

Impact of Climate Change on spread of Malaria in Vihiga County, Kenya

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Abstract: Malaria claims thousands of lives in Kenya is the third leading cause of mortality in the country. The country is divided into four major malaria region. Vihiga County is an endemic malaria region. The county is found along the equator that registers high temperatures and with many rivers that form vast wetlands providing an ambient environment for mosquitos breeding and maturity. However, the impact of changing climate to increasing malaria prevalence in the region has received little attention. Mosquitos are temperature sensitive, and high temperatures accelerate their breeding. The purpose of this study was to link the changes in climate trends to increased malaria prevalence in the region. Primary and secondary methods were used in data collection. The questionnaires, interviews, content analysis and focused group discussion (FGD). The officers in charge of health centers, nurses, doctors and household heads were used were involved to provide information using either of primary methods above. Content data analysis method was used to source information from the hospital registers (DHIS) District Hospital System, on the total number of patients treated for malaria for the past five years. Other valuable works of literature from the hospitals and the regions health department were used to find out the effects of malaria on the population. Meteorological data from Kakamega Metrological Station were used to evaluate rainfall and temperature trends in the region for the last fifty three years. Purposive sampling was used in the selection of the households and health centers due to the vast area and also to target the household heads in the area. The study used both qualitative and quantitative methods to analyze the data. Qualitative methods were used to analyze the responses from the questionnaires, interviews and focused group discussions while the quantitative methods, Microsoft Excel and SSP were used to analyse statistical data from the survey on malaria prevalence, DHIS data from hospital and climatic data from the metrological station. From the above data, the results revealed that temperature is increasing (0.04°C per annum) while rainfall amounts have dropped (150mm) for the past fifty three years in the region. The increasing temperatures provide ambient environment as it accelerates the mosquitoes maturity rates consequently leading to high malaria incidences in the region where rivers provide breeding grounds. The study concluded that temperature and rainfall changes in the region had an impact on the spread of malaria. From the study, it was recommended that the county government should work with international bodies like World Bank to enforce policies on land use and safe energy to mitigate the impacts of climate change. The county government to work with the national government in the war against malaria by implementing the policies of making Kenya a malaria-free country. However, further studies need to be conducted in the area of malaria immunization to find out how climate change will have on mosquito mutation to the drugs after vaccination.

Key words: Malaria, climate change, vector borne disease

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I. Introduction

The impact of climate change on human health globally is high. However, there is little documented information on how climate change affects the spread of malaria especially in East Africa. Temperature affects vectors life-cycle that significantly influences the spread of vector-borne diseases, malaria being one of them (Oliver & Brooke, 2017). Mosquitoes that spread malaria are sensitive to external changes in temperature as they do not have their internal thermodynamic system of temperature regulation. In the past, these changes in temperature and rainfall were not considered to be essential factors that contribute to the spread of malaria, however lately much interest has risen in the same (Okuneye & Gumel, 2016). Migration of people from low regions to the high land area and inadaptability of individuals to malaria disease due to the inability to develop immune resistance to the disease especially in children under the age of five years; were considered to be the main reasons that led to the spread of malaria (Omondi *et al.*, 2017).

The researchers have recently come up with various models that tend to incorporate climate change especially temperature and spread of malaria (Wang & Zhao, 2017). The use of the thermodynamic malaria development model demonstrates how temperature fluctuation can substantially alter the incubation period of the parasite and hence malaria transmission rates. In general, temperature variation may reduce or increase

malaria prevalence (Sigh, Yadav, Saraswat & Dhiman, 2016). Diurnal temperature fluctuation around the mean of <21°C slows parasite development compared with a constant temperature that tends to change between 21°C and 31°C which speeds development cycle of the mosquitoes (Oliver & Brooke, 2017). The higher temperatures and changes in rainfall trends observed in the country over the past couple of decades are broadly consistent with the changes in climate projected to occur in the country due to global climate change (Singh, 2010).

Regionally, analysis by the Intergovernmental Panel on Climate Change (IPCC, 2001) using the global circulation models, is a project that explain Eastern African will likely become wetter, particularly during rainy seasons (Ebi, Kovats & Menne, 2006). These models also anticipate rainfall patterns becoming less uniform over time, with possible increases in sporadic and intense precipitation. By the end of the century, the number of extreme wet seasons may increase by 5 to 20 percent (Kjellstrom *et al.*, 2016).

Kenya is expected to experience higher temperatures year round, though uncertainty remains regarding how much warming will occur. In the medium term, projections suggest that annual temperature in Kenya will rise by 1.0°C to 3.5°C by 2046 to 2065 (SEI, 2009). There are studies that project a less dramatic increase in temperature in the medium term; an increase of 1.0°C to 2.8°C by the 2060s and by 1.3°C to 4.5°C by the 2090s, which will manifest through increased frequency of hot days and nights. This is likely to be a scenario expected to be witnessed across the country hence an anticipated increase in malaria rates (Hay, Omundo, Craig & Snow, 2000).

