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Original Research

Ten Years Trend Analysis of Malaria Prevalence and its Correlation with Climatic Variables in Sibu Sire District, East Wollega Zone, Oromia Regional state, Western Ethiopia: A Retrospective Study

Temesgen Gemechu[1], Abdi Samuel[2*] and Delensaw Yewhalaw[1]

[1]Department of Biology, College of Natural Sciences, Jimma University, PO Box: 378, Jimma, Ethiopia

[2]Department of Medical Laboratory Sciences, College of Medical and Health Sciences, Wollega University, PO Box: 395, Nekemte, Ethiopia

Abstract

Malaria is one of the most devastating diseases in the World and caused by a protozoan parasite of the genus Plasmodium. The disease remains one of the most important causes of human morbidity and mortality with enormous medical, economic and emotional impact in the world, and in most African countries including Ethiopia. The complexity of the disease control process, expensiveness of the control program, resistance of the parasite to anti-malarial drugs and vectors to insecticides are some of the challenges. The aim of the study was to assess the ten years trend analysis of malaria prevalence and its association with climatic variables in the Sibu Sire district, Western Ethiopia. Ten years (2004-2013) malaria clinical and epidemiological data were collected from health facilities and climatic variables data from Ethiopian Meteorological agency. The data were analyzed using SPSS software package 16.0. Pearson's correlation analysis was conducted to see the correlation between plasmodium species and climatic variables. Within the last decade (2004–2013) a total of 30,070 blood films were examined for malaria in Sire health center and of this 6036 (20.07%) microscopically confirmed malaria cases were reported in the health center and *P. falciparum* becoming a predominant species. The result showed that maximum temperature, mean temperature and average relative humidity showed significant association with malaria ($P<0.01$).But minimum temperature ($P=0.094$) and rainfall ($P=0.729$), were not significant. In addition, regression analysis suggested that minimum temperature, rainfall, and average relative humidity ($P<0.001$) were statistically significant but the mean temperature ($P=0.706$) was insignificant. In conclusion the trend of malaria in the study area had a reducing but a fluctuating pattern and some of the metrological variables such as minimum temperature, rainfall, and average relative humidity were statistically significant.

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***Corresponding Author:**
Abdi Samuel

E-mail:
siinanabdii2010@gmail.com

INTRODUCTION

Malaria is one of the most devastating diseases in the World. There are ninety seven countries and territories with ongoing malaria transmission, and seven countries in the prevention of reintroduction phase, making a total of 104 countries and territories in which malaria is presently considered endemic. Globally, an estimated 3.4 billion people are at risk of malaria. WHO estimates that 207 million cases of malaria occurred globally in 2012 (WHO, 2013). The disease remains one of the most important causes of human morbidity and mortality with enormous medical, economic and emotional impact in the world (WHO, 2011), with2-3million deaths occurring each year (Snow *et al*., 2005). It is the leading cause of death in children under the age of 5 years and pregnant women in developing countries (Martens, 2000; Lagerberg, 2008).

It is estimated that 68% of the population lives in malarious areas and three quarters of the total land mass is regarded as malarious (MoH, 2008). *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 (MoH, 2002).

Malaria transmission in Ethiopia is seasonal and unstable, depending mostly on altitude and rainfall (Deressa *et al*., 2003). The two main seasons for transmission of malaria in Ethiopia are September to November, sometimes extended to December after heavy summer rains, and March to May, after the light rainy shower. Malaria epidemics are relatively frequent involving highland or highland fringe areas, mainly areas 1,000–2,000 meters above sea level, in which the population lacks immunity to malaria (Endeshaw *et al*., 2008). Meteorological factors have been considered as important drivers of malaria transmission by affecting both malaria parasites and vectors directly or indirectly

(Pemola and Jauhari, 2013). Besides this, other factors, such as any change in land use patterns and construction of water control could have considerable effects on malaria transmission (FMOH, 2007).

