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IMPACTS OF CLIMATE CHANGE ON THE INCIDENCE OF MALARIA AMONG AIR FORCE COMPREHENSIVE SCHOOLS: A CASE STUDY OF AIR FORCE COMPREHENSIVE SCHOOL, AGBANI-ENUGU

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ABSTRACT

Global climate change is expected to increase the incidence of vector-borne diseases, especially malaria. This study assessed the contribution of climate to a malaria epidemic in Enugu state, using Nigerian Air Force Comprehensive School, Agbani-Enugu as a case study. Five Years Malaria cases were collected from the School Medical Centre - where a diagnosis was consistent and non–climate variables well monitored. Lately, the prevalence of malaria in the school has increased with increasing frequency of students missing academic activities due to hospital admission. Pearson's correlation coefficient was used to compute the relationship between temperature variability and malaria cases in AFCS, Agbani-Enugu, and the result show that 99.99% of malaria transmission was attributing to climate variability. A steady fluctuation in the temperature regime from the least 26^{o}c to 27^{o}c plays a significant active role in increasing the incidence of Malaria cases in the School. One of the recommendations is that every student(s) should sleep under a insecticide mosquito net. Also there is the urgent need for a regular workshops and seminars on the relationship between climate change and malaria incidence as well as vector control programmes.

Keywords: Climate change, Malaria, Air Force Comprehensive Schools, Agbani-Enugu, Nigeria

INTRODUCTION

The World Health Organization (WHO) and the World Meteorological Organization have identified malaria as one of the most climate-sensitive diseases with a wealth of evidence suggesting significant associations between change in temperature, rainfall and humidity and malaria incidence. SDGs, (2015). The relationship between human health and weather has been

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established through direct results of research findings. Scientists argued that climate variation have a direct impact on the epidemiology of many vector–borne diseases especially malaria Omotosho (2007). According to Graham (2011) and Gadzama (2010) to the greatest surprise of many well – informed people in developed countries, malaria remains a major problem in the world today. The article also states that, although figures may not be very reliable, it was estimated that in 2008 one fifth of the world's population was at risk of malaria, leading to 240 million episodes and some 850,000 deaths, the majority occurring in Africa. Graham noted that, five countries, namely Nigeria, Democratic Republic of Congo, Uganda, Sudan, United Republic of Tanzania account for 50% of deaths. Just fifteen (15) countries now account for all deaths. Malaria is a major public health burden in the tropics, with potential to significantly increase in response to climate change Epstein (2006). Over the past century, the world has warmed by 0.6 degree Celsius, with a range of ecological consequences Ojo et al (2013). They state that, malaria kills over one million people each year, while 300 to 500 million people are suffering from chronic malaria around the world. This is one of the most common and serious disease of our time Epstein (2000). The disease thus constitutes a great burden on the already depressed Nigerian economy. Malaria causes great misery to sufferers, and adversely affects the social and psychological wellbeing of individuals, families and the nation at large (Lazarus, 2012). In Nigeria, a study by the United States Embassy in 2011 revealed an estimated 100 million malaria cases with over 300,000 deaths per year Alero (2016). The death toll is predicted to double in the next 20 years if no new control measures are developed Ojo et al (2013).

The International Panel on Climate Change (IPCC, 2001) has concluded that anticipated changes in temperature and rainfall will affect the natural habitats of mosquitoes, changing the prevalence of the vector or prolonging transmission seasons or both in some areas, and potentially exposing new regions and population to malaria and other vector-borne diseases Patz J.A et al., (2005)

There are many potential health impacts arising from climate change. Some of these impacts are beneficial, but many are very adverse. These impacts could also be direct or indirect. For example, deaths resulting from heat waves or cold spells are direct but deaths caused by changes in the range and transmissibility of vector-borne infection diseases are indirect IPCC, (2001). According to Ajadike (2008), indirect impact also includes deaths resulting from malnutrition (as a result of increasing food insecurity, lack of safe and adequate drinking water (as a result of pollution) and climate change would indirectly impact on public health which depends a lot on many factors including sufficient food, safe drinking water, secure shelter, good social conditions; and a suitable environmental and setting for controlling infectious diseases.

