International Journal of Preventive Medicine Research
Vol. 4, No. 3, 2018, pp. 60-67
http://www.aiscience.org/journal/ijpmr
ISSN: 2381-7038 (Print); ISSN: 2381-7046 (Online)

The Links between Climate and Malaria Disease in Ekiti State, Nigeria

Opeyemi Rabiu Salau[1, *], Oluwafisayo Adeteju Adeleye[2], Fatai Ayodele Adeleye[1], Jose Americo[3]

[1]Department of Physics, Ekiti State University, Ado-Ekiti, Nigeria
[2]Department of Guidance and Counseling, Ekiti State University, Ado-Ekiti, Nigeria
[3]Department of Surveillance, National Institute of Health, Maputo, Mozambique

Abstract

Malaria disease is a major health problem worldwide and especially in Africa where the favourable environmental conditions have led to high malaria infections and the death of millions of people. This study investigates the annual variations in the observed malaria infections from 12 Local Government Areas (LGAs) of Ekiti State, Nigeria for the period 1985-2014. The analysis of the anomalies of the malaria cases shows 10-year cycles with anomalously high number of cases in the period from 1985 to 1996 and anomalously less number of cases in the period from 1997 to 2013. Interestingly, the anomaly correlation of the number of malaria cases and the sea-surface temperature (SST) reveals a significant pattern similar to the Pacific Decadal Oscillation (PDO) in the Pacific Ocean with negative correlation between the local SST anomalies. The cycles of the malaria cases are also in good agreement with changes in the observed rainfall and temperature patterns over the study area. The overall result suggests that the link of Malaria to the PDO might be used as a long lead forecast predictor of Malaria over the study region and possibly beyond.

Keywords

Malaria Disease, Mosquito, Rainfall, Temperature, Ekiti, Climate Change, PDO

Received: July 1, 2018 / Accepted: July 23, 2018 / Published online: August 31, 2018

1. Introduction

The impacts of climate change on the prevalence of malaria areof major social concern. The malaria is a killer disease with about 300-500 million annual clinical cases globally in which almost 80% are reported to be from Africa where the existing tropical environment favours the spread of the disease [1]. Pregnant women and children within 5 years are very vulnerable to malaria [2]; a situation which has been linked to over 1 million deaths annually among the children from mostly rural regions of Africa [2, 3] and around 300, 000 of these are reported to be from Nigeria alone [4]. It is prevalent in the tropical and sub-tropical regions where the disease is transmitted through bites from female anopheles mosquitoes that breed in stagnant water under suitably high temperature, rainfall and humidity [5]. The mosquitoes suck plasmodium from the sufferer's blood and deposit it in the circulatory system of the new host [2] where it enters the liver to mature and reproduce.

The disease will manifest itself within 8-25 days of the bites through symptoms like frequent fevers, joint pain, back pain, headache, cold, sweating, dry cough, vomiting, diarrhea and even death when not treated [6]. The appearance of the disease is delayed or prevented if anti-malaria medication is taking [7] while the spread of the disease is usually high within 20°C to 30°C temperature range [8] and reduced under extremely low

* Corresponding author
E-mail address: o.salau@t-online.de (O. R. Salau)

or too high temperature. Also, the transmission rate of the disease is lowered as the life span of mosquito gets shortened if the average monthly relative humidity is below 55% and above 80% [9]. However, the disease could generally be reduced by taking the appropriate drugs, use of treated mosquito net, insect repellents, spraying of insecticides [10], domestic cleanliness, refuse and drainage evacuation to reduce mosquito population hence the overall infections.

Research has shown that the distribution and the abundance of the vector organisms and the intermediate hosts are affected by both physical and biological factors in an ecosystem. However, changes in climate will alter the distribution of these vectors and the spread of the disease into new areas [11]. Also, many social factors like the level of economic development, health facilities and living conditions may influence the occurrences of malaria disease [12]. Nevertheless, the disease is still a major public health problem which is responsible for human deaths in the tropical regions despite the successes achieved through research and the discovery of new drugs [13]. In this study, we try to link the long term variability of sea surface temperature (SST) to the annual malaria cases over Ekiti; a state in the south western part of Nigeria which is located in West Africa. The results would be important for the policy makers and planners as well as for the societyin general.

