INFLUENCE OF WEATHER ELEMENTS ON THE OCCURRENCE OF SOME COMMON DISEASES IN ANKPA LOCAL GOVERNMENT AREA, KOGI STATE, NIGERIA

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AN M.Sc. RESEARCH DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA-NIGERIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN GEOGRAPHY

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DECLARATION

I declare that this Dissertation entitled: INFLUENCE OF WEATHER ELEMENTS ON THE OCCURRENCE OF SOME COMMON DISEASES IN ANKPA LOCAL GOVERNMENT AREA, KOGI STATE, NIGERIA; has been carried out by me in the Department of Geography and Environmental Management, Faculty of Physical Sciences, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other Institution.

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Date_____

CERTIFICATION

The Dissertation entitled INFLUENCE OF WEATHER ELEMENTS ON THE OCCURRENCE OF SOME COMMON DISEASES IN ANKPA LOCAL GOVERNMENT AREA, KOGI STATE, NIGERIA by Habib Babangida MUHAMMED meets the regulations governing the award of the degree of M.Sc. Geography of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

To the man who conceived the idea of this programme Arc. (Dr.) L.D. Abalaka , am so grateful. Your love and sacrifices towards the success of this programme will never be forgotten. You are God sent indeed! You have always been there for me in my time of need. You shall always remain relevant to me because you believed in my potentials and dreams; you supported me in your own way to pursue them. May the Lord reward you sir.

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ABBREVIATIONS

ARIMA - - Autoregressive Integrated Moving Averages

CDC - - - Center for Disease Control

CHRR - - Climate and Health Resource Room

CSM - - Cerebro-Spinal Meningitis

DALY - - Disability Adjusted Life Year

HIMAL - - - Highland Malaria Project

IPCC - - - Intergovernmental Panel for Climate Change

LGA - - Local Government Area

PF - - - Plasmodium Falciparum

SST - - Sea Surface Temperature

TPF - - - Typhoid and Paratyphoid Fever

UNICEF - - United Nations International Children's Emergency Fund

WHD - - World Health Day

WHO - - World Health Organization

ABSTRACT

Weather induced diseases have been a major public health problem and a hindrance to socio economic development in Ankpa LGA of Kogi State. The aim of this study was to determine the influence of rainfall, temperature and relative humidity on the occurrence of selected diseases,namely malaria, typhoid, meningitis, pneumonia and diarrhea in Ankpa Local Government Area, Kogi State. Records of rainfall, temperature and relative humidity were obtained from the weather station at the Kogi State College of Education Ankpa, and the records of reported cases of the selected diseases were obtained from selected hospitals from 2006 to 2015. These records were used to carry out this study. Time series analysis was used to analyze the trend of each of the data collected, Pearson product moment correlation analysis was used to analyze the relationship between the five diseases and the climatic parameters. The seasonal occurrence of the diseases was analyzed by dividing the year into hot dry, rainy and cold dry seasons. The analysis showed that rainfall, relative humidity, malaria, typhoid, and diarrhea exhibited decreasing trends, while temperature, meningitis and pneumonia showed an increasing trend within the period of 2006 to 2015. The correlation analysis indicated that the five selected diseases are influenced differently by the various weather elements. Rainfall showed a positive relationship with malaria typhoid and diarrhea having r-values of 0.595, 0.167 and 0.544 and a negative relationship with meningitis and pneumonia having r-values of -0.285 and -0.144 respectively. Temperature showed a positive relationship with typhoid and meningitis having r-values of 0.087 and 0.305 and a negative relationship with malaria, pneumonia and diarrhea with r-values of -0.214, -0.041 and -0.533 respectively. Relative humidity showed a positive relationship with diarrhea with r-value of 0.472 and showed a negative relationship with malaria, typhoid, meningitis

and pneumonia having r-values of -0.115, -0.297, -0.542 and -0.438 respectively. The seasonal analysis showed that within the study period, malaria, typhoid and diarrhea had the highest reported cases during the rainy season while meningitis and pneumonia occurred highest during the hot dry and cold dry seasons respectively. The forecast showed that rainfall and relative humidity will be on the decrease up till 2025 while temperature will be on the increase. Consequently, malaria and diarrhea will be on the decrease while typhoid, meningitis and pneumonia will be on the increase. The study concludes that weather has profound influence on the rate of occurrence of the five selected diseases in the study area. Based on the findings of this research, the study recommends that proper town planning should be ensured by the town planning board, proper drainage channels should be constructed, sensitization programs should be organized to educate residents on climate change influences, provision of potable drinking water should be made, vaccines should be provided for immunization, mosquito nets should be provided and a study of this nature should be carried out yearly.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Weather is the state of the Earth's atmosphere with respect to temperature, humidity, precipitation, visibility, cloudiness, and other factors. Climate refers to the average long-term meteorological conditions of a place or region. All weather may be traced to the effect of the Sun on the Earth. Most changes in weather involve large-scale horizontal motion of air. Air in motion is called wind. This motion is produced by differences of atmospheric pressure, which are attributable both to differences of temperature and the nature of the motion itself (Glossary of meteorology, 2000a).

