINs) are the priority intervention for Roll Back Malaria (RBM) in the short- to medium-term. ITNs offer proven efficacy and can reach all target groups, even where infrastructure is minimal. Where epidemiologically and logistically appropriate, other vector control methods, alone or in combination - in particular IRS with recommended insecticides, for example DDT - are promoted (44, 45).Besides, the presence of a lag-time between peak malaria transmission and seasonal rainfall events is very important for forecasting malaria outbreak using observed weather data. However, the magnitude of the lag-time appears to depend on the season and location. This requires a site and season specific formulation of the relationship between weather variables and malaria transmission rates. Based on such relationships, an operational malaria outbreak forecast model could be produced in advance for a given area whose specific lag time may vary from a few weeks to months according to the region and season (46).Chemotherapy of life-threatening malaria with chloroquine and quinine has been countered by the emergence of resistant strains and currently artemisinin (ART) derivatives have become the treatment of choice. However, the accessibility and affordability of ART is a matter of great concern. In this context, vector control is one of the most powerful weapons in the process of managing vector populations to reduce/interrupt the transmission of malaria. At present, malaria control relies heavily on a limited arsenal; artemisinin derivatives and pyrethroids. Vector control relies chiefly on frontline interventions such as the regular deployment of ITNs and indoor residual spraying in order to reduce the malaria morbidity and mortality in resource-poor settings. However, these could also become ineffective, owing to the development of resistance. From this perspective, innovative user-friendly and environment-friendly alternatives to conventional vector control are inevitable going to be required (42).

5. Conclusions

Despite several decades of control efforts, malaria still remains the leading cause of morbidity and mortality in Ethiopia. At the moment, *P. falciparum* resistance strains and insecticide resistance, and unaffordable effective anti-malarias have contributed to the resurgence and emergence of malaria. The present analysis clearly reveals that malaria transmission is largely seasonal, unstable and quite epidemic in nature and may lead to further vulnerability in susceptible populations. Therefore, the following malaria interventions must be employed in order to minimize the malaria burden in this vicinity in the near future:

- Consistent administration of effective integrated malaria control strategies
- Urgent need to maintain rigorous monitoring of disease surveillance data, both nationally and regionally
- Selective implementation of vector controls as a tool to reduce/interrupt disease transmission
- Induction of active health education campaigns by means of electronic and printed media
- Malaria epidemic prevention and control through residual house spraying to minimize the vector population as well as their lifespan and active case management to reduce the parasite load
- Raising awareness on the importance of consistent and regular deployment of ITNs and other personal protection measures
- Allocating adequate funds for malaria control and health systems for early diagnosis and treatment could be an appropriate approach to minimize the unbearable burden of malaria

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Authors' Contribution

KK and MB, conceived, designed, and performed the retrospective analysis. MB performed data collection and KK analyzed and interpreted the data. Both KK and MB were responsible for writing and editing of the relevant methods, results and discussion sections of the manuscript.

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