2. Data and Methodology

The study area is Ekiti State in the south western part of Nigeria (7.667°N, 5.250°E) with Ado-Ekiti as the capital [14] (Figure 1). The state is bounded in the north by Kwara State and Kogi State while Osun State occupies the west and Ondo State lies in the south and extends to the eastern part of the state. The state has 16 Local Government Areas (LGAs) and population of about 2,384,212 people that spreads over approximately 5887.890 km^2 at an elevation of about 250 m above the sea level [15]. The tropical type of climate in the study region is characterized by high rainfall, strong humidity and high mean temperature ranging between 21°C and 28°C with the dry season centered within November-February while that of thewet season is March-October of every year [16]. These climatic conditions of the area lead to the presence of agricultural products like cocoa, palm tree, orange, colanut and abundant forest resources while food crops are yam, cassava, rice and maize in an environment blessed with rivers like Ero, Osun, Ose and Ogbese. Most of the inhabitants of the state are farmers, civil and public servants while others are artisans and traders.

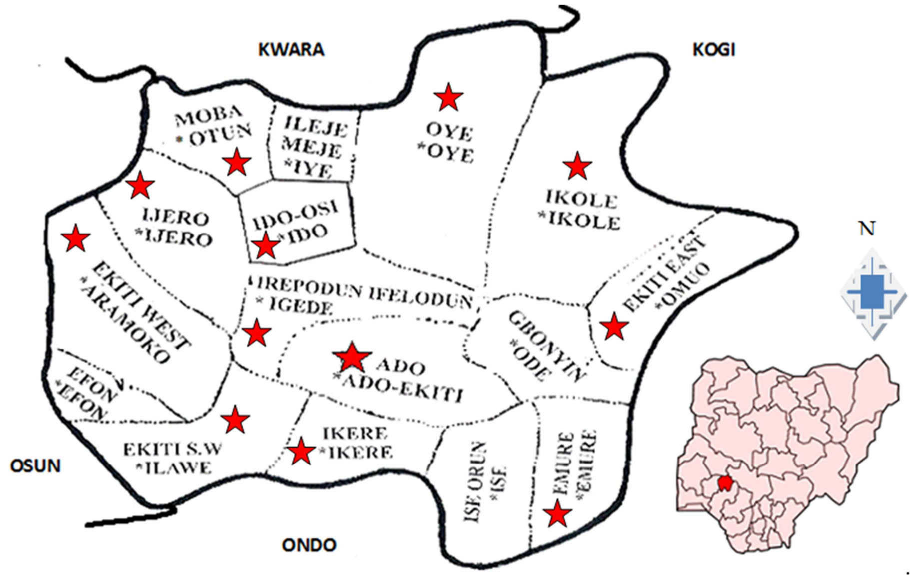

Figure 1. The map of Ekiti State showing the Local Government Areas (LGAs) with their headquarters marked with small stars (*) while bigger stars show the LGAs used in this study (adapted from nigerianmuse.com). Inserted is the map of Nigeria with the painted portion representing the location of Ekiti State (source: www.ngex.com/nigeria).

We used annual data of malaria from the 12 LGAs of the state where the available data covers the minimum 30 years (1985-2014) needed for studying climate changes. The data is obtained from the Federal Ministry of Agriculture in Ado-Ekiti and it consists of the numbers of infections among the youths, male and female adults. The data were smoothed with the outliers removed so as to get more accurate results. The rainfall used in the study is the Climate Prediction Center (CPC) African Rainfall Climatology Version 2 (ARC2; [17]). The SST used in the analysis is the NOAA Optimum Interpolation (OI) version 2 (OIV2; [18]). The plots of the observed variations are compared with the measured rainfall and temperature so as to understand the impacts of variations in the climate on the malaria distribution in the state and beyond.

3. Results and Discussion

A. The Total Malaria Cases

The total numbers of malaria cases among the youths, male adults and female adults inEkiti State, Nigeria are shown in Figure 2. The results indicate that the malaria cases rose among the three groups during the study period; especially within the youth population where the fastest upward trend is observed. For instance, the malaria cases are more stable within the adult populations between 1985 and 2005 after which it ascended slightly till 2015. The infections are slightly higher among the female group compared with the male while the highest cases are reported among the youths where the immunity against the disease is very low. The respective mean values of the malaria cases rose in 1985 among the youths, male adults and female adults from 41248, 22236 and 24870 to higher values of 89667, 38413 and 43093 in 2015; thus raising the corresponding total cases among the three groups from 88354 in 1985 to 171173 in 2015 (Figure 3).