Changes in temperature, rainfall, and relative humidity due to climate change are expected to influence malaria directly by modifying the behavior and geographical distribution of malaria vectors and by changing the length of the life cycle of the parasite. Climate change is also expected to affect malaria indirectly by changing ecological relationships that are important to the organisms involved in malaria transmission (the vector, parasite, and host) (Abebe *et al*., 2011). Because of those challenges malaria is one of the main public health problems in the study area. Therefore, this study is initiated to analysis the ten years trend of malaria prevalence and to determine any patterns of correlation existing between meteorological factors and malaria over the last decade in the study area.

MATERIALS AND METHODS

Study Area and Period

The study was conducted in Sibu Sire district, East Wollega Zone of Oromia Regional State, Western Ethiopia from 2004-2013. It is one of the districts in east Wollega Zone and is located 281Km in West from Addis Ababa and 50km East from Nekemte, the administration town of East Wollega Zone. This district is bordered in the East by Gobu Seyo, in the West by WayuTuka, in South by Wama Hagalo and Billo Boshe and on the North by Gudeya Bila and Guto Gida. This district has 22 kebeles from these 19 kebeles are rural and 3 municipals. The study area has a total population of 124,304 and from these urban dwellers male6744 and female 6954, rural dwellers male 54,920 female 55,686.Sibu sire district has an estimated population density of 27.8 people per square kilometer (SSDA, 2013).

Topography and Climate

The altitude of the district ranges between 1360masl to 2500masl.There is three agro-ecological zones represented in this district. The majority (74.3%) of the district is classified as mid-land with lowland (18.27%) and only 7.53% is considered as highland. The minimum, maximum and mean temperature of this area was 14.09 ºc, 27.30 ºc, and 22.55 ºc, respectively. The highest temperature occurs in February and March. The lowest temperature occurs in July and august. The annual average rainfall of the district is 1295mm (RLEPOSSD, 2013).

Study Design and Population

A retrospective study was employed to collect malaria epidemiological data from district health services to determine the ten year trend prevalence of malaria by reviewing blood film malaria record from Sire health center and metrological variables were collected from National Meteorology Agency.

In the study area peripheral smear examination of Giemsa stained blood film is used as the gold standard in confirming the presence of the malaria parasite as per the WHO protocol. The study participants were all individuals diagnosed for malaria using giemsa stained preparation and the data registered on laboratory registration book during the study period (2004 -2013).

Data Processing and Analysis

The data were analyzed using SPSS version 16.0 software package. Descriptive statistics was employed to present overall malaria prevalence, age and sex specific malaria, correlation with climatic variables. Average yearly mean temperature, total rainfall and relative humidity (January through December for each year) were calculated. All data from meteorological and clinical records were checked for completeness and cleaned of any inconsistencies. To observe the correlation between meteorological variables and malaria cases, the monthly malaria cases were regarded as the dependent variables, while meteorological variables such as monthly maximum, minimum and mean temperature, total monthly rainfall and monthly relative humidity were independent variables. Pearson's correlation analysis was conducted to examine the type and strength of relationship between meteorological variables and malaria. Then to observe independent effect of each independent variable on outcome, variable linear regression was fitted. Since there might be auto-correlation among independent variables over time, autocorrelation analysis was conducted.

Ethical Considerations

Ethical clearance was obtained from Jimma University College of Natural Science and written consent was sought from the head of Sire district health office to undertake the study. Individual information was kept confidential and the names of individuals were removed from the data taken from health center and identified only by identification numbers and the results were communicated in an aggregated manner.

RESULTS

During the study period (2004–2013) a total of 30,070 blood films were requested for malaria diagnosis in Sire health center and 6036 (20.07%) microscopically confirmed malaria cases were reported in the district with mean malaria cases of 603.6. A minimum (1.6%)number of microscopically confirmed malaria cases being reported in 2008 and the maximum (31.2%) microscopically confirmed cases of malaria being reported in 2004.The prevalence of malaria varies between sex and among place of residence, age ,month, season and year. In addition, the types of plasmodium species and the drug used within these years also varied.

