ANALYSIS OF THE SEASONAL DISTRIBUTION OF RAINFALL AND MALARIA DISEASE IN BWARI AREA COUNCIL OF THE FEDERAL CAPITAL TERRITORY, NIGERIA

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ABSTRACT
Malaria has become a great concern globally and has impacted negatively on the economies of developing nations. This aim of this study is to ascertain the influence of seasonal distribution of rainfall on the prevalence of malaria disease in Bwari area council of the Federal Capital Territory, Abuja, Nigeria. It was done to identify the most important determinants of malaria transmission, assess whether global warming was the leading cause of increased morbidity, and know the mortality rate ascribed to malaria in the area. Data used were of malaria cases from 61 hospitals in the area from 2008 to 2016. Meanwhile, rainfall and temperature data from 2008 to 2015 were collected from NIMET, Abuja. The methods employed were the correlation analysis statistical tool, radial basis function, kriging, and ANOVA Statistics. The results showed a higher prevalence of malaria observed in 2008; it seemed unlikely to have occurred due to chance, p-value, (χ^2) F stat, and p-value. The prevalence of malaria appears to have reduced progressively over the years, after which it declined in 2012, as depicted. Hence, the temperature and rainfall weather conditions have a relatively high influence on malaria prevalence in Bwari Area Council.
Keywords: Rainfall, Malaria, Mosquitoes, Disease, Morbidity

INTRODUCTION

Some environmental hazards facing human activities in recent times are climate-related (Ayoade, 2004). Given this, understanding the complex interrelationships between the atmosphere and those hazards is vital for solving these challenges. (Patz *et al.,* 2000). Rainfall acts as both a resource and a hazard to human beings if too much; the resource (anything that is of value to man) value of rainfall has to be optimized while the hazards posed by rainfall have to be managed (Omonijo, 2010). More importantly, it is observed that rainfall and its distribution have a devastating influence on the spread and expansion of insect species (Mosquitoes) and malaria cases (Hales, Wet, and Maindonald, 2002).

Malaria is greatly influenced by rainfall in the tropics. It creates an opportunity for *anopheles* mosquitoes to lay eggs, which can reach adulthood within nine to twelve (9- 12) days, necessary for the mosquito life cycle. Rainfall is one of the climatic variables that aid in multiplying mosquito breeding places and increases humidity, improving mosquito survival rates (Eludoyin and Weli, 2012). The rainy season is a fertile period for the numerous breeding sites. These species have the highest population density during the rainy season, accounting for the high incidence of malaria at this period of the year (Reid, 2000). Studies have established a complex relationship between malaria and rainfall because water is vital for larval development. A prolonged dry season can decrease mosquito numbers by reducing breeding sites and also minimizes malaria incidence.