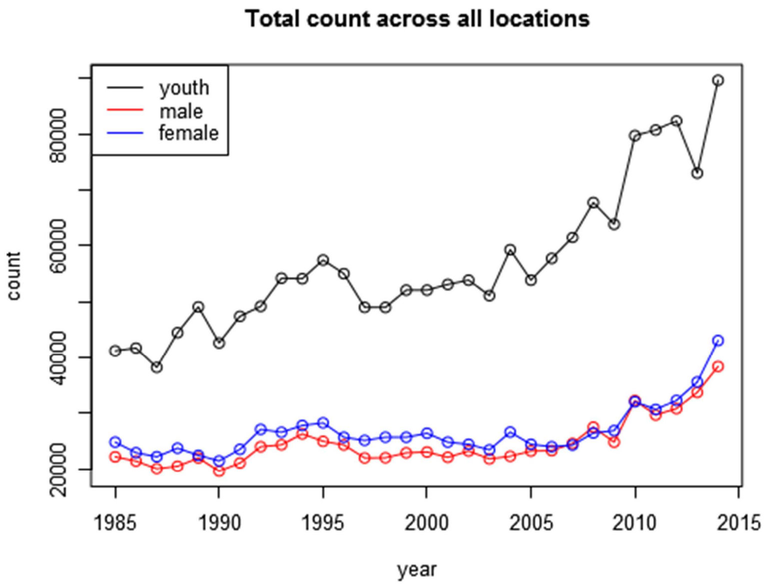

Figure 2. The total cases of the malaria among the youths, male adults and female adults.

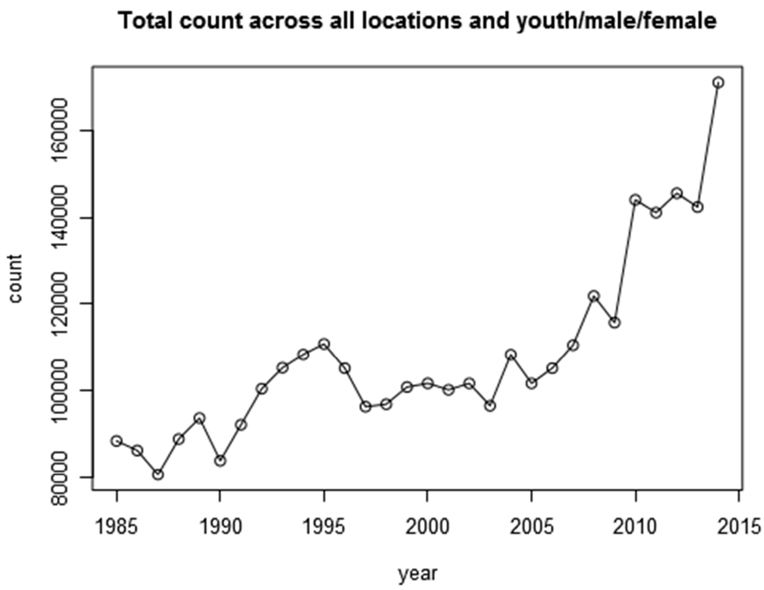

Figure 3. The overall total numbers of malaria cases among the three groups.

B. Anomalies of the number of malaria cases

The total malaria cases across the three age groups for each year and the overall mean value is used for estimating the anomaly that represents the malaria incidence rate anomaly.

The incidence rate was calculated by taking the total malaria count, divided by the population of Ekiti State. Since we did not have the population of Ekiti for every year at the time of doing this investigation, we had to estimate it by using the linearly interpolated population of Nigeria. As a result, Ekiti was estimated to be about 1.8% of the Nigerian population. We also saw that there was an increasing trend between the years 1985-2014. This led to calculating the incidence rate anomaly, which is the incidence rate with the linear trend removed. The anomaly takes into account the increase in population over the 30 years and sees whether there was any variability among the years. The result reveals ten years cycles in the malaria infections (Figure 4). The magnitudes of the infections vary strongly within each decade; however, the first positive cycle suggests that the malaria cases rose above the thirty years background mean value. The anomaly reached the peak in 1992 before a rapid decline to initiates the second but negative cycle around 1995. The amounts of infected people decline further till the lowest infections below the thirty years mean is seen between 2003-2005 before a gradual increase in the malaria cases is observed through the third decade. The anomalies show an increase after 2014 (Figure 4).