The table 1 shows the impact of temperature on the duration of sporogony, on the survival of the vector cohort survival after the required period for sporogony at different temperatures and on larval duration (Okuneye & Gumel, 2017).

Table 1: The effect of temperature Sporogenic Development of Mosquito

T(°C)	Duration of sporogony (days)	Daily vector survival(%)	Vector survival after period required for sporogony (%)	Larval development (days)
16	-	89.3	0	47
17	111	89.7	0.001	37
18	56	90	0.28	31
20	28	90.3	5.9	23
22	19	90.4	15	18
30	7.9	88.1	37	10
35	5.8	80.8	29	7.9
39	4.8	38.9	1.1	6.7
40	4.6	0	0	6.5

Source: Jon Cox (19) pg10

The spread of malaria is seasonal and limited to the warm and rainy months in Vihiga County. However, the changing climate conditions such as the persistence of warm and rainy days for more of the year can increase the incidence of malaria events in the area (Craig *et al.*, 2004).

The impact of precipitation and temperature points out that “warm conditions allows both the *Anopheles gambiae* mosquito and the malaria parasite it carries to develop more quickly” and “wet conditions increase mosquito life expectancy and provide breeding habitats” Rainfall generally increases vector populations by creating new breeding sites for mosquitoes in stagnant water (Siraj *et al.*, 2015). With these type of projected climate changes in temperatures and rainfall, there is a prediction of an increase in malaria transmission. Malaria is one of global killing disease with one million people dying per year. African is one of the most hit in malaria prevalence due to lack of preparedness and misuse of funds allocated for prevention and malaria treatment according to World Health Organisation report (WHO). Countries in the sub-Saharan region are the most affected because of high temperature and rainfall that facilitates the breeding of mosquitoes (Cairns *et al.*, 2015). High temperatures reduces incubation period of mosquitoes larva to a few days unlike when the temperatures are low while high rainfall experienced in the area provides breeding grounds for the mosquitoes. This explains why the region registers high malaria prevalence in the region.

In Kenya, malaria is ranked the second leading killer even though the disease deaths have halved from about 30,000 in 2012 to 16,000 in 2016 (Amboko *et al.*, 2016). The malaria prevalence has declined in the country with has highest drop in the Lake region from 38% in 2009 to 27% in 2014 (Idris *et al.*, 2016). Malaria claims thousands of lives annually, with population found in the lower regions being mostly affected than those at a high-level in the country (Omondi *et al.*, 2016). The most hit area is the Coastal, Nyanza and Western regions (Githinji *et al.*, 2016). Even though the current studies show the burden is decreasing in Kenya’s endemic areas, malaria is expanding in the low-transmission zones of highland areas, and the size of the outbreak is increasing (Otieno, Koske & Mutiso., 2016). The Kenyan highlands (1500m and above) were

malaria free before the 1910s, and have been compared with the western lowlands, where malaria has been endemic for generations (Zhiyong *et al.*, 2016). This new emergence of malaria prevalence in the highland region and increasing in the low region remain to be an area of research.

Vihiga County is found within the modified equatorial climate of the Lake Victoria basin region of Kenya. The region has been classified as malaria endemic region. This is based on high rainfall and high temperature received across the year (Shuford *et al.*, 2016). This condition favors breeding of mosquitos and quick maturity leading to high malaria prevalence in the area. However, the recent studies carried out by the various researcher, have revealed declining rainfall amounts, changing rainfall patterns and with increasing temperature in western Kenya (Amegah, Rezza&Jaakkola, 2016). These changes in climate trends are likely to have a great impact on the mosquitos' life-cycle which will directly impact on the level of malaria prevalence in the area especially on children under the age of five. This is because mosquitoes are temperature sensitive with high temperature favoring their breeding unlike low temperature (Garke, Ferguson & Ghani, 2013).

This study therefore aimed at filling the gap that currently exists that links the changes in climate that's, rainfall and temperatures to malaria. Previous research in the area by different researchers(Zhou *et al.*, 2012)have focused on several other factors surrounding malaria among them being the social and economic factors and how they contribute to malaria prevalence in the region. For example, in his study, Wanja *et al.* (2016), focused on the entire western region with few selected areas in Vihiga County.

II. Methodology

The research design that was used during the study was descriptive survey design. This is because of the vast region and high population in order to focus on the household heads and key health centers for provision of the needed data.

