Current Journal of Applied Science and Technology

25(5): 1-6, 2017; Article no.CJAST.38274
Previously known as British Journal of Applied Science & Technology
ISSN: 2231-0843, NLM ID: 101664541

Impacts of Climate Variability on Malaria Incidence in the Buea Municipality of Cameroon; Implications for Malaria Control and Prevention

Lawrence Fombe[1*] and Amenchwi G. Amahnui[2]

[1]Department of Geography and Planning, University of Bamenda, Cameroon.
[2]Department of Environmental Science, University of Buea, Cameroon.

Authors' contributions

This work was carried out in collaboration between the two authors. Author LF designed the study theme, developed the abstract, part of the discussions and wrote the conclusion, while author AGA performed the statistical analysis, wrote the protocol, and most of the literature searches. Both authors made inputs into the research methodology, the recommendations, read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2017/38274
Editor(s):
(1) Lesley Diack, Professor, School of Pharmacy and Life Sciences, Robert Gordon University, UK.
Reviewers:
(1) Leonardo Basco, Aix Marseille Université, France.
(2) Joaquin Cervantes, Mexico.
(3) Avinash Borkar, Pt. Deendayal Upadhyay Memorial Health Sciences and Ayush University of Chhattisgarh, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/22868

Original Research Article

Received 10th November 2017
Accepted 15th January 2018
Published 26th January 2018

ABSTRACT

Changes in global climatic conditions have had profound effects on the environment and human health as epitomized by the changing disease patterns. The case of malaria in the Buea sub-division of the Southwest Region of Cameroon is of profound interest. Fundamental changes in rainfall and temperature conditions have far-reaching implications on malaria incidence as revealed by field data collected from the Regional delegation of public health in the Region which was corroborated with climatic data for a period of 5 years (2010-2014) obtained from the meteorological station of the Cameroon Development Corporation in Tiko. By use of descriptive statistical techniques and the coefficient of variation, results indicate both positive and negative effects of climate variability on malaria incidence in the study area. Based on this, it is incumbent on the government to integrate climate variability in health policy and ensure that all health programs take climate variability concerns in their plans and operations.

**Corresponding author: E-mail: fombefon@yahoo.co.uk;*

Keywords: Malaria incidence; malaria prevalence; climate variability; Buea; climate change.

1. INTRODUCTION

Although the estimated global incidence of malaria fell by 17% between the year 2000 and 2010, the number of cases remain very high [1]. The global malaria cases in 2010 were estimated at 219 million, with 660,000 deaths. Africans accounted for about 91% of the deaths [2]. Of this number, 75% of deaths recorded were children, making malaria a very serious public health problem on the continent.

The population of Cameroon of over 22 million people is of high risk of malaria with about 4398 deaths in 2012 [2]. Malaria is, therefore, a major public health challenge in Cameroon and adversely affects the productivity and economy of the country. Due to the huge economic burden of the disease, understanding the factors that impact its incidence is crucial for its prediction and prevention.

Global climate change or variability, and extreme climate events have been noted to partially explain malaria prevalence. The climatic factors frequently considered are temperature, rainfall, precipitation and humidity. The climate-malaria relationship begins with the identification of the isolated effects of temperature on malaria incidence. Increasing temperatures shortens the extrinsic incubation period and increases vector numbers which in turn increases malaria transmission. The reverse is true when the temperature drops. At temperatures above 40℃, a mosquito desiccates and daily survival is zero (Center for Disease Control and Prevention, CDC 2004) [3]. The role of temperature correlates with the role of precipitation as the anopheles mosquito requires some amount of moisture to avoid desiccation as adults and precipitation also creates pools of water on which females lay their eggs. Relative humidity also affects malaria transmission through its effects on the activity and survival of mosquitoes. Mosquitoes survive better under conditions of high humidity and they also become active when humidity rises [3] as common in the equatorial tropical zone of Africa.