Some of the environmental hazards facing human activities in recent time are climate-related and in view of this, an understanding of the complex interrelationships between the atmosphere and those hazards are therefore vital for the solution of these challenges. Weather and climate act both as resource and as constraint to human beings. The resource value of weather has to be optimized and fully utilized while the hazards posed by weather have to be managed (Omonijo, 2010).

The World Health Organization (WHO, 2005) estimates that the temperature and precipitation trends due to climate change from the mid-1970s is already causing over 150,000 deaths and approximately five million disability-adjusted life years (DALYs) per year (McMichael, 2004). The prevalence of many human diseases are linked to climate fluctuations, from cardiovascular

mortality (Muthers, Matzarakis and Koch, 2010) and respiratory illnesses due to extreme bioclimatic conditions (Omonijo and Oguntoke, 2009), to altered transmission of infectious diseases and malnutrition from crop failures (WHO, 2002). Climatic variations and extreme weather events have profound impacts on infectious diseases. Infectious agents, such as protozoa, bacteria and viruses and their associated vector organisms such as mosquitoes, ticks and sandflies are devoid of thermostatic mechanisms, and reproduction and survival rates are thus strongly affected by fluctuations in air temperature (Kovats, Campbell-Lendrum, McMichael, Woodward, and Cox, 2001). Air temperature dependencies are seen in correlations between disease rates and weather variations over weeks, months, or years and in close geographic associations with key weather elements and the distributions of important vector-borne diseases (Omonijo, 2010),

While personal health may seem to relate mostly to prudent local environmental exposures and health care access, sustained population health requires the life supporting services of the biosphere. Population of all animal species depend on supplies of food and water, freedom from excess infectious diseases and the physical safety and comfort conferred by climatic stability. The world's climate system is fundamental to this life support (WHO, 2003).

The characteristic geographical distributions and seasonal variations of many infectious diseases are *prima facie* evidence that their occurrences are linked to weather and climate. Factors such as temperature, precipitation and humidity affect the life cycle of many disease pathogens and vectors (both directly and indirectly through ecological changes) and this can potentially affect the timing and intensity of disease outbreaks. Human societies have had long experience of naturally occurring climatic vicissitudes. The ancient Egyptians, Mesopotamians, Mayans and European population (during the four centuries of the little ice age) were all affected by nature's

great climatic cycles. More acutely, disaster and disease outbreaks have occurred very often in response to extremes of regional climate cycles such as the ELNINO/ southern oscillation (ENSO) cycles (WHO, 2003). Climate can affect human health directly (impact of thermal stress, death and injury in flood and storm) and indirectly through changes in ranges of disease vectors (mosquitoes, water borne pathogens, water quality and food availability and quality).

Climatic factors are important determinants of various vector borne diseases, many enteric illnesses and certain water related diseases. Relationships between year-to-year variation in climate and infectious diseases are more evident where climatic variations are marked and in vulnerable populations (WHO, 2003).

Variation in weather and climate affects the human body significantly. The physiological function of the human body responds to changes in weather conditions. Several specific body disorders such as heat and stroke occur only under particular climatic conditions. Likewise, the outbreak of several illnesses and diseases are induced by climate. Indeed, the periodic or seasonal nature of outbreaks of some human diseases suggests that climatic conditions play an important role in the seasonal variation (Adebayo, 2000).

Many diseases are highly sensitive to changes in temperature and precipitation. These include common diseases such as malaria, typhoid, cough, asthma, measles, meningitis and dengue fever as well as other major killers such as diarrhea (WHO, 2007). The Director General of world health organization (WHO) gave this report on world health day (WHD, 2008) that human beings are been exposed continually to the effect of climate sensitive diseases that kill in millions. The medical profession in its efforts to combat malaria and other seasonal diseases has long recognized the power of rainfall as it helps in the breeding of the mosquitoes. Certain

diseases also show a seasonal trend. It is well established that malaria, cold and cough may reach epidemic proportions during wet and cold seasons. Cerebrospinal meningitis is mostly common during warm season. The variation from year to year in the general character of a particular season is reflected in the degree of severity of the outbreak of certain diseases thereby making the climate an important factor that enhances disease establishment in man (Lixie, 2003).