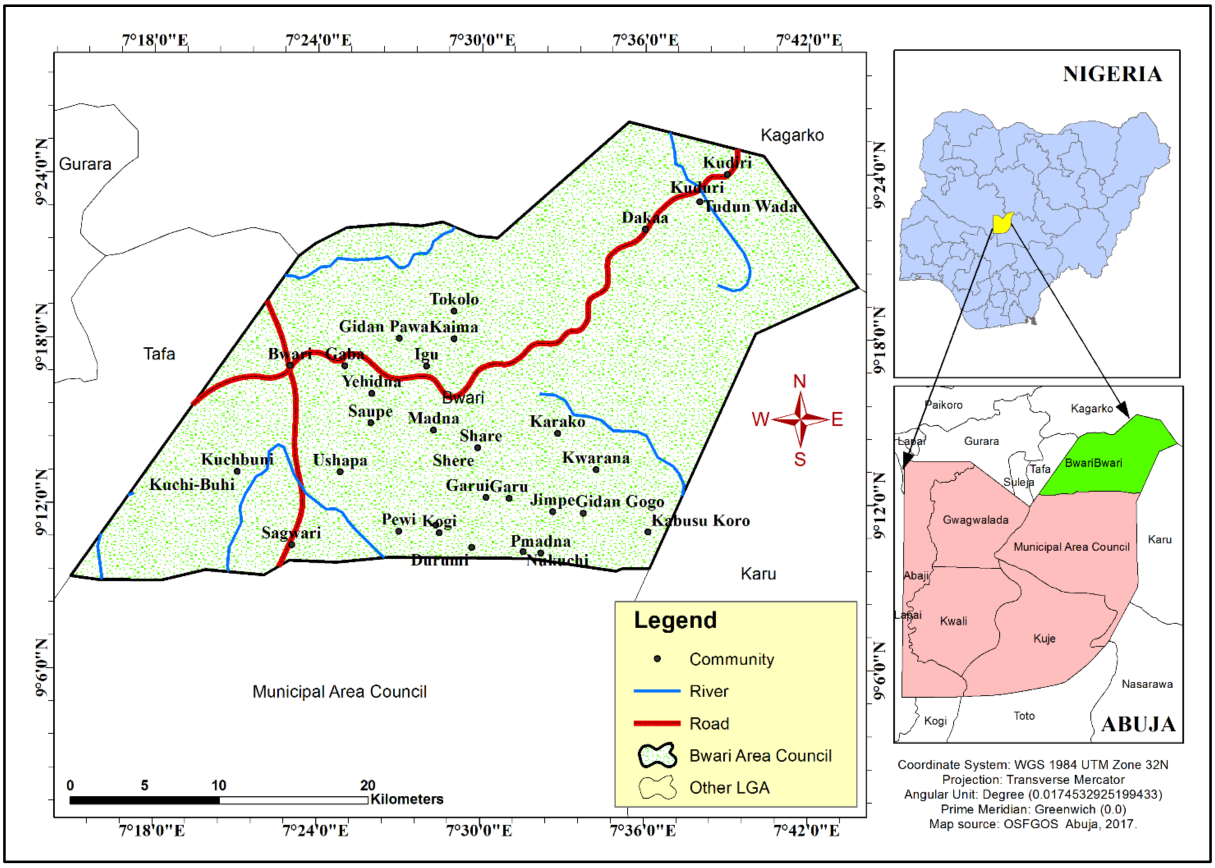
Malaria, which is an ancient disease, remains a major killer in many tropical regions of the world today (World Health Organization, 2004). It causes around 1 million child deaths annually (World Health Organization, 2003). In view of this, the governments of countries of Africa continent gathered in Abuja, Nigeria, to launch the Roll Back Malaria" program at the Abuja Malaria Summit in April 2000. The goal of Roll Back Malaria is to reduce the burden of malaria by half by 2010. A series of targets for realizing this goal in Africa were set at the Summit. This included the target that 60% of malaria occurrences should be detected within two weeks of onset (Alaba and Alaba, 2009).

In Nigeria, different interventions and policies to reduce morbidity from malaria diseases have been introduced at national and state levels. For example, Ondo State used to give insecticide-treated mosquito nets to pregnant women for free treatment of malaria diseases for pregnant women and children under the age of 5 years at the state government hospitals (Ondo State Ministry of Health, 2005). Other states have followed suit. Drugs and combination therapies such as "*artemether* and *lumefantrine*; *artesunate* and *amodiaquine*" for malaria treatment had been introduced by the National Malaria and Vector Control Division of the Federal Ministry of Health, believed to be more effective in combating malaria disease than the traditional "Chloroquine" (Aruna *et al*.,2009)

In the Bwari Area Council and environs, weather and climate tend to affect the spread of malaria. However, there are no demarcated seasons in Bwari because rain tends to fall virtually throughout the year, and it has given rise to increased annual precipitation and high temperatures (Weli and Worlu, 2011). This increased precipitation rate stimulates mosquito breeding sites, resulting in an increased mosquito bite. Due to the urbanization process going on in Bwari Area Council, most of the natural drains have been closed, and the constructed drains are blocked with litters of garbage, hence causing areas like Dutse, Byazhin, Dei-Dei, Saburi to experience a flood, which in turn results to breeding grounds for mosquitoes (Eludoyin and Weli, 2012). Thus, mosquito larvae development is at its maximum in the wet seasons because of the increase in precipitation and poor environment management (Grover-Kopec et al., 2016). The residents of Bwari Area Council are vulnerable to mosquito bites resulting in malaria because most of the houses are within the fringes of water bodies, farm gardens, tall grasses, and flight distance from their respective breeding habitats. Mosquitoes also breed on the edges of ponds and streams, open septic tanks, open cesspools, in salt marshes, overflowing sewages, holes in stumps or trees, water barrels, clogged troughs, street catch basins, empty tin cans, and jars. People tend to suffer from the impact of mosquitoes due to their biting and piercing, leading to swollen body parts when they are in their houses or come out at night to receive cool air from their surroundings. On this basis, the following research questions can be asked (Aruna *et al.*,2009). The aim of this study therefore is to ascertain the influence of seasonal distribution of rainfall on the prevalence of Malaria in Bwari area council of the FCT, Abuja.