The result of the study showed that malaria prevalence was higher in males than females. From the infected patients (53.6%) were male and (46.4%) were female but the difference was not statistically significant ($p=0.998$) According to the data review in the last ten years in the study area for the Prevalence of malaria parasites in relation to residence area in Sibu Sire district people who live in rural areas were more affected by malaria than those who live in urban areas. The infection rates among rural people were (69.3%) and urban people were (30.7%). There was no significant difference ($p=0.436$) between rural and urban residences.

Malaria case was reported in all age groups in the area but the age group between 15-44 years was more affected, with a prevalence rate of (48.1%), followed by 5 -14 years old and 1-4 years old with the prevalence rate (28.2%) and (15.4%), respectively. On the other hand, children below 1years old and above 64 years old were less affected with prevalence rate of 2.3% and 1%, respectively. But the difference was statistically not significant (p=0.712).

Malaria was reported in all years in the study area but in 2004, the prevalence rate was high (31.2%), followed by 2010, 2005 with the prevalence rate (13.7%) and (13%), respectively. Similarly, the prevalence rate of malaria in 2012, 2013 and 2009 was (9.8%), (9.7%) and (9.3%), respectively. But the rest years less number of malaria prevalence was reported. When we observe figure 1 the *P. falciparum* highly decreased from2004 up to 2008 and again rise starting2009 in 2010 remarkably increase and in 2011 become below the prevalence of *P.vivax*. In contrast to these in 2011 *P. vivax* prevalence was elevated a little above *P. falciparum* in the study area. The prevalence of mixed infection (*P. falciparum and P. vivax*) remained almost the same from 2004 up to 2013(figure 1).

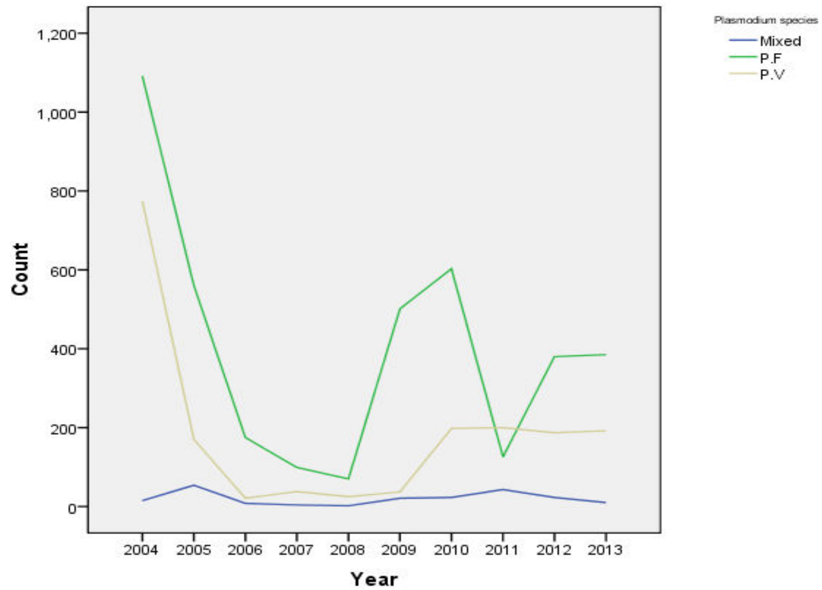

Figure 1: Trend of malaria prevalence with Plasmodium species and year in Sire health center, 2004 - 2013.

Despite the apparent fluctuation of malaria trends in the study area; malaria cases occurred in almost every season of the years. The highest peak of malaria cases in almost all years was observed during the wet season, with prevalence rate of (68.36%) and the dry season with prevalence rate of (31.64%), which was statistically significant (P=0.001).

Malaria occurred in all months of the year with different fluctuation rate. The highest peak is in June with prevalence rate 18.9%, followed by May, November, and July with prevalence rate 13.3%, 13.2%, and 11.2%, respectively. The prevalence rate in October, August, and September were 9.4%, 8.7%, and 7%, respectively. On other hand, the spread of malaria in December, January, February and March were low when compared with other months with prevalence rate of 4.2%, 4.2%, 4% and 2.9%respectively. Although a seemingly uniform monthly health center record, having higher values were recorded in Sibu Sire district starting from May up to November.