The greatest effect of climate on transmission of diseases is observed at the extremes of the range of temperature at which transmission occurs. Health risk due to climate will differ between countries that have developed health infrastructure and those without this infrastructure (Michael, 1995). Of all diseases that have plagued man, malaria has probably been responsible for the greatest morbidity and mortality from antiquity especially in the tropical regions. Temperature is an important factor in the spread of malaria and other mosquito borne diseases. Global climate change will affect daily temperature variations, which can have a more pronounced effect on the development of the parasite (Webwire, 2009).

The temporal and spatial variation of temperature, precipitation and humidity expected to occur under different climatic scenarios could affect the biology and ecology of vectors and intermediate hosts and consequently the risk of disease transmission (WHO, 2005). Climatic factors, particularly temperature and rainfall, may have a profound impact on transmission cycle of diseases by influencing the availability of vector breeding sites, extending vector longevity, altering host breeding of migration pattern and maintaining aggregation of vectors and host around water bodies (Hensel, 1979). Malaria is one of the World's most common and serious health problems. It is responsible for at least more than one million deaths every year in the

world, majority of which occur in the most resource poor countries (La'ah and Zubairu, 2007). Cerebrospinal meningitis (CSM) is partially a weather stress disease and shows a markedly seasonal character. It invariably begins with drier and colder weather towards the end of November and reaches its peak in March and April and subsides rapidly in May at the onset of the rainy season (Doney, 2008). The meteorological parameter which closely parallels it is the mean minimum temperature which is at its lowest level in December and January (13°C). In sub Saharan Africa, especially in Nigeria. Approximately 80% of these diseases and 90 – 95% of death related to these diseases in the world are recorded in Africa (Global health report, 2005), for example malaria is the leading cause of mortality in children in Africa and accounts for about 40% of health expenditure in most independent countries of Africa (Doney, 2008).

1.2 Statement of the Research Problem

Weather induced diseases such as malaria, typhoid, meningitis, pneumonia and diarrhea have been a major public health problem and a hindrance to socio economic development in Ankpa Local Government Area of Kogi State. The occurrence of these diseases have resulted in shortage of workforce in farms and work places thereby reducing productivity and also channeling scarce resources to the health sector to combat these diseases.

Despite the state government's efforts to combat the incidence of malaria and other common diseases by the provision of mosquito nets and potable water among others, these diseases still keep reoccurring; hence, the need to carry out this study to have a working knowledge of how weather elements influence these diseases.

Malaria has been a major public health problem and a hindrance to socio economic development in Nigeria (Omonijo, Matzaraki, Oguntoke and Adeofun, 2011). Clear knowledge of the driving

factors of malaria dynamics in a particular area is crucial for better planning and implementation of prevention and control strategies (Kochar, Budanis and Lakhotis, 2007)

A study carried out by climate and health resources room (CHRR, 2008) on climate and malaria in Africa showed that where malaria is not adequately controlled, its distribution and seasonality are closely related to seasonal characteristics of the weather, and where there were cases of anomalies, malaria which is seasonally endemic becomes epidemic in warm semi-arid regions of Africa. This applies to other weather related diseases also, like typhoid fever, pneumonia, meningitis and diarrhea.

The studies of the relationships between weather and the occurrence of diseases have taken various approaches globally; Ogbaji (2006) studied the role of temperature in the distribution of malaria in Zaria. He correlated temperature data with the reported malaria cases. The result showed that there is a positive relationship between temperature extremes and the prevalence of malaria. December to February recorded less cases of Malaria while March to May recorded more cases.

Sawa and Bukhari (2011), studied temperature variability and the outbreak of meningitis and measles in Zaria, using maximum and minimum temperature records and reported cases of meningitis (CSM) and measles in Zaria for 10years (1999-2008). Correlation analysis was used to check whether the occurrence of these diseases have a significant relationship with temperature and observed that there is a significant relationship between temperature and the outbreak of CSM. Measles showed a negative relationship with rainfall while CSM has no significant relationship with rainfall.

Akinbobola and Omotosho (2004) assessed the relationship between meteorological variables and the occurrence of malaria, measles, chicken pox, meningitis and pneumonia in Ikeja, Akure and Kaduna. Logarithmic transformation was applied to malaria incidence and the meteorological parameters and homogeneity of variance of the residuals, Autoregressive Integrated Moving Averages (ARIMA) models and cross correlation were used to evaluate the relationship between weather factors and monthly malaria incidence, the result showed that there is a relationship between diseases and the seasons. It showed that malaria and pneumonia are associated with the rainy season while measles, chicken pox and meningitis are common during hot periods.