METHODOLOGY

This study commenced with reconnaissance visits to the community leaders, NIMET, and the Ministry of Health. From 70 copies of the questionnaire that were administered purposively to residents of the Area Council, 60 were retrieved. Data for the mean annual rainfall for the period of 8 years (2008 -2016) were obtained from the Nigerian Meteorological Agency (NIMET), Abuja. Also, the mean annual data on malaria occurrence for this same period were obtained from the Monitoring and Evaluation Unit, Ministry of Health. The relationship between rainfall and malaria for the study period was measured using correlation, while charts and tables were used to present and analyse other data.



Source: Office of the Surveyor General of the Federation (2023)

Figure 1: Bwari Area Council showing satellite towns

RESULTS

The results obtained from this study are shown in the tables and figures below. Analysis of varience was performed in the overall data set to determine the degree of variation or correlations between malaria, rainfall and the temperature factors explained from the years 2008 to 2016. The weather and climatic factors were analysed by individual pairwise comparisons (cross-correlations). A distance matrix was generated and used to compute the genetic variation observed within and among the populations, as summarised in Tables 1, 2, and 3.

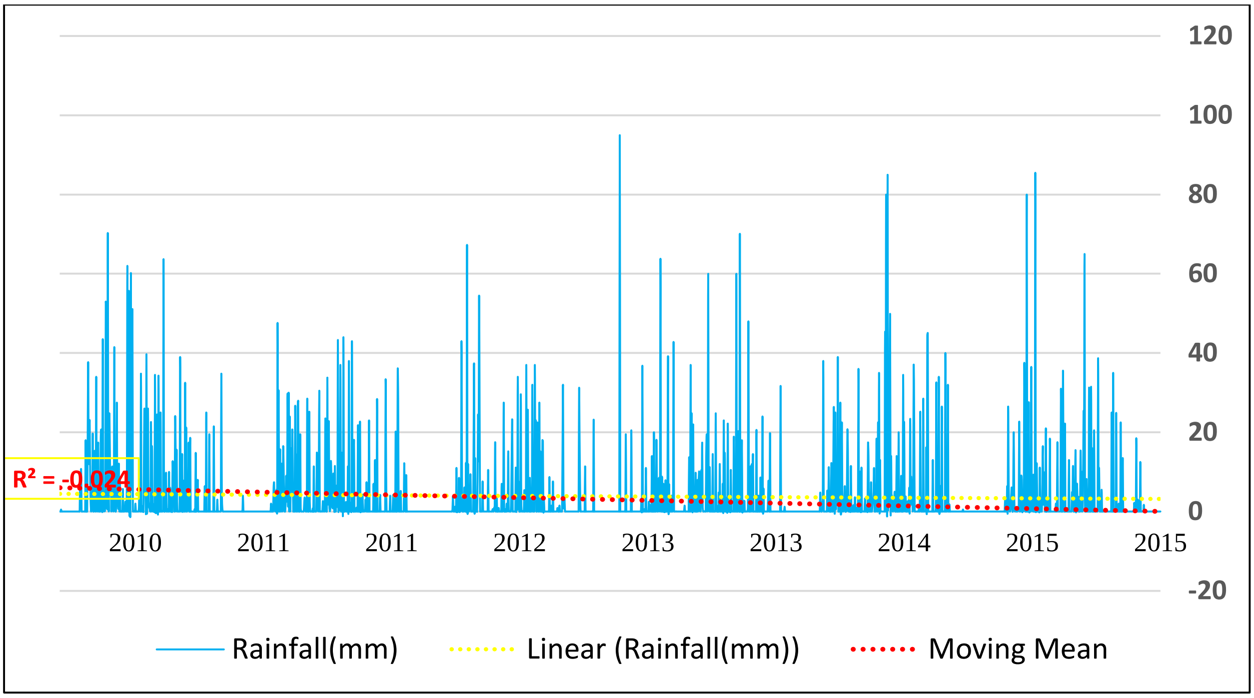


Figure 2: Temperature Seasonal variation from 2010-2015

Table 1: Linear Model Summary Temperature Influence on Malaria Incidents

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.023	0.101	-0.038	4338.226

Table 2: ANOVA Result of Temperature Influence on Malaria Incidents

	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.466	1	0.466	0.261	0.614
Residual	46.492	26	1.788		

Table 3: Growth Model Summary of Temperature Influence on Malaria Incidents

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.100	0.010	-0.028	1.337

The results show that the majority of these indices are correlated. The overall sum of squares in the regression was 0.466, and the sum of squares in the residual is 46.492, while the mean square regression is 0.466, the mean square residual is 1.788 and statistically significant p value of 0.614, and also as given by the frequency distribution or the randomised value of 0.261versus the observed (Figure 2).

