Effect of Some Atmospheric Variables on Malaria Prevalence in Kebbi State, Nigeria


Department of Physics, Kebbi State University of Science and Technology, Aliero, Nigeria

* Author to whom correspondence should be addressed; E-Mail: malabdul01@yahoo.com; Tel.: +234-8035894585.

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Abstract: As human health is affected by many environmental factors, the importance of studying the effect of such factors on some diseases cannot be overemphasized. This paper focuses on the effects of some atmospheric variables such as rainfall, temperature and relative humidity on malaria. Three years data (i.e. 2008-2010) for both the three variables and malaria cases were collected and analyzed using Microsoft excel and the result shows that temperature, relative humidity and rainfall all have a strong correlation with malaria. Therefore, improved personal hygiene, domestic cleanliness, proper ventilation, clean food and water, refuse and drainages evacuation and air-conditioning will all help in maximizing better healthcare delivery.

Keywords: malaria; prevalence; rainfall; relative humidity; temperature; human health.

1. Introduction

Human health is affected by natural environmental factors such as temperature, rainfall, relative humidity, wind direction etc. These factors influence life expectancy and humans are vulnerable to the impact of climate change in an environment. Atmospheric variables plays an important role in determining the conditions in which living matter exist. Human being must be
protected from extreme atmospheric changes. For instance, the periodic temperature changes are due to the climate change mainly. This issue of climate change is a global phenomenon which has been attracting international concern; some areas such as Sahara desert, Polar Regions and Kilimanjaro in Kenya are noted to be more affected by these changes than others.

Also, many diseases are influenced by weather conditions and it has direct physical consequences on human beings. Among the effects of these variables on human is loss of water from the body and increase chemical activity, these effects disturb human comfort considerably. At higher temperatures, increased evaporation rates of chemicals and water in the room will increase chemical gases and water vapour in the air. The importance of determining the role of weather on human health cannot be overemphasized. Reports of large increases in mortality during heat are commonplace, and this is because many environmental factors are affected negatively by extreme atmospheric disturbances.

Statistics have shown that disease prevalence and spread are largely associated with adverse changes in climatic conditions and most disease–causing organisms thrive better under extreme climatic conditions and consequently increase their activity. Malaria is a mosquito-borne infectious disease of humans and other animals caused by protists (a type of microorganism) of the genus plasmodium. It begins with a bite from an infected female mosquito (anopheles mosquito), which introduces the protists through its saliva into the circulatory systems, and ultimately to the liver where they mature and reproduce. The signs and symptoms of malaria typically begin 8–25 days following infection (Fairhurst et al., 2010). However, symptoms may occur later in those who have taken antimalarial medications as prevention (Nadjm et al., 2012). Malaria can be carried by mosquitoes in temperate climates, but the parasite disappears over the winter. The disease is a major health problem in much of the tropics and subtropics. In some areas of the world, mosquitoes that carry malaria have developed resistance to insecticides. In addition, the parasites have developed resistance to some antibiotics. These conditions have led to difficulty in controlling malaria. Malaria is infectious disease of humans and other animals and is widespread in tropical and subtropical regions including much of Sub-Saharan Africa. An increase in temperature would allow the spread of both the vector of the disease (anopheles mosquitoes) and the causal agent (the plasmodium parasites) to higher latitudes and altitudes. This increase in temperature would also affect areas where malaria is already established by reducing the interval between the mosquito's blood meals and shortening the incubation period of the parasite in the mosquito. Both of these events would increase the prevalence of malaria. There is evidence that suggests that malaria is more sensitive to increases in the minimum temperature for a region, rather than the maximum. This can be attributed to the relatively small temperature range in which a mosquito may live. It should also be noted that warming trends during cold periods may make
the transmission of malaria less seasonal, which would increase overall incidence. Currently, increases in malaria have been linked to increasing temperature in Rwanda (Loevissohn, 1994) and increasing temperature and precipitation changes in Venezuela (Bouma et al., 1997).