Figure 2 below showed that there was fluctuated trend of *P.falciparum and P.vivax* throughout the year in different months. The peak malaria cases were seen in June, May, and November months with high *P.falciparum* and then *P.vivax* respectively. In contrast, the less malaria cases were confirmed in March, April, February, December, and January months respectively. Almost the mixed cases less fluctuate through each month.

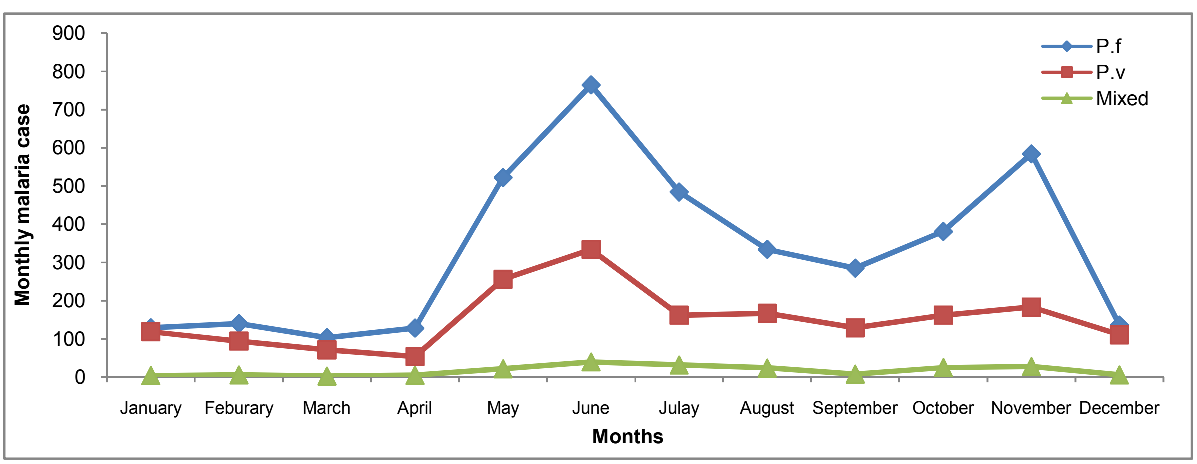

Figure 2: Trend of malaria prevalence with Plasmodium species and month in Sire health center, 2004 – 2013

Regarding the identified plasmodium species, both species of *plasmodium* were reported in each year with *P. falciparium* being the predominant species in the study area. *P. vivax* accounted for 66.1% and 30.5% of malaria cases, respectively and the mixed (both *P.falciparum* and *P.vivax*) accounted 3.4%. In the year 2011 *P. falciparum* was decreasing while *P. vivax* was increasing, which showed that there was a trend shift from *P. falciparum* to *P. vivax* in the study area.

Of the cases diagnosed for malaria from different kebeles the highest (23.7%) malaria confirmed cases were from Jarso Wama kebeles, followed by Sire-02 kebele(16.9%), Sire-01 kebele(13.9%%), Bikila kebele(13.2%) and Lalisa(9.4%). Figure 3 below showed the fluctuating trends of malaria in the study area.