Linear model summary malaria cases in 2008 analysis of the overall data set yielded a correlation coefficient (Rxy) = 0.023, $p < 0.05$ for the actual geographic distances and 0.135, $p<0.05$ with the log-transformed. A slightly significant relationship by regression analysis (R^2= 0.101) was observed between the genetic and actual geographic distances of the variables. The analysis performed with the log-transformed geographic distances showed even less statistical significance by regression analysis (R^2 = 0.010). Based on these observations, the H_0 was accepted. Hence, the temperature and weather conditions have a relatively low influence on malaria prevalence in the Bwari Area Council.

Also, ANOVA was performed in the overall data set to determine the degree of variation or correlations between malaria and the rainfall factors explained from 2008 to 2016. The weather and climatic factors were analysed by individual pairwise comparisons (cross-correlations). A distance matrix was generated and used to compute the genetic variation observed within and among the populations, as summarised in Tables 4, 5, and 6.

Table 4: Linear Model Summary Rainfall Influence on Malaria Incidents

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.010	0.009	-0.038	552.284

Table 5: ANOVA Result of Rainfall Influence on Malaria Incidents

	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.057	1	0.057	0.067	0.797
Residual	22.150	26	0.852		

Table 6: Growth Model Summary of Rainfall Influence on Malaria Incidents

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.051	0.003	-0.036	0.923

The overall sum of squares in the regression was 0.466, the sum of squares in residual was 22.150, the mean square for regression was 0.057, the mean square for residual is 0.852 slightly statistically significant P (rand >= data) of 0.797, and also as given by the frequency distribution or the randomised value of 0.067 versus the observed.

Linear model summary of rainfall influence on Malaria Incidents analysis of the overall data set yielded a correlation coefficient (Rxy) = 0.010, $p< 0.05$ for the actual geographic distances and (Rxy) = 0.051, $p<0.05$ with the log-transformed. A slightly significant relationship by regression analysis (R^2= 0.09) was observed between the malaria cases and actual rainfall variables. The analysis performed with the log-transformed geographic distances showed an even greater statistical significance by regression analysis (R^2 = 0.03). Based on these observations, the H_0 was accepted but not strongly indicative of a. Hence, the rainfall weather conditions have a relatively low influence on malaria prevalence in the Bwari area council.

Table 7: Records of malaria cases from 2008 to 2016

Year	Reported cases	%
2008	20513	26.77
2009	17849	22.98
2010	19105	25.00
2011	11648	14.28
2012	1865	2.40
2013	2155	2.77
2014	2271	2.92
2016	2232	2.86
Total	**77638**	**100.00**

The higher prevalence of malaria observed in 2008 seemed unlikely to have occurred due to chance, p-value, (χ^2) F stat, and p-value (F), as shown in Table 7. The prevalence of malaria seemed to have reduced progressively over the years, after which it declined, as depicted in Figure 3.