Omonijo, Matzarakis, Oguntoke and Adeofun (2011) carried out a study on the influence of weather and climate on malaria occurrence based on human bio-meteorological methods in Ondo State, Nigeria. They used meteorological and malaria dataset in the state for the period from 1998 to 2008. In addition, sea surface temperatures (SSTs) over equatorial Pacific Ocean were integrated in the analysis. The study showed that there is significant association between wind speed, sea surface temperatures, air temperature, solar radiation, mean radiant temperature, physiologically equivalent temperature and universal thermal climate index and malaria cases for the eleven years examined. Malaria transmission in the two eco-climatic zones of Ondo State, Nigeria for the period 1998 to 2008 is high and occurs all-year round but more prevalent at the beginning of rainy season.

Bako (2012) investigated the influence of some weather elements on the occurrence of some common diseases in Kafanchan, Kaduna State using correlation and regression analysis. The researcher observed that malaria showed a significant relationship with both rainfall and relative

humidity and also that there is a significant relationship between typhoid fever and rainfall and relative humidity and that the occurrence of typhoid fever is higher during the rainy season.

Anumonye (2016) investigated the effects of some weather elements on the occurrence of malaria, typhoid and tuberculosis in Onitsha North Local Government Area, Anambra state Nigeria. The research showed that malaria and typhoid are the most common diseases in the study area. The relationship between malaria, typhoid and the weather elements was high while that of tuberculosis was relatively moderate with relative humidity having the most significant effect on the diseases.

The impact of climate on human health has received increasing recognition. Human health is highly influenced by the increase in the social changes of climate variables. Climate change is one of the existing factors that affect the various changes in the health of humans. Weather has different influences on human health in different regions due to different socio-economic development levels, various adaptation capacities and different geographic locations (Zhou, 2010). Climate change can affect human health through a wide range of mechanisms and for a range of diseases or health outcomes. Climate variability, as characterized by extreme weather events, and inter annual variability, is known to affect human health.

A study of this nature is necessary since the study area has a different climatic characteristic from the areas similar studies have been carried out. It is against this backdrop that this research examined the influence of rainfall, temperature and relative humidity on the occurrence of Malaria, Typhoid, Meningitis, Pneumonia and Diarrhea in Ankpa Local Government Area of Kogi State, Nigeria.

For the purpose of this research, the following research questions were asked. These are:

1. What is the temporal pattern of occurrence of rainfall, temperature and relative humidity in the study area between 2006 – 2015?
2. What is the temporal pattern of reported cases of the common diseases (Malaria, Typhoid, Meningitis, Pneumonia and Diarrhea) in the study area within the period of study?
3. What is the relationship between the weather elements and the selected diseases?
4. How has the seasons influenced the occurrence of these common diseases in the study area?
5. What will be the temporal trend of these weather elements and the occurrence of the common diseases in the study area from 2016 to 2025?

1.3 Aim and Objectives of the Study

The aim of this study is to examine the influence of rainfall, temperature and relative humidity on the occurrence of Malaria, Typhoid, Meningitis, Pneumonia and Diarrhea in Ankpa Local Government Area of Kogi state, Nigeria.

The stated aim was achieved through some specific objectives, which include to:

i. determine the temporal pattern of rainfall, temperature and relative humidity between 2006-2015 in the study area
ii. assess the temporal pattern of reported cases of malaria, typhoid, meningitis, diarrhea and pneumonia between 2006-2015 in the study area
iii. examine the relationship between the selected weather elements and the selected common diseases in the study area
iv. determine the seasonality of Malaria, Typhoid, Meningitis, Pneumonia and Diarrhea

v. forecast the trend of rainfall, temperature and relative humidity and the occurrence of Malaria, Typhoid, Meningitis, Pneumonia and Diarrhea in the study area from 2016 to 2025.

1.4 Research Hypothesis

The following null hypothesis was formulated for the purpose of this study:

H_o: There is no significant relationship between the stated weather elements and the occurrence of the selected diseases in Ankpa LGA.