2.1 Study Site

Vihiga County is one of the counties forming the former Western Province in Kenya. The County has five sub-counties; Sabatia, Hamisi, Emuhaya, Luanda, and Vihiga. These regions constitute the area of this study. The region receives rainfall ranging between 1800mm-2000mm with distinct long and short rainy seasons. The temperature ranges between 14-32°C with a mean temperature of 23°C. The altitude varies between 1300m and 1500m above the sea level. (GoK. 2009). The area is located 0°17'N, 34°74'E. The County covers the area 531.0 km² and about 30 km² forest cover in Hamisi Sub-county. The county borders Nandi to the east, Kakamega County to the North, Siaya County to the West and Kisumu County to the South. The county is densely populated with population growth rate of 2.98% per annum with an average population of 900 persons per square kilometre (GoK, 2009). The county is the most populous rural setting in Kenya with a total population of 615734 according to 2015 population projection.



Figure 2.1: Map of Vihiga County

Source; Kenya Data

2.2 Data Sources and Data Collection

Both primary and secondary data were collected. Primary data included the responses and views of patients and health personnel on their perceptions on climate change and malaria prevalence. The information was gathered using the questionnaires that were administered to the households and health workers in various health centres. Interviews schedules were held from the key informants to gain information on malaria prevalence and the effectiveness of the control and treatment measures currently being used. Those interviewed comprised of the Director of health in Vihiga County, malaria coordinator of the county, officers in- charge in every health centres, the nurses and the house holds heads.

Secondary data collected included statistical data on rainfall and temperature retrieved from the meteorological stations within the area of the study. This was mainly from Kenya Meteorological Department but more specific data from Kakamega Meteorological Station. Statistical data for malaria prevalence for the past fiveyears were obtained from the District Hospital Information System (DHIS). The open and closed ended questionnaires were used to find out the views of the parents (households) and health personnel on issues of climate change and spread of malaria and mitigation measures that have been put in place by both national and county government.

2.3 Sampling Procedure

Vihiga County has five sub-counties that have various ecological zones with changes in rainfall and temperature that have a significant influence on mosquito life cycle. All these five sub-counties formed the basis of this study targeted for sampling. The study made use of the Morgan table and out a population of 290,325 households, a sample size of 298 households was derived (Kothari, 2004). The study involved both families and health center in all these sub-counties.

Table 2: The Sample Size

Sub-County	Total Households(2015)	Sample size
Vihiga	62,124	63
Hamisi	64,475	67
Emuhaya	49,871	51
Luanda	54,732	57
Sabatia	59,123	60
Total	290325	298

Source: Central Bureau of Statistics 2009 for households per Sub County.

A total of 298 questionnaires were distributed out which 267 were returned. Out 65 health centres in the county, twenty were chosen purposively, five from every sub-county. Their selection was based on their location either in high, medium and lower level so as to analysis the malaria prevalence in relation to temperature and rainfall variation. Both public and private hospitals were sampled. This because public health centres offer free malaria treatment hence the likelihood of registering a higher number of patients, unlike the private health centres that charge for the treatment.

2.4 Data Analysis

The collected data were subjected to both qualitative and quantitative analysis with the help of standardized statistical packages that included Microsoft Excel and SSP to extract needed information on household characteristics, malaria prevalence and climate changes from the questionnaires and interviews.

Quantitative analysis data from the health centres on malaria prevalence in the region (DHIS), temperature and rainfall trends from the metrological department were analyzed quantitatively. Microsoft Excel and SSP were used in generating graphics on rainfall and temperature trends in the county.

Qualitative analyses using SSP was carried on data collected using questionnaires and interviews on the household heads and medical practitioners' perception of climate changes, malaria prevalence, impacts of both climate change and malaria prevalence on the society and the success of prevention and treatment measures.

III. Results and Discussions

3.1 The Temperature Trends in Vihiga County

Temperatures in Vihiga have been on the increase over this period of study. There has been a notable increase of approximately 2°C from 1994 to 2008 and this would definitely have an impact to the breeding of the mosquitoes. See Figure 3.1.