The impacts of climate change include warming temperatures, changes in precipitation, and increases in the frequency or intensity of some extreme weather events, and rising sea levels

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USGCP (2016). These impacts threaten our health by affecting the food we eat, the water we drink, the air we breathe, and the weather we experience Schiff (2002).

The severity of these health risks will depend on the ability of public health and safety systems to address or prepare for these changing threats, as well as factors such as an individual's behaviour, age, gender, and economic status EPA (2014). Impact will vary based on where a person lives, how sensitive they are to health threats, how much they are exposed to climate change impacts, and how well they and their community are able to adapt to change Sara (1990).

Malaria is a major health problem in Nigeria with a stable transmission throughout the country Onuche (2009). It accounts for 50 percent of outpatient consultation, 15 percent of hospital admission, and is prime among the top three causes of death in the country National Malaria control plan of action 1996 to 2001. The trend is rapidly increasing due to the current malaria resistance to first-line anti-malaria drugs (Ojo, 2013; Anyasina et al, .2013).

Climate Change and Vector borne-diseases

Vector-borne diseases are illnesses that are transmitted by disease *vectors*, which include mosquitoes, ticks, and fleas Nurain (2004). These vectors can carry infectious pathogens such as viruses, bacteria, and protozoa, from animals to humans. Changes in temperature, precipitation, and extreme events increase the geographic range of diseases spread by vectors and can lead to illnesses occurring earlier in the year Nurain (2004).

Mosquito thrives in certain climate conditions and can spread diseases like malaria and dengue fevers. Extreme temperatures—too cold, hot, wet, or dry—influence the location and number of mosquitoes that transmit malaria Molta et al., (1995).

Climate change is real Ajadike (2017) and can affect human health (Willet, et al., 2007). Appropriate climate and weather conditions are necessary for the survival, reproduction, distribution and transmission of disease pathogens, vectors and hosts Anyasina (2013). Hosts refer to living animals or plants on or in which disease pathogens resides Jamulligam et al., (2008). Pathogen refers to a wide range of disease agents, including virus, bacterium, parasite germ, and fungi Kalu (1992). The impact of climate change on pathogens can be direct through influencing the survival, reproduction and the life cycle of pathogens, or indirect through influencing the habitat, environment, or competitors of pathogens. As a result, not only the quantity but also the geographic and seasonal distributions of pathogens may change Kanu (1992).

The Temperature may affect disease by impacting the cycle of pathogens, first, a pathogen needs

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a certain temperature range to survive and develop. For example, a minimum temperature of $22^{0}C$ - $23^{0}C$ is required for mosquito development. Excessive heat can increase the mortality rates for some pathogen (Kuhn et al., 2005). The development of malaria parasite (Plasmodium Falciparum and Plasmodium vivax) cease when the temperature exceeds $33^{0}C$ - $39^{0}C$ (Patz et al., 2005) cited in Vezzulli et al., (2016). According to Githeko (2000) cited in Samdi et al (2012) warming of $34^{0}C$ generally has a negative impact on the survival of vectors and parasite. Change in precipitation may impact disease vectors and hosts as well. Many vector-borne infectious diseases are found to be positively associated with rainfall. Larval development of some mosquito vector accelerates with increased rain and rising temperature (Hatakoshi, et al and Morse, 2000). Adult Anopheline, a vector of malaria, reproduce in small natural ponds of clean water; droughts may limit the quality of the breeding site for these mosquitoes, resulting in a reduction in vector population and disease transmission Gentile et al., (2001). However, rainfall is not always favourable to vectors. Excessive precipitation may have catastrophic impacts on mosquito population because strong rain may sweep away their breeding sites (Kuhn et al., 2005).