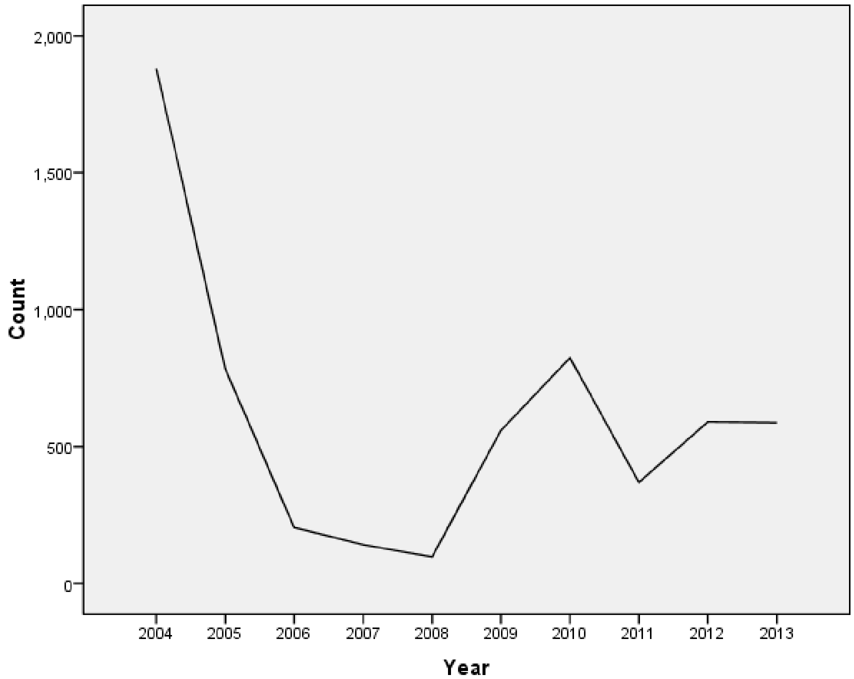

Figure 3: Annual trends in total malaria cases in Sire Health Center, 2004 – 2013

Correlation between Malaria and Meteorological Variable

The study area is generally characterized by moderate climate with a mean annual maximum and minimum temperature 27.3^{0}c and 14.09^{0}c. The annual rainfall ranged from 650mm to 2590mm.The annual mean relative humidity 68.66% from 2004 to2013 in study area.

In general, the relationship between malaria cases and meteorological variables were checked by using mean and standard deviation and also further checked by Pearson's correlation and linear regression analyses (table 1).

Depending on climate variable in 2004 the mean minimum temperature higher than the mean minimum temperature in2008 and also average relative humidity of 2004was greater than the average relative humidity in 2008. Moreover, the annual mean temperature of the study area from 2004 to 2013 was showed that low temperature (18.67^{o}c) in 2011 and high temperature (26.87^{o}c) in 2004. A high fluctuating trend in temperature was observed during the study period. The condition of rain fall in the study area in the past ten years (2004-2013) indicated that minimum rainfall 650mm, maximum rain fall 2590mm and mean annual rainfall 490mm. However, a high fluctuating trend of rainfall was recorded through the years of 2004 to 2013.

Pearson's correlation analysis was employed to assess the correlation between malaria and climatic variables (temperature, rainfall, and relative humidity). It showed that maximum temperature (P=0.007), mean temperature (P=0.001) and average relative humidity (P=0.001) showed significant correlation with malaria. But annual mean minimum temperature (P=0.094) and annual rainfall (P=0.729) were not statistically significant.

Table 1: Mean and Standard deviation of different species of Plasmodium with climate variable

Plasmodium species	Mean temp. Mean(±SD)	Minimum temp. Mean(±SD)	Maximum temp. Mean(±SD)	Rain fall Mean(±SD)	Relative humidity Mean(±SD)
Mixed	19.98±3.82	13.7±3.4	25.38±5.54	7.42±7.28	67.7±15.78
P.F	22.33±3.26	14.08±1.38	27.45±2.88	4.79±3.93	69.39±16.03
P.V	23.35±4.35	14.19±2.33	27.19±3.86	4.84±5.06	67.24±16.59
Total	22.54±3.69	14.09±1.79	27.3±3.34	4.90±4.47	68.66±16.22
P-value	0.001	0.004	0.001	0.001	0.001

Key- SD-Standard deviation

The malaria cases were positively correlated (+0.028) with annual minimum temperature, (+0.128) with annual average mean temperature, and (+0.005) annual total rainfall. The negative correlation of malaria cases were observed (-0.037) with annual average maximum temperature and (-0.062) with annual average relative humidity.