Climatic variables can have adverse effects depending on the level and time frame in which they affect the human environment. Wilson (1990) maintained that climatic factors of importance are precipitation and its mode of occurrence, humidity, temperature and wind, all affect evaporation and transpiration. Many studies have found that extreme temperatures are associated with an increased risk of illness and death (Hajat et al., 2008). Heat-related mortality is a growing public health concern due to climate change, population ageing and increasing urbanization (Luber et al., 2008). Climate change is projected to increase global mean surface temperatures by 2–4.5 °C with 76% probability and over 4.5 °C with 14% probability by 2010 (Rogelj et al., 2012) and will increase the frequency and intensity of heat waves. These changes are likely to have a greater impact on those living in old or poorly-constructed houses which offer less protection from the outside heat and those without air conditioners (Kovats et al., 2008). Population ageing may further amplify vulnerability, as the elderly and those with pre-existing disease are often susceptible to heat (Basu, 2009). More people living in cities may also contribute to additional pollution and heat, and higher concentrations of susceptible people (Harlan and Ruddell, 2011). Managing the health effects of temperature in response to climate change is a global public health challenge (Hajat et al., 2010). Until now, most studies have focused on: quantifying temperature–health relationships, characterizing vulnerable subgroups, identifying effect heat-related health problems because of urban heat islands, an interaction between air modifiers (e.g., air pollution, socioeconomic status), and projecting future health impacts under climate change scenarios (Basu, 2009). There has been less research on minimizing the health risks of temperature exposure, and long-term strategies to address the health effects of temperature have not been sufficiently considered in public health practice and activities (Ebi, 2011). In drier areas, outbreaks of malaria have been predicted with reasonable accuracy by mapping rainfall (Abeku, 2007). Malaria in Africa is present in both rural and urban areas, though the risk is lower in the larger cities (Machault et al., 2011).

Based on documented cases, the WHO estimates that there were 216 million cases of malaria in 2010 worldwide resulting in 655,000 deaths and 1.2 million people died from the disease (Nayyar et al., 2012), many of whom were children in Africa. A 2012 study estimated that the cases (65%) occur in children under 15 years old. Pregnant women are also especially vulnerable: about 125 million pregnant women are at risk of infection each year. In Sub-Saharan Africa, maternal malaria is associated with up to 200,000 estimated infant deaths yearly (Hartman et al., 2010). Malaria is presently endemic in a broad band around the equator, in areas of the Americas, many parts of Asia,
and much of Africa; however, it is in Sub-Saharan Africa where 85–90% of malaria fatalities occur (Layne, 2006). The geographic distribution of malaria within large regions is complex, and malaria-afflicted and malaria-free areas are often found close to each other (Greenwood et al., 2002) Malaria is prevalent in tropical and subtropical regions because of rainfall, consistent high temperatures and high humidity, along with stagnant waters in which mosquito larvae readily mature, providing them with the environment they need for continuous breeding (Jamieson et al., 2006). Periodic epidemics of malaria occur every five to seven years (Sharma, 1996). The global climate may warm by 1.4 to 5.8 °C and precipitation may increase up to 7%, and global sea level will rise from 0.09 to 0.88 m by the year 2100. For most Anopheles vector species of malaria optimal temperature range for their development lies within 20 °C to 30 °C (Patz et al., 1998).

However, transmission of P. vivax requires a minimum average temperature of 15 °C and transmission by P. falciparum, requires a minimum temperature of 19 °C. The transmission window in terms of the temperature range should extend over a period of time for completion of the sporogeny. Malaria survival is also dependent on the time of the year, i.e. the wet or dry season. However, no clear relationship has been observed between the positive malaria cases and the annual precipitation (Singh et al., 2002). Some actually contend that amount of rainfall may be secondary in its effects on malaria to the number of rainy days or the degree of wetness that exists after a rain event. Also, if the average monthly relative humidity is below 55% and above 80% (Dhiman et al., 2004) the life span of the mosquito gets so shortened that the scope of malaria transmission diminishes. There has been some suggestion that higher water temperatures will lead to more prolonged survival of pathogens in the environment. Higher temperature can affect both the distribution of the vector and the effectiveness of pathogen transmission through the vector. Gubler et al. (2001) list a range of possible mechanisms whereby changes in temperature impact on the risk of transmission of vector borne disease: (1) Increase or decrease in survival of vector, (2) Changes in rate of vector population growth, (3) Changes in feeding behaviour, (4) Changes in susceptibility of vector to pathogens, (5) Changes in incubation period of pathogen, (6) Changes in seasonality of vector activity, and (7) Changes in seasonality of pathogen transmission.

The impacts of heavy rainfall events, flooding, increased temperature and rainfall are also associated with high counts of indicator bacteria in river and marine waters (Crowther et al., 2001). Malaria has been controlled effectively in Europe and North America, but it remains a serious public health problem in Asia, Africa, and Latin America (Vollaard et al., 2004). Many social factors, especially economic development level, health facilities, and living conditions may influence the incidence of malaria (Kelly-Hope et al., 2008). Environmental factors, such as climate, have also been investigated to assess their influence on water/food-borne infections (Shuman et al., 2012). Many
meteorological factors can affect bacterial contamination of food and/or water. For example, heavy rainfall has been associated with an increase in outbreaks of enteric pathogens, usually due to the contamination of water supplies (McMichael et al., 2006). However, the complex relationship between climate variations and enteric diseases is far from clear, with only a very small number of studies having been conducted in developing countries (Kelly – Hope et al., 2008).