The variability of these climatic elements constitutes a serious drive to malaria outbreaks. In recent years, a number of studies have tried to quantify the impact of global climate change, climate variability and extreme climate events on malaria incidence [4]. Bomblies, Arme & Elfatih [5] for example established a link between mosquito mortality and daily average temperature. Specifically, the study found that high temperature (or low precipitation) decreases daily survival probability of mosquitoes, mosquito abundance, and the fraction of infected mosquitoes that survive an extrinsic incubation period. Also, rainfall was found to increase the abundance of breeding grounds of mosquitoes [6]. Although malaria is climate-driven, there are limited studies linking climate variability and malaria disease transmission in the Buea municipality. The understanding of the complex climate and malaria relationship is thus needed to better explain the malaria burden in the Buea Municipality since the number of malaria cases has been on an increase.

2. MATERIALS AND METHODS

2.1 Climate and Malaria Outpatient Data Collection

The association between climatic variability and number of malaria outpatients in the villages around the study area was investigated. The study area is the Buea municipality which is the capital of the South West Region of Cameroon located on the eastern slopes of Mount Cameroon with a population of about 150,000 inhabitants.

A record-based cross-sectional design was used for this study. Malaria outpatients' data of all ages were collected from the Regional Delegation of Public Health between 2010 and 2014. Monthly malaria data for these years were collected for the analysis. Six health practitioners from private and public health units spatially distributed in the study area were interrogated to get information on the various periods when malaria transmission is highest to complement the data collected from the Regional Delegation of Public health. The meteorological data from 2009 to 2014 were records supplied by the Cameroon Development Cooperation (CDC) weather station. Monthly records of temperature and rainfall were collected during the study periods. Monthly averages of temperatures and rainfall were calculated and used for comparison with malaria incidence within the same periods.

2.2 Analysis of Climate Variability and Frequency of Malaria Epidemics

Patterns of observed monthly rainfall and temperature variability were analyzed using Microsoft Excel. The months were further divided into the rainy season (March, April, May, June, July, August, September and October) and dry season (November, December, January and February) and seasonal rainfall and temperature for the study period were then calculated. Mean monthly rainfall and temperature and standard deviation was calculated and presented in tables using Microsoft Excel. Monthly and seasonal averages of rainfall, temperature and malaria case numbers were presented in tables and a comparison was made to determine periods during which malaria transmission was highest. The Statistical Software for Social Science (SPSS) version 2.0 was used to run a Pearson correlation analysis to determine the relationship between malaria incidence and climate variability.

3. FINDINGS

3.1 Climate Variability

3.1.1 Monthly variability of rainfall and temperature

Findings revealed that the highest amount of rainfall was recorded in the months of July and August which is the rainy season period. The lowest amount of rainfall was also recorded in the months of December, January and February (Fig. 1) which also corresponds to the dry season period.

Findings also revealed that the highest temperature was experienced in the month of February, March and April which is the transitional period from dry season to rainy season. High temperatures were also recorded in November (Fig. 2) which is the transitional period from rainy to dry season and during the months of December and January which is the dry season period.

3.1.2 Annual temperature and rainfall variability

Results show that temperature has increased between 2010 and 2011 but is stable from 2012 to 2014. The highest temperatures (27.2℃) was recorded in 2012 and 2014 while the lowest temperature (26℃) was recorded in 2010. The average temperature recorded within this period was 26.8℃ and the standard deviation was 0.46℃. Annual rainfall fluctuations were also recorded within the study period. The highest rainfall (3,135 mm) was recorded in 2013 and the lowest rainfall (1,992.5 mm) was recorded in 2014 (Table 1). The mean rainfall was 2,490.3 mm and the standard deviation was 428.18 mm.