DISCUSSION

The result of this study revealed that during the last ten years, a fluctuating trend of occurrence of malaria cases was observed in SibuSire district almost similar to the study conducted in Kola Diba health center, North Gonder by (Abebe *et al*., 2012) and also the study done in Butajira by(Tesfaye *et al*., 2012). An increase in malaria cases occurrence with peak cases occurring in 2004 was similar with the thesis conducted in Mvomero, by (Xiaochen, 2013), and malaria cases were reduced the following three consecutive years (2006-2008) but a remarkable increase in 2010 was observed. Except for the year 2011, the remarkable increment of total malaria cases was mainly due to an increase of *P.falciparum* with little increase of *P.vivax*. But for 2011 total malaria cases, *P.vivax* contributed more than *P.falciparum* the same to the study done by (Abebe *et al*., 2012) in Kola Diba health center and also Similarly the study conducted around Gilgel Gibe show that in 2008 and 2010 when the *P. vivax* prevalence was elevated a little above *P. falciparum (*Sena,2014). Resistance of *P.vivax* to the commonly used drug (chloroquine) during these years may have contributed to total malaria case occurrence (WHO, 2003; MoH, 2004; Jima, 2005).

A decrease in malaria cases occurrence after the 2004 maximum occurrence was observed. The increased attention to malaria control and preventive activities by different responsible bodies, increased awareness of the community on use of ITNs and other malaria control activities, increased accessibility of ITNs to community, increment of budget for malaria control and prevention activities might contributed the decrement in malaria case occurrence in addition to meteorological factors (Abebe *et al*., 2011; Abebe *et al.,* 2012).

In this study, males were more affected than females. Because they stay outdoors to keep agricultural products at night when mosquito becomes active to find food (meal).The results were comparable with an earlier study, carried out by. (Jamaiah *et al*., 1998; Karunamoorthi and Bekele, 2009; Abebe *et al*., 2012; Getachew *et al*., 2013).The female population mostly stays back in the house, thus their contact with malaria infection is minimized. Malaria prevalence was more series in rural than urban because rural communities they do not use bed net appropriately. In addition their houses are full of cracks and holes so mosquito can easily enter it. The number of kebeles in the rural area is 19 and there is only 3 urban kebeles in the district. This has contributed to the increment of the number. This study had also showed similar result to the study done by (Abebe *et al*., 2011) in Jimma town, South-West Ethiopia.

The age group 15-44 years was more affected with malaria. This could be attributed to the fact that people in this age group stay outside till late evening for work as they are in productive age. This is consistent with a the study conducted by Abebe *et al*. (2012) in Kola Diba, North Gonder, and North West Ethiopia was obtained the same result.

Malaria occurred in almost every season of the year. The highest peak of malaria observed in summer. So the season before the dry season has rain and temperature that enough for Sporogonic cycles reproduction of Anopheles mosquitoes. A study by Jason (2007) in Democratic People's Republic of Korea has similar results in that the summer season has highest malaria incidence. The district have high irrigation farming in the Autumn Season these condition may be increase the number of malaria transmitting mosquitoes. The same result can be found in China and India Country (Peng *et al*., 2003; Pemola, 2006; Srinivasulu, 2013).

The study also showed that the highest peak of malaria infection was occurred in June with high occurrence of malaria which could be due to the fact that June is the starting time for Summer season and May the last month in autumn season was suitable condition for malaria disease increment that is the amount of temperature and rain enough for the reproduction of mosquitoes and *Plasmodium species* (Peng *et al*., 2003; Pemola, 2006).

P. falciparum was the predominant species followed by *P. vivax* in the study area and the prevalence rate accounted for 3991(66.1%) and1842 (30.5%) respectively. The study conducted in Sarbo, Kola Diba, Butajira health center and Metema Hospital by (Abebe *et al*., 2012; Karunamoorthi and Bekele, 2012; Solomon *et al*., 2012; Getachew *et al*., 2013) almost similar to these results. Other earlier studies have also documented the predominance of *P. falciparum* species in many places of Ethiopia.

The major climatic factors that have an impact on malaria transmission due to spatio-temporal changes in malaria vectors are temperature, relative humidity (RH) and precipitation (Pampana, 1969). Increasing atmospheric temperature causes decrease in the duration of the gonotrophic cycle as well as the extrinsic incubation period, leading to increased biting frequency, and therefore, increased rate of malaria transmission (Molineaux, 1988).