2. Materials and Methods

2.1. Study Area

The study area is located between longitudes 12°40 and 11°51 N and latitude 3°58 and 4°47 E. The area is characterized by the interplay of two different air masses: the moist, tropical, maritime air mass from the Atlantic and the dry continental air mass from the Sahara. This two air masses migrates north-south in accordance with the seasons. Therefore, harmattan and disturbance-line thunderstorms form in the dry and wet season’s respectively. The average annual rainfall of the study area ranges from 793 mm to 955 mm. The wet season lasts from May to September while the dry season lasts for the remaining period of the year. Temperature is generally high with mean annual temperature of about 26 °C in all locations and up to 40 °C during the months of April to June in the day time. Night temperatures are generally lower. Relative humidity is generally low (approximately 40%) for most of the year except during the wet season when it reaches an average of eighty percent. This explains the hot dry environment

2.2. Materials

The materials used for the analysis are as follow: (1) Malaria data, (2) Meningitis data, (3) Typhoid data, (4) Temperature data, (5) Rainfall data, (6) Relative humidity, and (7) Microsoft office. Items number 1 to 3 were obtained from the World Health Organization office Birnin Kebbi while items number 4 to 6 were obtained from Kebbi Agricultural and Rural Development Authority (KARDA), Birnin Kebbi. All the data is for the period ranging from 2008 – 2010.

2.3. Method

The method employed is the graphical method. This involves graphs and chart that rapidly convey a visual picture of the data. Graph is a diagram used to indicate relationships between two or more variable quantities. The quantities are usually measured along two axes set at right angles to each other. In this study, it is employed to show the distribution of the data over a range of time.
3. Results and Discussions

3.1. Results

Figs. 1-3 represent the graph of temperature, rainfall, relative humidity and malaria for the year 2008 to 2010, rainfall and relative humidity on primary axis, temperature and Malaria on the secondary axis.

**Fig. 1:** Graph of temperature, rainfall, relative humidity and malaria for the year 2008.

**Fig. 2:** Graph of temperature, rainfall, relative humidity and malaria for the year 2009.

Fig. 1 is a graph of temperature, rainfall, relative humidity and malaria for 2008. Malaria increases as the temperature increases from January to April. Malaria increases again with increase in rainfall. Relative humidity and temperature are highly correlated. This shows that malaria has a high
relationship with temperature and rainfall. Whereas increase in rainfall means increasing number of breeding sites for mosquitoes which in turn cause malaria, high temperature also supports both the reproductive capability and life span of plasmodium parasites which in turn cause malaria, this clearly justifies the average distribution of malaria cases throughout the year because even in the dry season when rainfall is zero, the other surface water bodies such as rivers, streams, stagnant water sites around domestic areas coupled with the average warm temperature of the area will be able to support the growth and reproduction capability of plasmodium parasites which in turn cause malaria.

![Graph of temperature, rainfall, relative humidity and malaria for the year 2010.](image)

**Fig. 3:** Graph of temperature, rainfall, relative humidity and malaria for the year 2010.

Fig. 2 is a graph of temperature, rainfall, relative humidity and malaria for 2009. Malaria is at its peak at the month of April and the temperature also increases. Rainfall and relative humidity have a high correlation, as the relative humidity increases, rainfall also increases and at the month of September the relative humidity is at its peak so also the rainfall and they both drop at the same time respectively. This shows that there is a high relationship between malaria, temperature, rainfall and relative humidity.

Fig. 3 is a graph of temperature, rainfall, relative humidity and malaria for 2010. The malaria and temperature are related, the malaria rises with increase in temperature and it drops with decrease in temperature. Relative humidity and rainfall also have a high correlation with each other and with malaria which means increase in malaria is affected by rainfall and temperature. Therefore, there is positive correlation between malaria and the other three variables, i.e. rainfall, temperature and relative humidity and it can be compared with the results obtained from the previous years of 2008 and 2009.

**4. Conclusions**

After a careful review of the different literatures on the effects of temperature, relative
humidity and rainfall on malaria, and also after subjecting the data obtained on Birnin Kebbi metropolis, the results obtained had clearly indicates that temperature, rainfall and relative humidity have a positive correlation with malaria. From the above result, we recommend that: (1) Environmental factors that have direct effects on human health needs to be improved such as food and drinking water, (2) Rooms should be cleaned and be constructed in such a way as to allow enough ventilation across them especially in the dry season, (3) Air conditioners can be incorporated where possible, (3) Evacuation of drainages and refuse dumps will enhance the hygienic condition of the area which will eventually be a hindrance to the growth or spread of disease-causing organisms, and (4) Public awareness campaign be made to educate the society on the effects of atmospheric variables on human health.

References