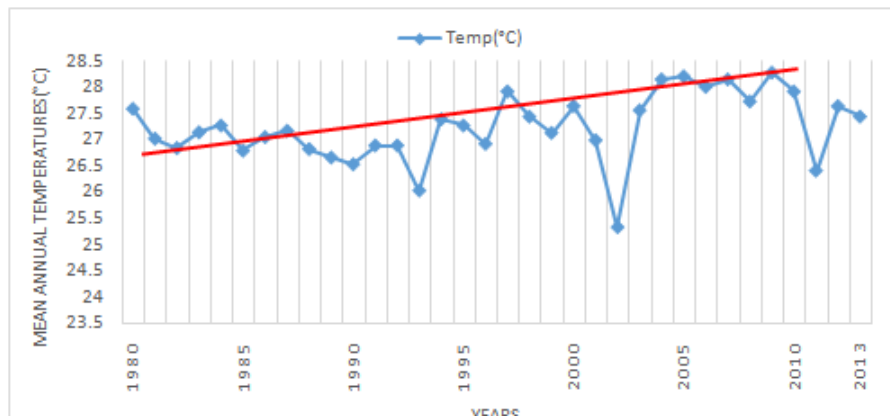


Figure 3.1: Mean Annual Temperature of Vihiga County since 1980-2013

A similar study by Mulinya (2017), on climate change adaptation strategies by small scale farmers in anieghbouring Kakamega County revealed a positive trend of 0.04°Cper annum. This change when accumulated over years, preferably fifty years, can be of massive impact to both the survival of flora and fauna in the area.

3.2 The causes of Temperature Change in the region

This study deemed it necessary to establish the causes of the temperature changes in the area. The following were some of the reasons.

Table 3: The causes of Temperature Change in the region

Cause	Percentage (%)
Deforestation	23.3
Global warming	36.7
Don't Know	40.0

A majority of the respondents at 40% were not aware of the causes of the temperature changes in their area. With 23.3% noting that deforestation was the cause of these changes in the mean temperature and citing the example of deforestation of the Maragoli Hill Forests by the locals for provision of wood fuel and timber. The area sited for encroachment of settlement was Kaimosi forest and the general cutting down of trees in homes for domestic use and creation of room for settlement and agriculture. About 36.7% of the respondents agreed that the changes in temperature were due to general global climatechange in the region. According to Kuya (2015), climate change in Vihiga is associated with the human settlement in forest reserves and frequent deforestation for firewood and timber. The cutting down of Marogoli Hill Forest is the key example in his study. General global warming was also sited to be the major cause of climate change in the region.

3.3 Rainfall Trends in Vihiga County.

Majority (78.0%) of the respondents reported that there had been a change in the rainfall the received while 22.0% of them admitted that there had been no change in the amount of rainfall received.The findings are shown in the figure 3.3.

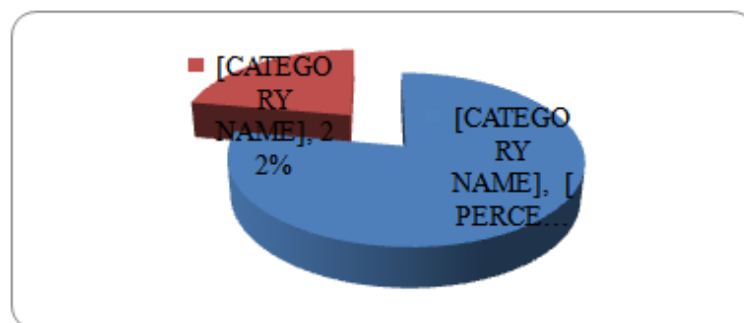


Figure 3.3: There has been change in Rainfall

From those who responded positively for the changes in rainfall, attributed these changes to the land use activities in the region that has led to massive deforestation citing the Maragoli Hill Forest and the riverine trees. This is to create room for settlement, agriculture to cater for the food security to the increasing population. Those suggest negatively cited lack of knowledge about the changes.

Rainfall analysis was done for a period of Fifty Three years (1960-2013) and these were the findings(See Figure 3.4).

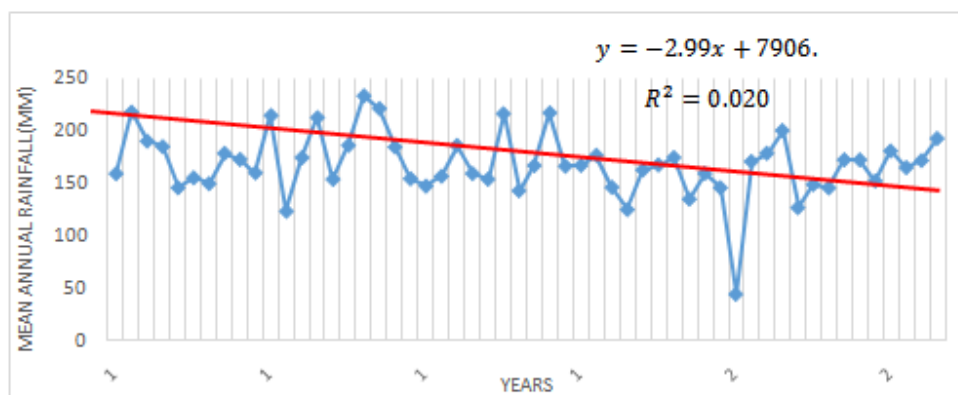


Figure 3.4: Mean Annual Rainfall of Vihiga County since 1960-2013

There is a notable downward trend in the mean rainfall in the county. There has been a drop of about 150mm. In the year 1975, the region recorded 200mm while in the year 2000 recorded less than 50m. From the year 2005, there has seen an increase in the rainfall again up to 2013. With rainfall not falling below 100mm each year, it is an indication of enough amount of water to provide the breeding grounds for the mosquitoes.