3.2 Association between Climate Variability and Malaria Incidence

3.2.1 Monthly rainfall/temperature variability and malaria incidence

The highest number of malaria cases was recorded during the months of April, November and December (Table 2) during which there is high temperature (27℃ to 28℃) and moderate rainfall (14 mm to 151 mm). The lowest malaria cases were recorded during the months of July and August during which there are relatively low temperature and high rainfall.

3.2.2 The influences of seasonality on malaria incidence

The highest number of malaria cases was recorded during the months of April, November and December (Table 2) during which there was high temperature (27℃ to 28℃) and moderate rainfall (14 mm to 151 mm). The lowest malaria cases were recorded during the months of July and August during which there was relatively low temperature and high rainfall.

3.2.3 Annual rainfall/temperature variability and malaria incidence

The highest malaria case numbers (37,741 cases) were recorded in the year 2012 followed by 36,231 cases in 2013 during which annual temperature was 27.7℃ and 27℃ for 2012 and 2013 respectively and annual rainfall was 2,188.6 and 3,135 for both years as well (Table 3). The lowest malaria case numbers were recorded in the year 2010 with an annual temperature of 26℃ and rainfall of over 2,290 mm (Table 3).

3.3 The Relationship between Climate Variability and Malaria Incidence

Results of Pearson Correlation (r=0.8) between temperature and malaria incidence shows that these two variable are positively related. With a P value of 0.04 at 0.05 level of significance, it can be concluded that there is enough evidence to show that the correlation between temperature and malaria incidence was statically significant. On the other hand, the Pearson correlation analysis (r = -0.07) between rainfall and malaria incidence shows that rainfall and malaria incidence have a weak negative relationship. With a P value of 0.6 at a 0.05 level of significance, we can conclude that there is not enough evidence to indicate that the correlation between rainfall and malaria incidence was statistically significant.

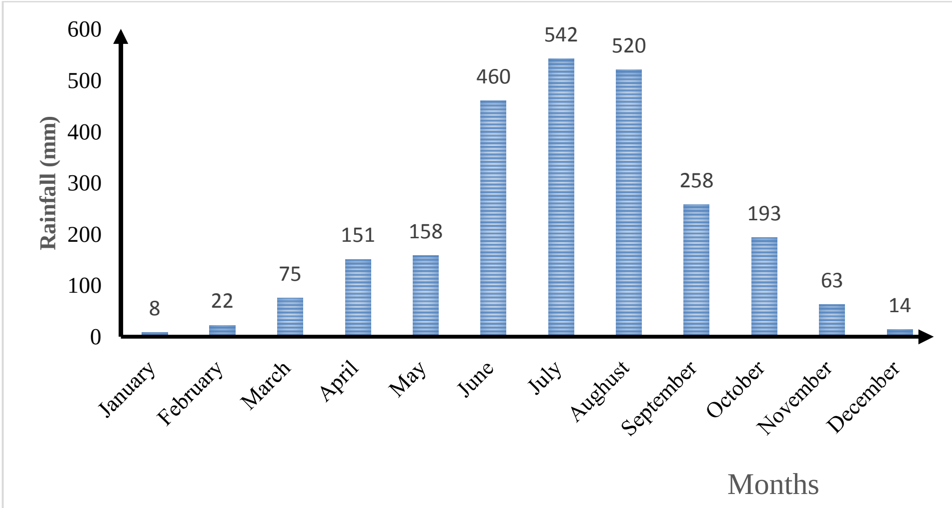

Fig. 1. Mean monthly rainfall variability from 2010 to 2014 in the Buea municipality