Many disease hosts tend to respond strongly to humidity change. Relative humidity affects malaria transmission by impacting the activity and survival of mosquitoes. If the mean monthly relative humidity is under 60%, the lifespan of malaria vector mosquito become too short to incur malaria transmission Vezzulli et al., (2016). Low humidity when coupled with high temperature, constitute unfavorable conditions for mosquitoes to develop.

Wind is a key factor affecting the pathogen of airborne disease. Wind has dual effects on disease vectors/hosts. Wind may affect the malaria cycle both negatively and positively. Strong wind can reduce the biting opportunities for mosquitoes, but can extend their flight distance Kent et al., (2007).

Rainfall, temperature, and humidity are the three main variables that can strongly influence transmission of malaria and climate change will affect all the three factors. According to Ajadike (2008) increase in rain, warmer temperature and humidity create perfect condition for the spread of the plasmodium parasite that causes malaria.

Challenges of Malaria Diagnosis and Management in Underserved Environments

The diagnosis and management of malaria at an individual level presents major challenges for health care providers. The first challenge is that symptoms may be indistinguishable from many other simple or serious conditions from viral illness or dengue fever to life-threatening cerebral malaria or epidemic meningitis Robert (2001). A diagnosis of malaria infection is confirmed by taking a blood sample, adding a chemical stain, then examining under a microscope. This is

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made more difficult in a rural region where microscopes and skilled microscopes are not available, and a low concentration of parasites in the blood may be virtually undetectable yet still cause symptoms. Schiff et al.,(1993) Newer rapid diagnostic tests relying on a simple colour change when blood is added to filter paper may partly overcome this problem. Another complication is that a child or adult with a degree of immunity may have parasites present in the blood yet be quite well, or suffering from another cause of fever. A second challenge is to provide the correct medication on the assumption of a correct diagnosis, at the correct dose, and ensure that all medication is consumed by a patient who may be crying, vomiting, or disinclined to continue treatment when symptoms start to subside. A third challenge is the emergence of resistance of malaria to cheap, easily available drugs and the need to use combinations of drugs that may have side-effects, or require longer terms of administration Schaefer (1991). A fourth challenge is that drugs effective for acute treatment of symptomatic disease may neither be effective against the sexual forms of the parasite that maintain transmission when a mosquito bites again, nor for eradication of long-lasting forms of two species (*P. vivax* and *P. ovale*) that have the troublesome characteristic of relapsing from dormant liver stages months or years following initial infection, to cause recurrent illness Graham (2011).

In Air Force Comprehensive Secondary school Enugu, environmental conditions are already favorable for malaria transmission. Weather and climate tend to affect the spread of malaria. Climate suitability for the transmission is defined as the coincidence of monthly total precipitation greater than 80 mm, mean temperature between 18^0C and 32^0C, and relative humidity greater than 60% Oguche et al., (2006). There are several vulnerable areas, the students' hostels, especially the boys' hostels with decayed infrastructures. For example, the old abandoned toilet, old soaks way and septic tanks. The students are vulnerable to mosquito bite resulting in malaria because the school is within the border of semi-forest vegetation, farmlands and tall grasses. In the rainy season, mosquito's larvae development is at maxima because apart from an increase in precipitation due to climate change, the school is located in a valley where runoff from the environs flow through the school with some water sluggishly deposited into marshes creating breeding habitats for mosquitoes. Also, mosquitoes breed in old and open septic tanks. Malaria affects student's development and compromise future productive capacity due to absenteeism from school. Directly or indirectly, malaria impairs the ability of students to study adequately by losing productive time in the hospital. The illness is not only threatens the academic excellent performance of the school but also generates new financial burden to cover medical treatment. The students and personnel suffer from the impact of mosquito bite especially during prep-periods at night. In the recent times, the incidence of malaria among the students and their supervisors is increasing.