These findings are in consonance with Mulinya (2017), study on the constraints faced by small scale farmers in adapting to climate change in Kakamega County where it was established that there has been a change in rainfall and temperature in the county for the past forty six years. The study revealed that rainfall amount has had a negative trend of 3mm per annum while temperature had a positive trend of 0.04°C on yearly basis. A similar study on climate change in Vihiga County by Kuya (2014), Vihiga County has experienced a decline in rainfall of about 150mm for the recent past thirteen years.

3.4 Mean Monthly Rainfall of Vihiga County for 2012

The study also sorts to describe rainfall across the year in order to establish which months that are likely to record high rainfall for the mosquito breeding. The mean monthly rainfall of the year 2012 were analysed and the finding were depicted in the bar graph in the figure 4.8 below.

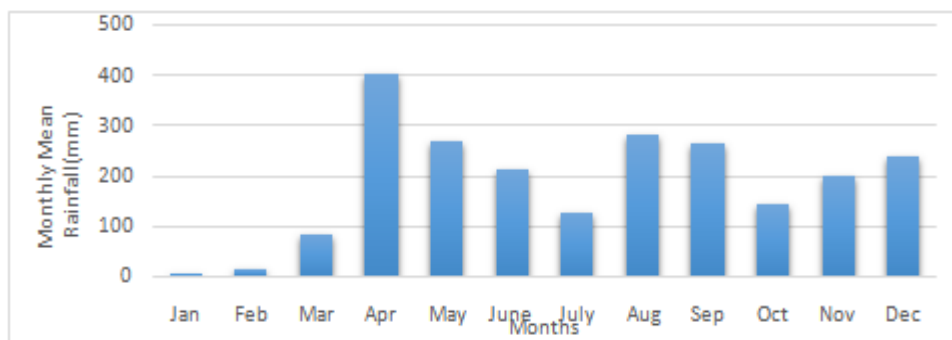


Figure 3.5: Mean Monthly Rainfall of Vihiga County for 2012

From the figure 3.5, the rainfall starts to rise from the month of February reaching the climax of 400mm in the month of April. The rainfall the drops to about 150mm in the month of July and starts to rise again reaching its climax in the month of August of about 280mm. This gives rise to double maxima rainfall in the region with long rains from the month of March to June with short rains from the months of September to November.

The above findings on the declining in rainfall in Vihiga County, does correlates with findings from the previous studies carried in the region by various researchers. Kuya (2013) in his study, he cites that rainfall is high in Vihiga County just like other parts of Western Kenya. However, the study revealed declining in rainfall amount, a trend that has been evident in the recent past years. His study, it was evident that Vihiga County receives long rains in the months of March-April-May with short rains in the months of August to December. However, the study revealed a changing pattern in the last part years. Long rains are delaying up to mid-April and ending as early as June. Shorts rains on the other hand, is expected to start as from late as July, have been pushed to early September and end s in November leading to high dry period from December- March (Kuya, 2015). The rainfall trends are similar to the findings in this study. Just like in this study, Kuya cited deforestation due to settlement in the forest reserves, search for fire wood and timber is the major contributor to this climate change in the region.

3.5 Changes in Rainfall and Temperature contribution to Malaria Outbreak

The study further sought to establish whether the changes in rainfall and temperature contributed to increased malaria outbreak in the area. Results in figure 4.10 below, indicated that 83.0% of the respondents indicated that changes in rainfall and temperature contributed to malaria outbreak with only 17.0% of them indicating that changes in rainfall and temperature did not contribute to malaria outbreak.