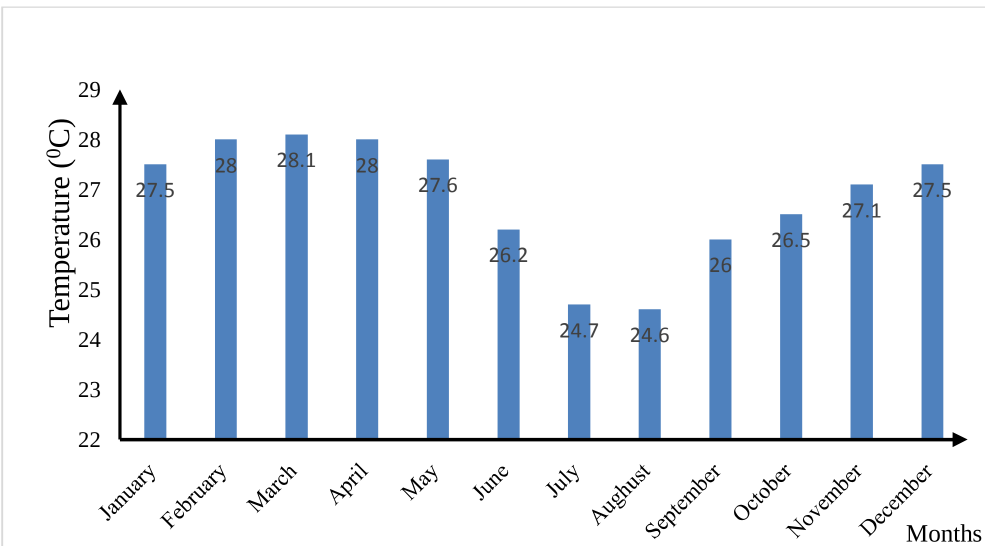

Fig. 2. Mean monthly variability of temperature from 2010 to 2014 in the Buea municipality

Table 1. Annual rainfall variability in the Buea municipality from 2010 to 2014

Year	Annual average temperature (°C)	Annual total rainfall (mm)
2010	26	2,293.6
2011	26.5	2,841.8
2012	27.2	2,188.6
2013	27	3,135
2014	27.2	1,992.5
Average	**26.8**	**2,490.3**
Standard deviation (Std)	**0.46**	**428.18**

Table 2. Average monthly temperature, rainfall and malaria cases in the Buea municipality from 2010 to 2014

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Temp (℃)	27.5	28	28.1	28	27.6	26.2	24.7	24.6	26	26.5	27.1	27
Rainfall (mm)	8	22	75	151	158	460	542	520	258	193	63	14
Malaria cases	2155	2131	2273	3188	2447	2771	1917	1920	2509	2812	3042	3294

Table 3. Association between annual rainfall variability and malaria incidence

Year	Annual average temperature (℃)	Annual total rainfall (mm)	Total malaria cases
2010	26	2,293.6	23,697
2011	26.5	2,841.8	25,983
2012	27.2	2,188.6	37,741
2013	27	3,135	36,231
2014	27.2	1,992.5	29,147
Average	26.78	2,490.3	30,559.8
Standard deviation (Std)	0.46	428.18	5,545.68

4. DISCUSSION

The temperature observation from the CDC weather station within the period of study ranged from 23.5℃ to 28℃ which is within the range that supports malaria transmission. High temperatures occur mostly between November and February (dry season) while low temperatures generally occur between July and August in the study area (rainy season). Monthly rainfall observations ranged from 18 mm to 528 mm meanwhile the highest malaria numbers were recorded in the months of March and April (transitional periods from dry to rainy season) and November and December (transitional periods from rainy to dry season). These are periods with very high temperature/humidity and moderate rainfall which are favorable conditions for the breeding of mosquitoes. This is similar to the findings of Patz et al. [7] who found an increase in malaria cases as a result of an increase in temperature and humidity. Malaria case numbers registered were lowest in the months July and August during which temperature is lowest coupled with very high rainfall that causes overland flow which washes off mosquito eggs from pools of water. Another possible reason to explain the low malaria case numbers in July and August may be because majority of Buea residents are away from their homes during summer vacation. This corroborates studies undertaken by Goufa Z et al. [8].