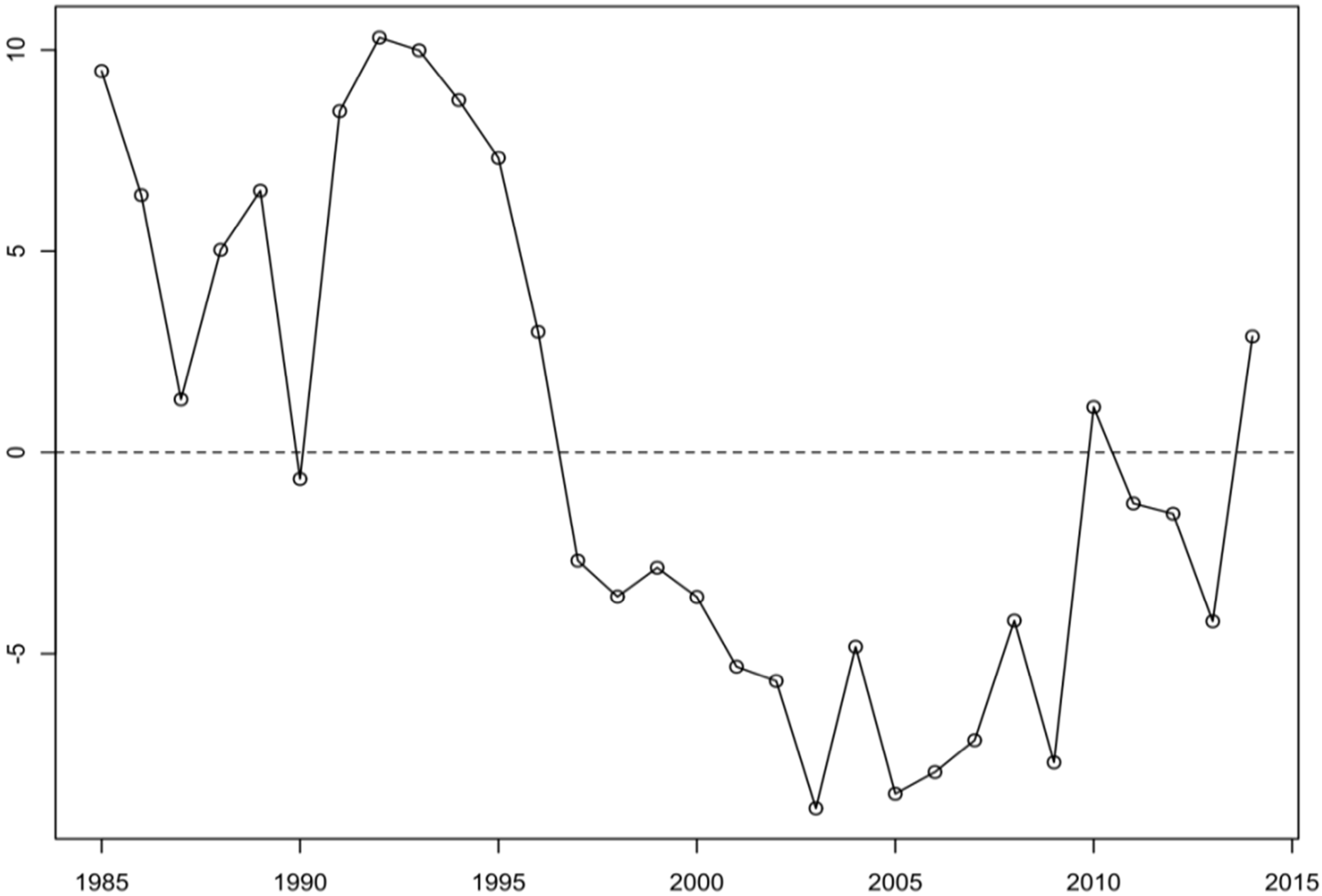

Figure 4. The malaria variations showing ten years cycle.