The objective of the study is to assess the impact of climate variability on the increasing

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incidence of malaria among the students of Nigerian Air Force Comprehensive School, Agbani-Enugu. The study is designed to source temperature data from Nigerian Metrological Station Enugu (ESUT) and data of malaria cases from the Nigerian Air Force comprehensive School Medical Center Agbani- Enugu.

LOCATION AND DESCRIPTION OF THE STUDY AREA

Enugu urban lies approximately between latitude $6^{0}20'$ N and $6^{0}30'$ N and between $7^{0}26'$ E and $70^{0}37'$E. The total area coverage is approximately 72.8 square kilometres. Enugu urban comprises three council areas; Enugu North, Enugu East, and Enugu South Local Government Area. It is bounded in the east by Nkanu LGA, in the west by Udi LGA, in the North by Igbo-Etiti and Isiuzor and in the south by Nkamu west LGA. The soil ranks among the poorest Nigerian soils because of its low natural fertility and the soil is prone to erosion. There are two distinct seasons, dry season from November - Match and the rainy season from April - October. The vegetation in Enugu lies under Rain Forest and Woodland – Tall Grass Savannah.

The study area is located in a town called Agbani, a town in Nkanu West LGA, Enugu. It is situated about 35 kilometers from Enugu City. Agbani town is seen as a student town because of the presence of several institutions of learning, these include; the Nigerian Law School, Enugu State University of Science and Technology (ESUT), Renaissance University, Mea Metea Secondary School and Air Force Comprehensive School (AFCS) Agbani-Enugu which was established on the 2nd of January 2002 with initial intake of 117 students into JSS1. As at the time of this study, the school has over 500 students under the leadership of Wing Commander US Ibrahim Researcher’s Field Survey (2018).

MATERIALS AND METHODS

To allow a higher focus, two research variables were selected and subjected to statistical test, using the spearman correlation coefficient. That is five years temperature record of Enugu from 2013 to 2017, obtained from Nigerian Meteorological Agency (NIMET) station ESUT. And five years cases malaria - period 2013 - 2017 obtained from Nigeria Air Force Comprehensive School, Medical Centre, Agbani-Enugu was used. The two research variables, temperature (X) represents climate factor, and malaria cases (Y) represent social factor. Non climatic variables like environmental factors and other social factors were also considered. The school is located within a wetland, marshy areas with thick vegetation resulting to mosquito breeding grounds. Land covered with vegetations is directly related to malaria incidence, as mosquitoes tend to flourish in such areas. Migration and human travel is another factor, which can result in the spread of malaria from one region to another. For example, if a student with untreated malaria

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resumed to school, he can transmit the disease to another student.

Malaria cannot spread without mosquitoes. Therefore mosquito control is one of the best measures for malaria eradication. The school has a programme of DDT spraying a week before the school resumes for every term. If this effort is sustained, there will be a massive reduction of malaria incidence in the school. Another important factor worthy of mention is resistance to the drug chloroquine. Chloroquine resistance has been identified as an important factor for the increased incidence of malaria in the entire country. The school compound was inspected, including students' hostel facilities. At the time of compiling this study, a work was on going to replace old mosquito window nets, and faulty bulbs to improve the lightning points. Empirical observation revealed that not all of the students have insecticide - treated nets. Those students who have their insecticide – treated nets, only few of the students use it. Also, among the students who have their insecticide – treated nets, some students do not use it properly. And some students use their nets with holes allowing access to mosquito.