The Pearson Correlation analysis (r=0.8) for temperature and malaria incidence shows there is a strong positive relationship between these two variables. This implies that as temperature increases, there is likely going to be an increase in malaria cases everything being equal. This is similar to the finding of WHO (2012) [2]. The Pearson correlation analysis (r = -0.07) for rainfall and malaria incidence shows that rainfall has a weak negative relationship with malaria incidence. This means that as rainfall increases, there is likely going to be a small decrease in malaria incidence everything being equal. This may be because as rainfall increases beyond a certain threshold, it creates overland flow that can sweep away mosquito eggs from pools of standing water which are favorable habitats for mosquitos leading to less mosquito population and low malaria incidence as result of this. This finding contradicts the results of Patz et al. [7] who indicated a positive relationship between rainfall and malaria incidence. However, temperature was found to be very important as a driver for malaria outbreaks than rainfall in the study area which is similar to findings of studies undertaken by WHO (2012) [2].

The main limitation of this study is that it took into consideration the incidence of malaria in the study area which represents just new cases of malaria per 100,000 people per year. This assumes that all the cases registered are new cases of malaria in the study area. However, the data is not very accurate because the same individual can get tested and diagnosed with malaria being positive more than once in a year due to drug tolerance to the malaria disease in some individuals.

5. CONCLUSION

This study demonstrated the important role of climate variability in malaria dynamics in the villages within the Buea Municipality. The climatic factors considered for this study were rainfall and temperature. Mean monthly, seasonal and annual variations in rainfall and temperature were analyzed. High temperatures were recorded in the dry season than in the rainy season and high rainfall was recorded in June, July and August in the rainy season. A general increase in annual temperature was noticed from 2010 to 2012 while the annual temperature was constant in 2013 and 2014. Fluctuations in annual rainfall were also noticed. Malaria transmission was highest during seasonal transition periods. The relationship between climatic elements and malaria incidence suggests that there is a strong positive correlation between temperature and malaria incidence which is statistically significant and a weak negative correlation between rainfall and malaria incidence which is not statistically significant.

6. RECOMMENDATIONS

Based on the findings, the following recommendations have been proposed;

- The study area was found to be vulnerable to the effect of climate variability as seen by its impacts on the health sector. There is a need for the government to integrate climate variability in health policy and ensure that all health programs take climate variability concerns in their plans and operations. Through this, the sector can be able to adapt and minimize the direct and indirect impacts of malaria on the population.
- Malaria treatment should be subsidized in the health institutions especially during transitional periods.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World Health Organization (WHO). World Malaria Report: 2012; World Health Organization: Geneva, Switzerland; 2012.
2. World Health Organization (WHO). World Malaria Report: 2010; World Health Organization: Geneva, Switzerland; 2010.
3. CDC. Center for Disease Control and Prevention. Department of Health and Human Services; 2004.
   Available:http:/www.cdc.gov/diagnoses_treatment/diagnosis.htm
   (Accessed on 06.06.08)
4. IPCC (Intergovernmental Panel on Climate Change). Climate Change. 2007: Impacts, Adaptation and Vulnerability. In Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Parry, M.L., Canziani, O.F., Palutik of, J.P., van der.
5. Bomblies Arme, Elfatih. Assessment of the Impacts of climate shifts on malaria transmission in the Sahel, Eco Health, 2009;26-437.
6. Egbendewe-Mondzozo AK, Musumba M, McCarl BA, Wu X. Climate change and vector- borne diseases: An economic impact analysis of malaria in Africa. Int. J. Environ. Res. Public Health. 2011;913–930.
7. Patz JA, McGeehin MA, Bernard SM, Ebi KL, Epstein PR, Grambsch A, Samet JM. The potential health impacts of climate variability and change for the United States: executive summary of the report of the health sector of the US National Assessment. Environmental Health Perspectives. 2000;108(4):367.
8. Guofa Zhout, et al. Climate variability and malaria epidemics in the highlands of East Africa. Trends in Parasitology. 2005;21.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/22868