4. The Comparison with Observations

To understand the role of climate on the decadal variation of the number of cases anomalies, we correlated the anomalies of the annual number of cases and the annual SST anomalies. Interestingly, the spatial pattern of the significant correlation coefficients resembles the pattern observed during the Pacific Decadal Oscillation (PDO)[19] in the Pacific (Figure 5). The PDO is a mode of variability in the Pacific which varies at decadal time scales. The positive (negative) phase of PDO has a spatial pattern with warm (cold) waters off the coast of North America from Alaska to the Equator and cool (warm) waters over the North Pacific. The correlation coefficients between the anomalies of the number of malaria cases and the SST reveal a negative correlation with the local water off the coast of Nigeria (Figure 5). The negative correlation between the two variables is expected since a rise (reduction) in number of cases is associated with increase (decrease) in rainfall which may be due to high (low) sea surface temperatures off the coast of Nigeria. The difference in the SSTs between the decades; 1998 to 2007 and 1988 to 1997 shows a pattern similar to the negative phase of PDO over the north Pacific. The mechanism of how the PDO affects the number of malaria cases over Ekiti is beyond the scope of this paper.

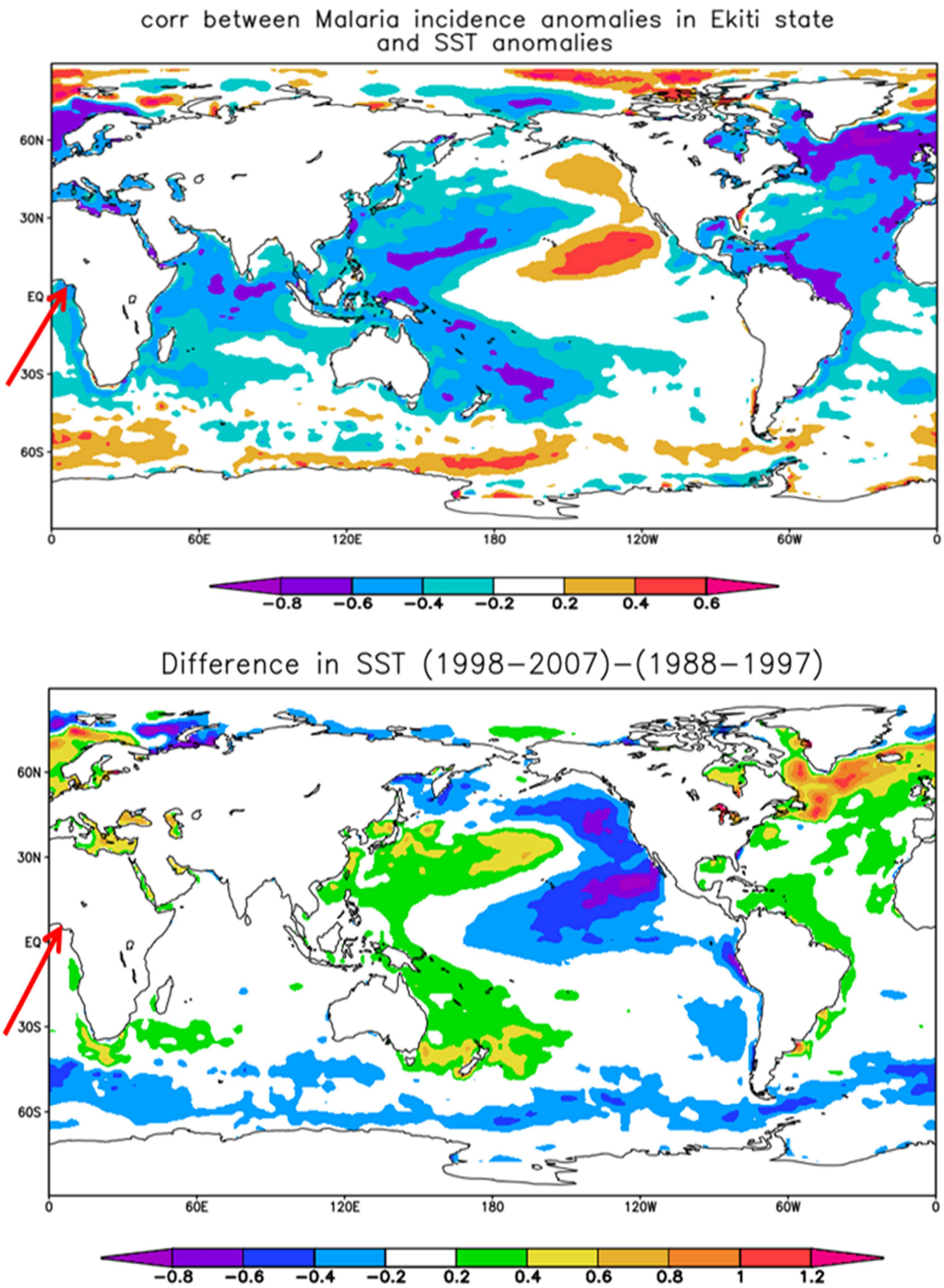

Figure 5. A) The correlation between the malaria cases and SST, and B) changes in the SST (obtained by subtracting values in 1988-1997 from 1998-2007), resembling negative phase of PDO.