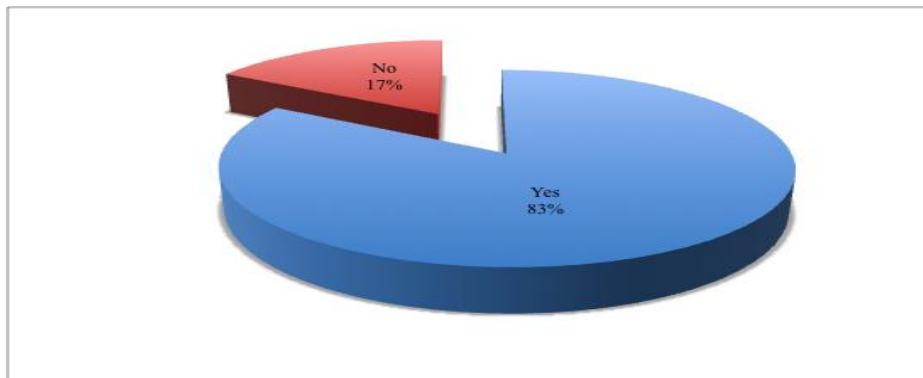


Figure 3.6: Changes in Rainfall and Temperature contributed to Malaria Outbreak

From the findings, majority of the respondents agreed to the changes of temperatures and rainfall having an impact on the malaria prevalence in the region. This is because of high malaria cases witnessed at homes by the household heads during the rainy periods as compared to similar periods in the previous years. Those who had declined, could be because they might have no knowledge on how climate changes could impact on malaria prevalence as malaria prevalence in the region remains high across the years. The study evaluated the trend of malaria prevalence amongst children under five years in Vihiga County for the past five years. The information from the DHIS was used as shown in figure 3.7.

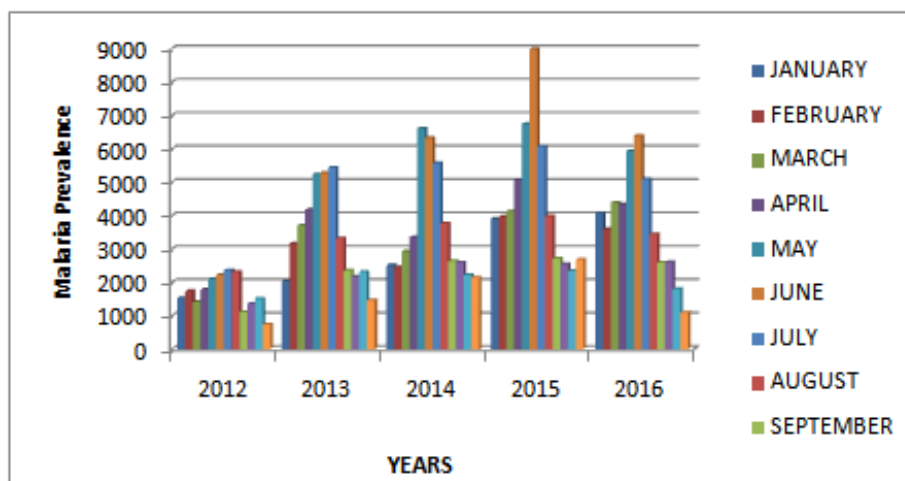


Figure 3.7: Trends of Malaria Prevalence under five years in Vihiga County.

Figure 3.7, the region records high malaria prevalence even though there is a downward trend in 2016. The prevalence rose from the month of March reaching its climax in the month of June then drops to below 2000 patients in the month of August. This periods correlates with season of high rainfall and temperature in the region as shown in figures 3.2 and 3.5. At the start of the rainy season in March, the prevalence is low. This is because during this time, the mosquitoes are breeding. This may last for a period of two to three weeks (Sandeu *et al.*, 2016). After the completion of mosquito life-cycle in water, is starts the Sporogenic cycle that requires feeding on blood meal. It is during this stage that the vector starts to transmit the malaria causing virus. This led to rise of malaria for three consecutive months.

To shade more light on the impact of climate changes on the spread of malaria in the region, the respondents were interviewed on causes of rapid malaria prevalence. Results in Table 4 indicates that 3.3% of the respondents believed that poor use of mosquito nets was the main cause of rapid malaria prevalence while another 1.1% of them indicated that there was no clear cause of rapid malaria prevalence. However, majority (95.6 %) of the respondents believed that rapid malaria prevalence occurred due to other reasons.

Table 4: Causes of Rapid Malaria Prevalence leading to increased Malaria outbreak

Cause	Percentage (%)
Poor use of bednets	3.3
None	1.1
Don't Know	95.6

From the finding, majority of the respondents (96%) pegged high malaria prevalences to other factors that could either known to them or not. From the previous responses, it is clear that these other factors could betemperature and rainfall changes. The relationship between malaria and climate change has been broadly studied than any other disease in Africa especially in West and South Africa (Connor *et al.*, 2006). This is owing to the fact that climate information can be used to generate malaria risk maps in the process of absence of high quality epidemiological information (Connor *et al.*, 2006).