RESULTS

Table 1: Five years Temperature Conditions and Malaria Cases in AFCS, Agbani-Enugu

Year	Total Temp^{0}C	Mean(X) Total Temp^{0}C	Total Malaria Cases	Average Malaria Cases
2013	324.1	27.06	3008	250.67
2014	318.5	26.54	2815	234,58
2015	322	26.83	3468	289
2016	327.8	27.32	3382	281.85
2017	**327.8**	**27.32**	**3849**	**281.85**

Source: Nigerian Meteorological Agency (ESUT, 2018) and AFCS Agbani-Enugu (2018)

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Table 2: Statistical Table for Computing the Correlation between X and Y variables

S/N	X	Y	X^2	Y^2	XY
1	27.06	250.67	732.2436	62835.45	6783.1302
2	26.54	234.58	704.3726	55027.78	6225.7532
3	26.83	28 9	719.8489	83521	7753.87
4	27.32	281.85	746.3824	79439.42	7700.142
5	27.32	281.85	746.3824	79439.42	7700.142
∑	135.07	1337.95	3649.5925	360263.07	36163.0374

Source: Researcher's Field Survey (2018).

CORRELATION ANALYSIS

Table 2. X is Temperature regime (climate factor), an independent variable while Y Malaria cases (social factor), and a dependent variable. Therefore Y is dependent upon X that is the temperature verse malaria cases.

The formula for computing the Pearson's Correlation Coefficient is:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{\left(n\sum x^2 - (\sum x)^2\right)\left(n\sum y^2 - (\sum y)^2\right)}}$$

Where n = 5

$\sum xy = 36163.0374$

$\sum x = 135.07$

$\sum y = 1337.95$

$\sum X2 = 3649.5925$

$\sum Y2 = 360263.07$

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$$r = \frac{5(36167.0374) - (135.07 \times 1337.97)}{\sqrt{5 \times 3649.5925}) - (135.07)^2 \, (5 \times 360263.07) - (1337.95)^2}$$

$$r = \frac{180815.187 - 180716.9065}{\sqrt{18247.9625 - 18225} \times (1801315.36 - 1790110.2025)}$$