In order to investigate the changes in the rainfall and 2m air temperatures over Ekiti during the decades, we calculated the changes in the rainfall and 2m air temperatures over the two periods (1998-2007 and 1988-1997). During 1998 to 2007, there was less rainfall over Ekiti (Figure 6) compared to 1988-1997 which is consistent with the anomalous decrease in the number of malaria cases in the 1998 to 2007 decade compared to the cases in the 1988 to 1997. As expected also, the observed changes in temperature (2m air temperature) patterns revealed that reduction in the rainfall is accompanied by the warmer condition in Ekiti State, Nigeria during the study period [(1998-2007)-(1988-1997] (Figure 7; in the box). This is expected since temperature will be more damped under the cloudy conditions that come with periods of higher precipitation (like in 1988-1997) than in the period characterized by reduced rainfall (like in 1998-2007). This observed pattern implies that the breeding of mosquitoes and hence the spread of the disease is enhanced during the periods of elevated rainfall. It also suggests that a period of negative PDO in the north Pacific (Figure 5B) and high temperature in the study region will coincide with reduction in malaria cases in the study area and possibly within the whole country through reduction in the rainfall intensity. However, the opposite event (enhanced infections) will be seen in the study area during the positive phase of the PDO cycle.

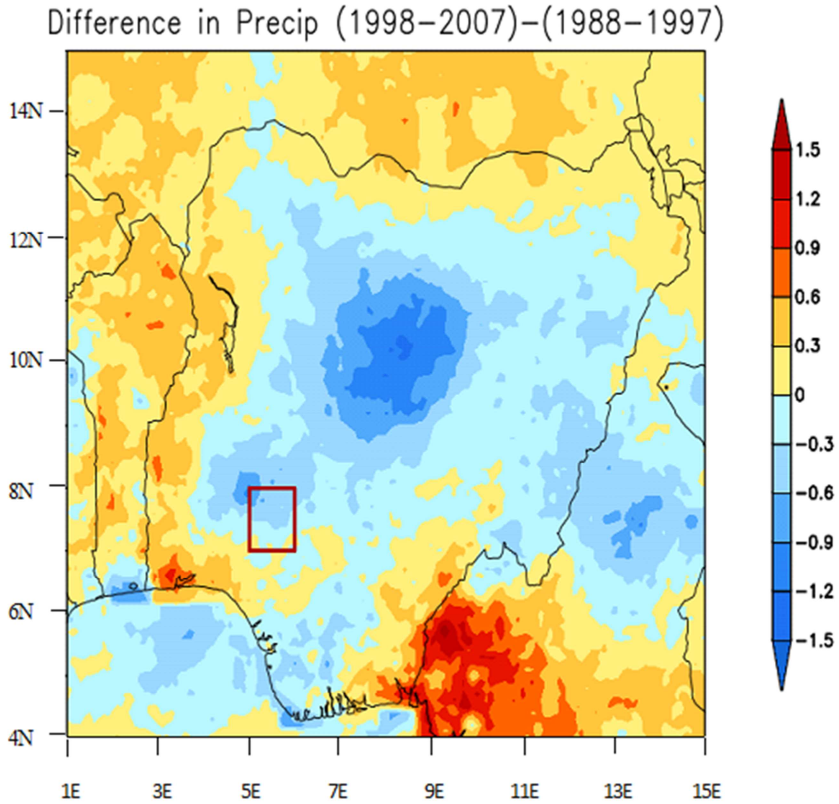

Figure 6. The observed change [(1998-2007)-(1988-1997] in the precipitation patterns (mm/day).