Changing climate has lead to warmer temperatures in the highlands of East Africa leading to increased malaria cases. Additional cases occurs when increased temperatures occur simulateneously with increase in precipitation (Confalonieri *et al.*, 2007). Kenya experienced a six-fold increase in the number of malaria cases compared with previous years (McMicheal *et al.*, 2003). A significant body of researchers suggest that overall global warming is expected to increase the seasonality and range of malaria both across africa andon the global scale(McMicheal *et al.*, 2003). Malaria infection rate is expected to increase by 16-28 percent in person month in Africa by the year 2100 (Patz *et al.*, 2005).

Even though majority of the study confirms that climate change has contributed to higher malaria prevalence in the region, other studies disagreed. These studies suggest that for climate change to be the primary contributor to increased malaria, other factors that contribute to transmission rates should be considered. These include the use of drug resistance, human migration, mosquito control programmes and immune status of the patients and changing in the land-use patterns (Patz *et al.*, 2005).

To establish the trend of malaria prevalence leading to increased malaria outbreak.Finding revealed that 55.0% of the respondents indicated that malaria prevalence was declining while 45.0% of them indicating that malaria prevalence was increasing.

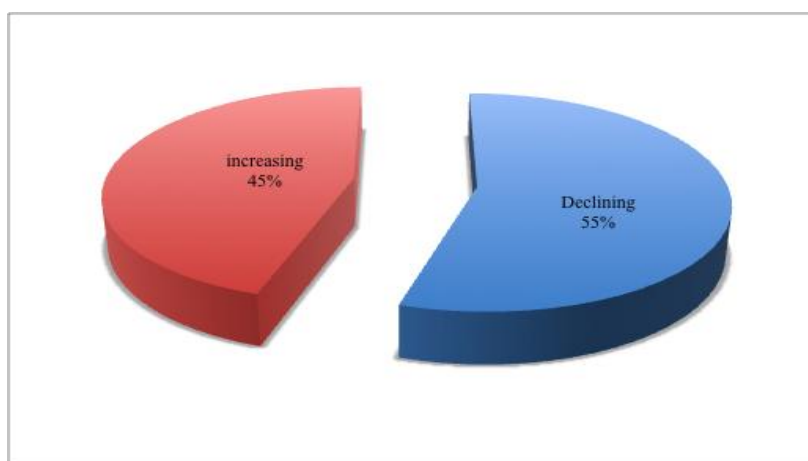


Figure 3.7: Trend of Malaria Prevalence for the past 20 years

From the responses, it was evident that malaria prevalence have fallen for the past five years. This could be attributed to free malaria drugs and use of treated mosquitoes bednets. However, the 45% of the respondents suggested that malaria prevalence has not declined in the past years. It is because most of them still suffer from malaria and prevalence has risen especially amongst childrens.

The study also sought to find out the level of malaria prevalence in every sub-county for the last five years (2012-2016) as obtained in DHIS, 2017. The figure 3.8 shows the results.

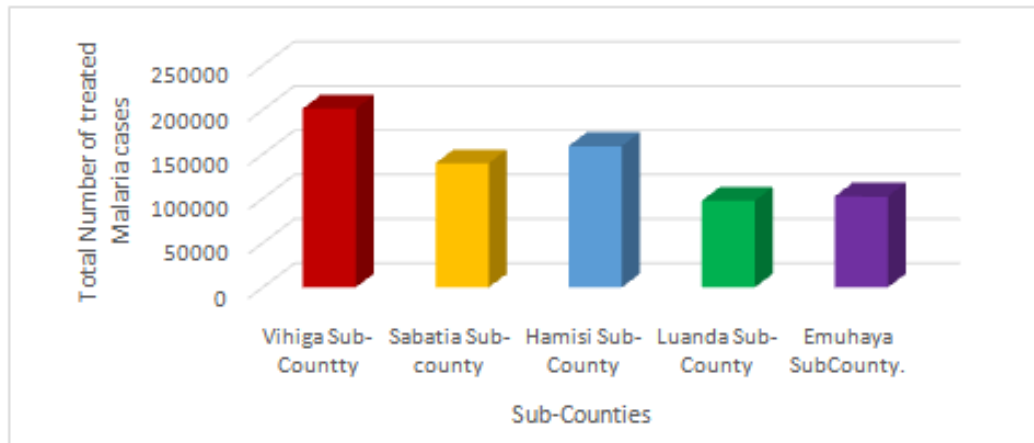


Figure 3.8: Total Malaria Prevalence in Vihiga County from 2012-2016

3.6: The Impacts of Malaria to the Local Community in Vihiga

The study also sought to establish the impact of malaria prevalence to the community in the region and the following were the responses during the interviews and focused group discussion.

High infant mortality- There have been high mortality rates of infants in Vihiga County for the last five years. As the statistics from the hospital registers revealed mortality rates in the county of about 202,521 children for the last five years (DHS, 2017). This has brought a lot of loss to the families within the county.