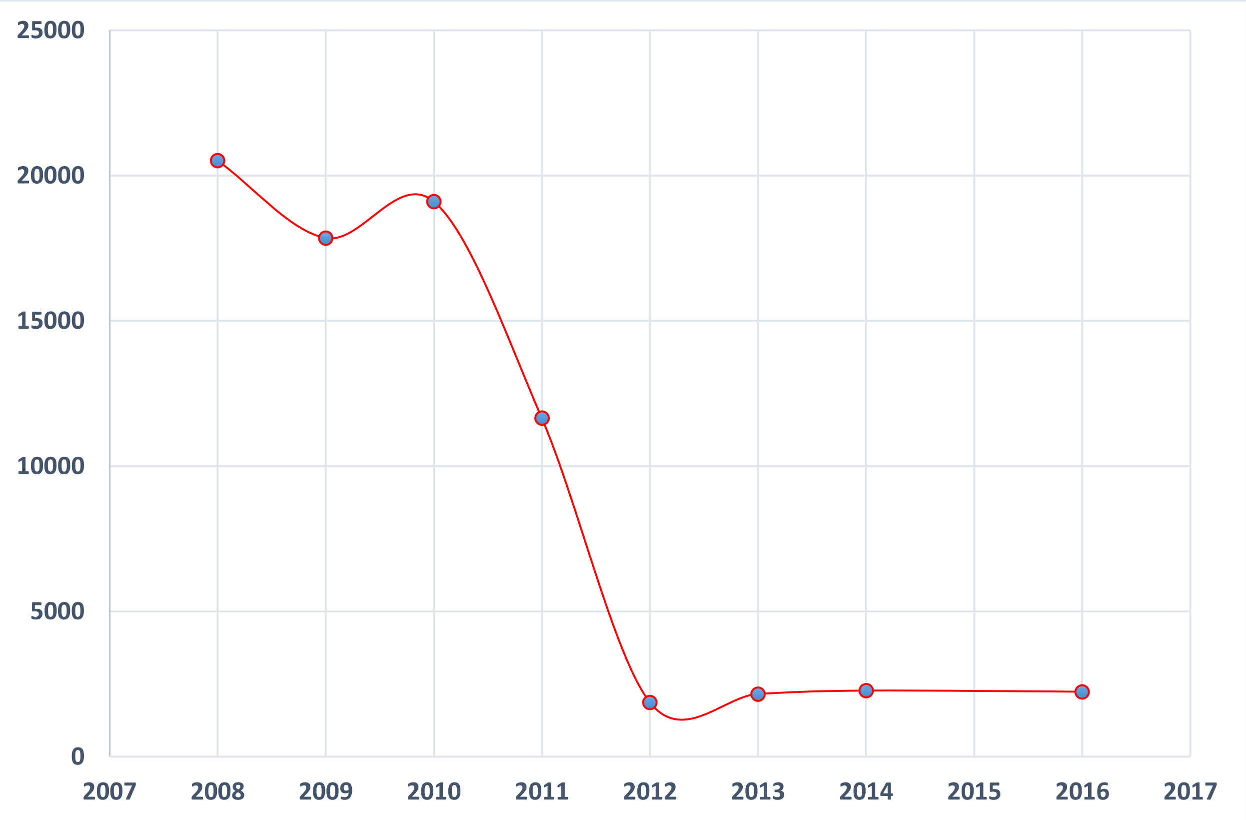


Figure 3: Reported malaria cases from 2008 to 2016.

DISCUSSION

The study focused on how climate variability has influenced the malaria epidemic in the Bwari area council of F.C.T, Abuja. It also explored the possible relationship between climate variability and malaria and corresponding coping strategies. Rainfall plays the most important role in influencing the malaria epidemic both directly and indirectly, though the rise in temperature also contributes (Aruna *et al.*, 2009). Directly, it has created many breeding grounds and sites for mosquitoes, and indirectly, strong and more concentrated rains have induced landslides, erosion, and degradation of the soil and fields in the higher-altitude villages (Eludoyin and Weli, 2012). The effects of heavy showers compared to the continuous drizzling effects of rainfall definitely influence the harmful effects of rainfall run-off. These effects are not captured in the daily statistics showing rainfall for the whole day. All these impacts of climate variability influencing deterioration of the soil and degradation of cultivated land have indirect impacts on the prevalence of malaria (Aruna *et al.*, 2009). Their socio-economic condition forces some people to leave the rural settlement and go to the urban part of Bwari Area Council either to settle, look for work entertainment, or access some social services like health centers and schools, as seen on the maps (Ayoade, 2004). Climate variability plays an important role in that seasonal weather and climatic conditions indicated through heavy rainfall and high temperature have been varying, hence increasing susceptibility to diseases like malaria (Eludoyin and Weli, 2012). Studies have revealed that malaria epidemics have increased in areas originally considered malaria-free zones, like the higher-altitude village of Bufukhula (Ayoade, 2004). This shows that there have been variations in climatic conditions, especially temperature, which have enabled mosquitoes to find suitable habitats in areas that have historically not faced malaria risk. This has resulted in climate variability-induced malaria. The population at this high altitude is vulnerable due to low immunity. The change in temperature in recent years has also played a role in the breeding and survival of mosquitoes (Eludoyin and Weli, 2012). This partly explains why the population at higher altitudes is now affected by the malaria epidemic, especially in 2008. In 2010, the minimum temperature ranged between 20-25°C and the maximum temperature ranged between 30-40°C (Aruna *et al*., 2009).

CONCLUSION

The findings from this study reveals that in the Bwari Area Council, all age groups are at equal risk of being attacked by malaria. This is because of the (increasing) breeding of mosquitoes, which bite at any time in the evening and early morning when they go to the bushes. The result of this study therefore suggests that there are hot spots in the study area. It is recommended that regular cleaning of drains and the surrounding environments on monthly basis should be intensified, as well as the distribution of mosquito's insecticide net by the three tier of government.

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