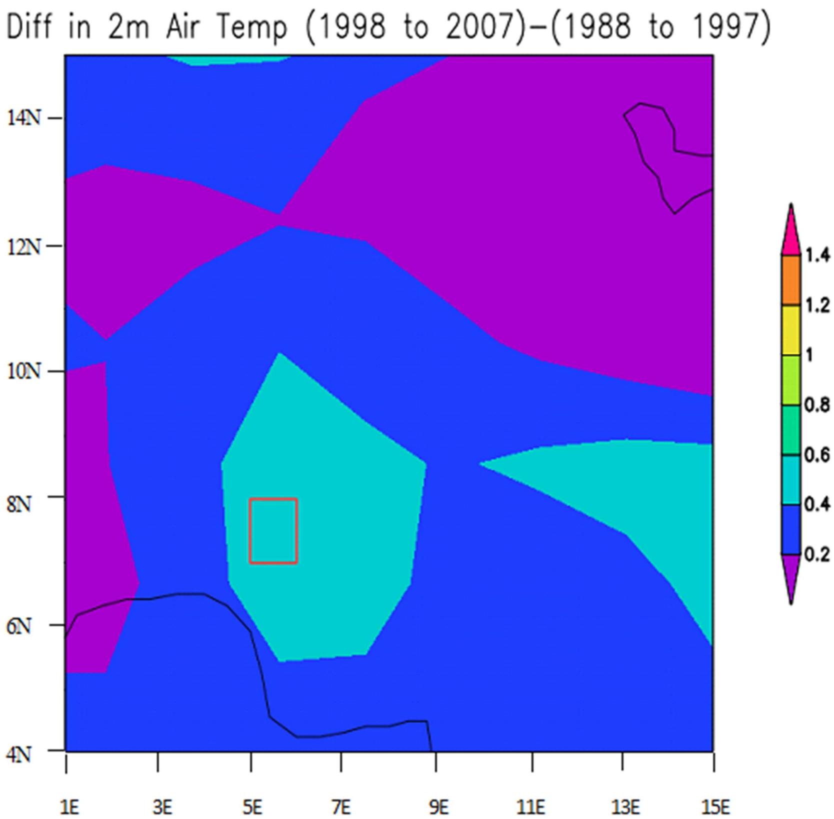

Figure 7. The observed change [(1998-2007)-(1988-1997] in the 2m air temperature (°C).

5. Conclusions and Recommendations

This study investigates the annual variations in the observed malaria infections from 12 LGAs of Ekiti State, Nigeria; the data covers 1985-2014 and we relate the results with changes in climate variables like temperature and rainfall. The results indicate that the annual magnitude of the malaria rises over the study periods and also among the youth population while it appeared stable within the male and female groups till about 2005 before a small increase is seen till 2014. The highest number of infections is seen among the youth and the observed cases are slightly higher in female adults compared to male adults. This agrees with high vulnerability of the youths to the malaria infection due to their weaker immunity compared to adults while women, particularly those that are pregnant, are also at higher risk than men. However, the recorded infections might be far less than the ideal situations in the study area due to unreported cases of the disease. This might be caused by self-medication which is more widely practiced by male adults while poverty seems to play important role in their inability to visit hospitals for proper medical treatments.

Also, the anomalous change in the malaria cases revealed ten years cycles where the first positive cycle declined through 1995 to a negative cycle that rose from the minimum negative anomaly in 2005 towards positive anomaly to create the third cycle. Furthermore, negative correlation is seen between the malaria infections and SST in the study area while a spatial pattern resembling a PDO condition is observed over the northern Pacific Ocean. The cycles of the malaria cases are in good agreement with changes in the observedrainfall and temperature patterns over the study area. Overall, the observed malaria cycles tend to link the infections to the PDO phenomenon such that the disease will spread more in the study region during the positive phase of the PDO events and vice versa. Thus, the link of malaria to the PDO might be used as a long lead forecast predictor of the diseasewithin Ekiti State, Nigeria and possibly outside the study area.

Acknowledgements

The authors wish to thank the Federal Ministry of Agriculture in Ado-Ekiti, Ekiti State, Nigeria for the availability of the malaria data used for this study. In addition, many thanks to the Climate Prediction Center (CPC) African Rainfall Climatology Version 2 for the free rainfall data and the NOAA Optimum Interpolation (OI) version 2 for their free observed SST.