High financial burden- Malaria prevention and treatment requires high budgetary allocation. Each year, the Kenyan government spends over 15 billion on malaria which accounts for 26%. County government support currently stands at 22% of expenses each year for malaria prevention and treatment. External donors like World Bank, World Health Organization and other organization accounted for 40% of the expenses. This leaves the patient with 12% of the expenses. However, with current signs withdrawal of foreign aid in the future, the patients are likely to pay heavily for malaria treatment in the future.

Increase in population- The current statistics from the department of statistics Vihiga County, has revealed an increase in population within the county for the last five years. During the 2009, the population was about 546,929 people, but this has increased to 676,456 in 2015. This is because of high infant mortality rate. The parents therefore tend to give birth to more children with hope that some of them will survive the malaria epidemic. This has led to high fertility rate of 5.3 % (GoK 2009). However, in most cases, all these children live beyond five years which translates to high population that translates to high dependency ratio hence high poverty level in the county.

Lost working hours- The also revealed that most women waste their working hours to attend to their sick children suffering from malaria infections. The long queues witnessed in the all health centers are made up of women waiting to be attended to. This has led to high economic loss to the county as a lot of working hours are lost. This has also led to imbalanced in gender employment in the county. Many firms tend to prefer male candidates to women. This has rendered many women unemployed making them unable to compete with their male counterpart favorably economically.

Health Complication- From the study, it was revealed that children who suffer from severe malaria especially cerebral malaria, they become vulnerable to other diseases in the future. These include mental disability in the adult life. Vihiga County, has many mentally disable people especially in major towns of Luanda, Mbale, Majengo, and Chavakali among others. This could be caused by other factors like stress due to hard economic life, drug abuse among others. However, the impact of malaria cannot be neglected even though it requires broader perspective.

IV. Conclusions And Recommendations

The study revealed a positive trend in temperature. The views from the respondents responded the rise in temperatures as compared to the previous years. Analysed meteorological data from Kakamega Metrological Station revealed a rise in 2°C in temperature for the last forty five years with 0.04°C annual rise. Similar studies on climate change in the region and neighbouring counties reveals a positive trend in temperatures. The study too revealed a negative trend on precipitation. The rainfall has declined with about 150mm for the last fifty three years after analysis. The study also revealed a change in rainfall trends with long rains season being shortened. These results implies that there will be a reduction in precipitation in the future years. Therefore, temperatures is rising while rainfall is declining in Vihiga County.

The rise in temperature in the region of 0.04°C annually. For the past fifty three years, the region has registered about 2°C. This has led to high mean monthly temperature of about 22°C in the area across the year. High temperatures have provided a momentarily suitable condition for uncontrollable multiplication of mosquito hence high transmission of malaria in population of five years old and below that have acquired little functional immunity. These high temperatures recorded in the area favours the breeding and quicken the maturity of mosquito larva to adult within short time. This in return led to high mosquitos' population that enhances the spread of malaria. Even though the area recorded low rainfall, when it rains, it leads to accumulation of pools of waters. Combined with high temperatures in the area, stagnant waters creates an ambient environment for hatching and maturation of larvae into adult mosquitoes that responsible for malaria transmission. This changes in rainfall and temperatures provides a warmer environment hence increased mosquitoes, malaria vector in the area. Regardless of the provision of ITNs net, free treatment of malaria in public hospitals and use of domestic spray, the study noted an increase in the malaria prevalence for the past five years in Vihiga County.

The study has reveals climate change as human problem worldwide and locally. The involvement of international bodies like World Bank, in collaboration with other bodies, are working hard to mitigate the present climate changes impacts in various sector of human life. These include agriculture, tourism, forestry, and health. They are meant to foster strategies for climate resilient development that aims at mitigation and adaptation. The national government of Kenya and county government of Vihiga should work hand in hand with such bodies to foster better land use, forest management and advocate for knowledge and use of technology like mass media with aim of improving climate knowledge among the local community.

In conclusion, regardless of the correlation between malaria prevalence and changing climate trends globally, malaria still remains a health problem which could be an pandemic in the future especially in the countries in the southern part of Sahara. Therefore, programes needs to be increased to control the prevalence. All involved bodies both at local and national level should work hand in hand to reduces it s prevalence withouting ovelooking the impact of climate change on the malaria prevalence.

The study therefore recommends both the national and county government with help of international bodies to work together and come up with a joint financial kitty. This will help in incoming up with programs and infrastructures that will help monitor climate changes and disseminate the information to the locals. Among these infrastructures include the metrological station based in the county. This will help monitor the local changes of temperature and rainfall. Vihiga currently relies on weather stations in Kakamega and Kisumu. This is likely to give inaccurate readings based on ecological differences of the regions involved.

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