Unlike some diseases, which flourish under one particular set of environmental conditions, the environmental factors that contribute to the transmission of malaria vary greatly from one ecological zone to another. Of all of these, the two most important ones are temperature and humidity. Organisms cease to develop in the mosquito when the temperature falls below 16°C. At 20°-30°C, the parasites develop optimally in the vector. High humidity prolongs the life of the vector and transmission is extended under these conditions. In the human host, the parasite must function at 37°C or higher, since the infection induces a significant rise in core temperature during the height of the infection (Githeko, 2008; Anon, 2012).

Temperature rise is expected to increase transmission and prevalence of malaria by reducing the interval between mosquito blood meals, thus decreasing the time to produce new generations and by shortening the incubation period of the parasite in the mosquitoes. Sporogonic cycles take about 9 to 10 days at temperatures of 28°C but higher than 30°c and below 16°C have negative impact on parasite development (Craig, 1999). Also the minimum temperature for *P. falciparum* and *P.vivax* parasite development approximates to 18°C and 15°C, respectively and the daily survival of the vector is dependent on temperature as well. At temperatures between 16°C and 36°C, the daily survival is about 90%. The highest proportion of vectors surviving the incubation period is observed at temperatures between 28° - 32°C. So, temperature of 20°C to 30°C and relative humidity greater than 60% are optimal for Anopheles survive long enough to acquire and transmit the parasite (Craig, 1999).

Rainfall plays an important role in malaria epidemiology because water not only provides the medium for the aquatic stages of the mosquito's life but also increases the relative humidity and thereby the longevity of the adult mosquitoes (McMichael and Martens, 1995). The impact of rainfall on the transmission of malaria is very complicated, varying with the circumstances of a particular geographic region and depending on the local habits of mosquitoes. Rains may prove beneficial to mosquito breeding if it is moderate, but may destroy breeding sites and flush out the mosquito larvae when it is excessive (McMichael and Martens, 1995).

The annual total rainfall was positively correlated that determines malaria transmission in the study area next to mean temperature and minimum temperature. Rainfall plays an important role in malaria epidemiology because water not only provides the medium for the aquatic stage of the mosquitoes' life cycle but also increases the relative humidity and then the longevity of the adult mosquitoes (McMichael and Martens, 1995).

Both the correlation and regression analyses suggests that temperature, rainfall and relative humidity act on yearly malaria case. Although all meteorological variables were less likely to predicts the occurrence of malaria in Sibu Sire district. This finding contradicts the findings in Dehradun, Uttaranchal, India (Anthony and McMichael, 2000), Shuchen County, China (Donald and Pend, 2000), Rwanda (Loevinsohn, 1994), Madagascar (Bouma, 2003), and east Africa Highlands (Rogers, 2000) which concluded that meteorological variables were highly likely correlated with malaria occurrence and the prediction was higher than this finding with higher R square value. This variation might be due to the fact that this study was conducted in lowlands in which malaria is endemic. In lowlands, the factors that contribute to malaria transmission dynamics are microclimate variation due to anthropogenic effects and other non- climatic factors like, health system, population growth, population movement and others (Gebere-Mariam, 1984; Abeku *et al*., 2004).

In general, there was a fluctuation in malaria prevalence during the last ten years. Many factors might be responsible for seasonal changes, like climatic variables, ecologic and environmental factors, host and vector characteristics, and social and economic determinants such as change in health care infrastructure. Social, biological and economic factors such as mosquito control measures, population immunity, local ecological environment, governmental policy, availability of health facilitates and drug resistance also has an impact on malaria prevalence. Although there were different malaria control activities in each year, such as indoor residual spraying, environmental management, health education about malaria, distribution of LLINs and anti-malarial drugs and other activities to decrease mortality and morbidity of malaria, the prevalence is still sustained.

CONCLUSIONS

The study showed a decrease but fluctuating trend in the last ten years (2004 – 2013). When compared with the previous prevalence of malaria currently there is a big difference that means malaria prevalence is highly reducing. Metrological variables such as maximum temperature mean temperature and average relative humidity showed significant correlation with malaria transmission. But malaria is still a major public health problem and deadly that needs sustainable intervention on variables such as keeping the ecology.

Conflict of Interest

Conflict of Interest none declared.

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