$$r = \frac{98.2805}{(\sqrt{162590.185})\,(16223405.1475)}$$

$$r = \frac{98.2805}{\sqrt{26366444261.9775}}$$

$$r = \frac{98.2805}{1624120.2062}$$

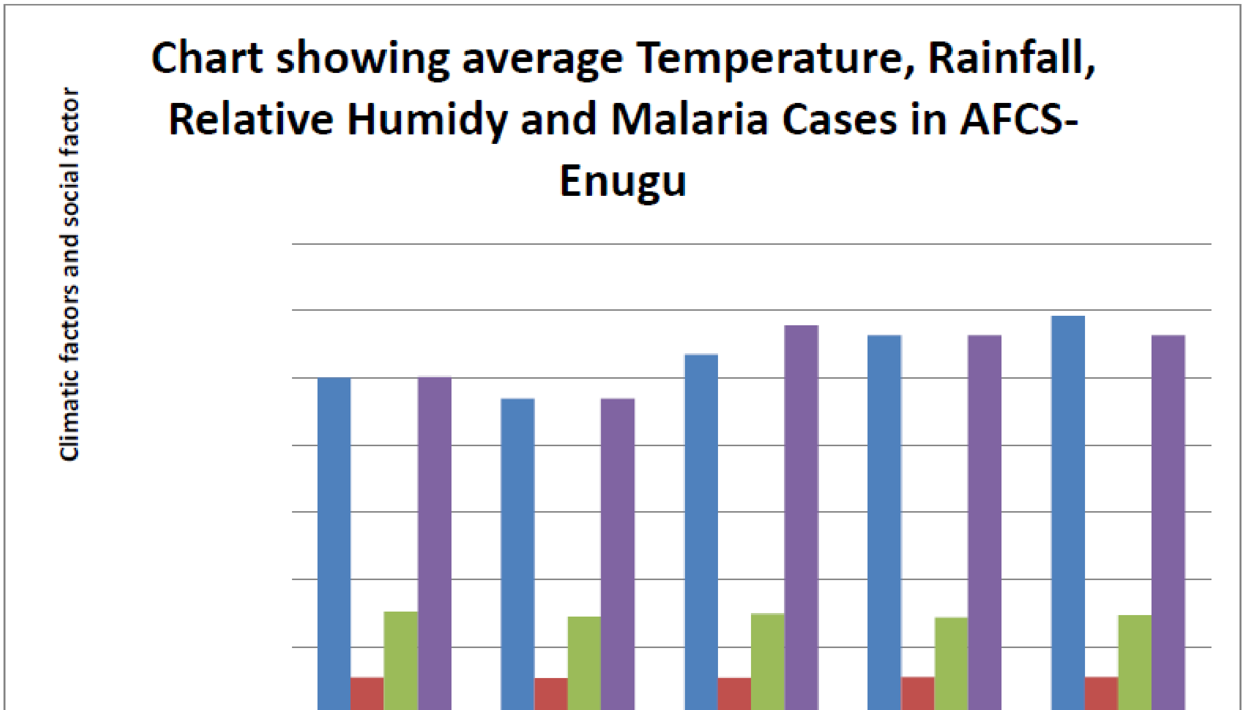
r = 0.00006051313

r^2= 0.00000000366

r = 1-0.00000000366

r = 0.9999999999634

Figure 1: Average Temperature, Rainfall and Relative Humidity and Malaria cases in AFCS, Agbani Enugu



	1st Year	2nd Year	3rd Year	4th Year	5th Year
Rainfall (mm)	250.1	234.6	267.5	281.8	296.1
Temperature (0C)	27.06	26.54	26.83	27.32	27.32
R. Humidity	75.6	72.2	74.1	71.6	73.4
Malaria Cases	250.7	234.6	289	281.9	281.9

Source: Researcher's Field Survey (2018).

RESULT AND DISCUSSION

The value of r = 0.9999, indicating a positive correlation between increase in average temperature and malaria incidence in Air Force Comprehensive School, Enugu between 2013 and 2017. This implies that 99.99% of malaria cases in AFCS Enugu can be attributed to climate variability. There was a steady fluctuation in the temperature regime from the least 26^0C to 297^0C. Malaria transmission was throughout the periods under review with the highest case recorded in 2015. The incidence of malaria remains high with about 282 cases from 2016 and 2017. The average temperature also remains at its peak with 27-32^0C.

Malaria is a disease of warm climates. The disease is a threat to students of AFCS Enugu. The

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students are more vulnerable to mosquito bite during night pre in classrooms and when they are sleeping in the hostels. The complex epidemiology of the malaria parasite and the vector and its relationship to the host and environment, temperature is of great significance in this study, therefore there is the need to properly ventilate the classrooms and hostels using ceiling fans and Air conditions.

CONCLUSION

Malaria epidemic is a serious threat to students of Air Force Comprehensive School, Enugu. A better understanding of the relationship between climate parameters and malaria cases is required for effective vector control, climate change adaptation planning and disease control. The study confirmed that, there is a positive relationship between temperature change and incidence of malaria cases in among the students of Air Force Comprehensive School, Enugu.

RECOMMENDATIONS

In conformity with the Federal Government Ministry of Health roll-back malaria programme, the following recommendations are made;

- Parents should cooperate with the school management to ensure that their children are treated of common illness especially malaria before resuming to school.
- The school management should reinforce the policy of no insecticide mosquito treated net no school. Again, every student should change his/her insecticide mosquito treaded net every session.
- The school management should extent the fumigation and DDT praying to cover all parts of the school compound including marshy areas within and outside the perimeter fence, especially during the rainy seasons when mosquito larva development is at its maximum.
- The windows of all hostels should be covered with mosquito nets, and all opened septic tanks should be covered.
- The management should ensure proper cleanliness of the entire school compound, cut grasses to get rid of mosquitoes breeding sites.
- There is the need for a regular workshops and seminars on the relationship between climate change and malaria incidence as well as vector control programmes.
- Most of the students do not like oral medications. The school Medical Centre should ensure that students complete their malaria treatment.
- The girl's hostel is renovated. The boy's hostel is due for total renewal.

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