Conflicts of Interest

The authors declare no conflict of interest

References

[1] Lucas A. O. and Gilles H. M. (2003). Malaria: Short Textbook on Public Health Medicine forthe Tropics. India, Arnold Publication.

[2] Nmadu P. M., Peter E., Alexander P., Koggie A. Z., Maikenti J. I. (2015). The Prevalence ofMalaria in Children between the Ages 2-15 Visiting Gwarinpa General Hospital Life-Camp, Abuja, Nigeria, Journal of Health Science, Vol. 5 No. 3, 2015, pp. 47-51. doi: 10.5923/j.health.20150503.01.

[3] Fawole, O. I. and Onadeko M. O. (2001). Knowledge and Management of Malaria in UnderFive Children by Primary Health Care Workers in Ibadan South East Local Government Area. Nigeria. Post Graduate Medical Journal. 8 (1): 1-5.

[4] Oyewole, I. O. and Ibidapo, A. C. (2007). Attitudes to malaria, prevention, treatment andmanagement strategies associated with the prevalence of malaria in a Nigerian urban centre. African Journal of Biotechnology. 6 (21); 2424-2427

[5] Jamieson, A., Toovey, S., and Maurel, M. (2006). Malaria: A Traveller's Guide. Struik, p. 30.

[6] Fairhurst, R. M. and Wellems, T. E. (2010). “Chapter 275. Plasmodium species (malaria)”. In: Mandell, G. L., Bennett, J. E. and Dolin, R. (eds.), Mandell, Douglas, and Bennett'sPrinciples and Practice of Infectious Diseases 2 (7th edn). Philadelphia, Pennsylvania: Churchill Livingstone/Elsevier, p 3437-3462. ISBN 978-0-443-06839-3.

[7] Nadjm B., Behrens R. H. (2012). "Malaria: An update for physicians", Infectious DiseaseClinics of North America 26 (2): 243–59, doi: 10.1016/j.idc.2012.03.010, PMID 22632637.

[8] Patz J. A., Kovats R. B. (2005). Hotspots in climate change and human health. BMJ 2005; 325: 1094-1098.

[9] Dhiman, R. C., Bhattacharjee S., Adak, T. and Subbarao, S. K. (2004). Malaria ResearchCentre, Private Communications.

[10] Caraballo H (2014). "Emergency department management of mosquito-borne illness: Malaria, dengue, and west nile virus", Emergency Medicine Practice 16 (5).

[11] Ali H, H., Ahmed, S., and Sulaiman, S., (2008). Climate change and health in Sudan. Capacity strengthen in the least developed countries for adaptation to climate change.

[12] Kelly-Hope, L. A.; Alonso, W. J.; Thiem, V. D.; Canh do, G.; Anh, D. D., and Lee, H. (2008). Temporal trends and climatic factors associated with bacterial enteric diseases in Vietnam, 1991–2001. EHP., 116: 7-12.

[13] Khan, J. S., Usman, M., Abbass, Y., Hussain, M, &Alli, M. (2010). Knowledge, attitude andPractice study on malaria. Gomal Journal of Medical Sciences. 8 (2): 204-208.

[14] Salau O. R. (2016). Dependence of Malaria Disease on Changes in Rainfall and Temperaturein Ado Local Government Area of Ekiti State, Nigeria, Intern. J. of Res., vol. 3, issue 9.

[15] EKSG (Ekiti State Government), About Ekiti (2016). Retrieved on 04/05/16 (available on:ekitistate.gov.ng/).

[16] Salau O. R. (2017). The Links between Variations in Climate Patterns and ITCZ Position overNigeria, World Science News (WSN), Intern. Res. online J., vol. 87, pg/ 191-204.

[17] Novella, N. S. and W. M. Thiaw (2013). African rainfall climatology version 2 for FamineEarly Warning System. *J. Appl. Meteor. andClimatol*., 52, 588-606.

[18] Reynolds, R. W., Rayner, N. A., Smith, T. M., Stokes, D. C., and Wang, W., (2002). Animproved in situ and satellite SST analysis for climate. J. Climate, 15, pp 1609-1625.

[19] Mantua, N. J. and S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis (1997). A Pacificinterdecadal climate oscillation with impacts on salmon production. Bulettin of theAmerican Metorological Society, 78, pp. 1069-1079.