1.5 Scope of the Study

This study concentrated on the main town of Ankpa, which is the headquarters of the Local Government Area because this is the area where the meteorological data and hospital records were available. It examined the temporal pattern of occurrence of the climatic parameters and the diseases, assessed their relationship, examined seasonality of occurrence and predicted climatic parameters and disease pattern up to 2025. The researcher used data from some selected hospitals (General hospital, Bethel hospital, Omega hospital, Living hope hospital and Madonna hospital) in the study area that have records of common diseases such as malaria, typhoid, meningitis, diarrhea and pneumonia up to 10 years (2006-2015) since most of the hospitals do not have organized data for up to 10years. The researcher used these diseases because they are most prevalent in the study area.

1.6 Justification of the Study

Climate is an inevitable dominant element of man's environment and powerful factor in his well-being. Its

critical elements such as temperature, rainfall and humidity can influence diseases. Although medical science has made remarkable progress in fighting diseases through modern technology, the health of the human population is still influenced to a great extent by weather and climate. It is also ood to know that the environmental conditions that favor persistence of the vectors that transmit most of these diseases need also to be known. Although, several environmental factors influence the occurrence of these diseases differently, the researcher is only interested in the roles played by the selected weather elements in influencing the occurrence of the stated diseases.

In this study, the researcher examined the ways in which the major meteorological variables (Rainfall, Temperature and Relative humidity) influence the occurrence of some diseases (Malaria, Typhoid, Meningitis, Pneumonia and Diarrhea) in Ankpa Local Government Area, Kogi state, Nigeria. This was born out of the need to get detailed information about the occurrences so as to prepare for effective mitigation measures.

The study ensured availability of established findings as literature on the relationship between the weather elements and the selected diseases for researchers who intend to explore similar field of study in the future.

This study also helped to determine the role that meteorological elements play in disease occurrence and transmission. It will also provide information on what enhances the survival of the causative agents of the diseases. This study therefore wishes to devise a systematic method of unveiling, curbing and predicting the occurrence of common diseases in Ankpa Local Government Area of Kogi State.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 *Weather Elements*

According to the Glossary of meteorology (2000a), Weather is the state of the Earth's atmosphere with respect to temperature, humidity, precipitation, visibility, cloudiness, and other factors. Climate refers to the average long-term meteorological conditions of a place or region. All weather may be traced to the effect of the Sun on the Earth. Most changes in weather involve large-scale horizontal motion of air. Air in motion is called wind. This motion is produced by differences of atmospheric pressure, which are attributable both to differences of temperature and the nature of the motion itself.

2.1.1.1 Rainfall

Glossary of meteorology (2000a) defined rain as liquid water in the form of droplets that have condensed from atmosphericwater vapor and then becomes heavy enough to fall under gravity. Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth. It provides suitable conditions for many types of ecosystems, as well as water for hydroelectric power, plants and crop irrigation.

The major cause of rain is moisture moving along three-dimensional zones of temperature and moisture contrasts known as weather fronts. If enough moisture and upward motion is present, precipitation falls from convective clouds (those with strong upward vertical motion) such as

cumulonimbus (thunder clouds) which can organize into narrow rain bands. In mountainous areas, heavy precipitation is possible where upslope flow is maximized within windward sides of the terrain at elevation which forces moist air to condense and fall out as rainfall along the sides of mountains. On the leeward side of mountains, desert climates can exist due to the dry air caused by downslope flow which causes heating and drying of the air mass. The movement of the monsoon trough, or intertropical convergence zone, brings rainy seasons to savannahclimes (Glossary of meteorology,2000a).

planet guide (2011) suggests that the urban heat island effect leads to increased rainfall, both in amounts and intensity, downwind of cities. Global warming is also causing changes in the precipitation pattern globally, including wetter conditions across eastern North America and drier conditions in the tropics. Air contains water vapor, and the amount of water in a given mass of dry air, known as the *mixing ratio*, is measured in grams of water per kilogram of dry air (g/kg) (Steve, 2009). The amount of moisture in air is also commonly reported as relative humidity; which is the percentage of the total water vapor air can hold at a particular air temperature (glossary of meteorology, 2000a). How much water vapor a parcel of air can contain before it becomes saturated (100% relative humidity) and forms into a cloud depends on its temperature (glossary of meteorology, 2000a). Warmer air can contain more water vapor than cooler air before becoming saturated. Therefore, one way to saturate a parcel of air is to cool it. The dew point is the temperature to which a parcel must be cooled in order to become saturated (Naval Meteorology and Oceanography Command, 2007).

According to Glossary of Meteorology (2009), there are four main mechanisms for cooling the air to its dew point: adiabatic cooling, conductive cooling, radiational cooling, and evaporative

cooling. Adiabatic cooling occurs when air rises and expands. The air can rise due to convection, large-scale atmospheric motions, or a physical barrier such as a mountain (Orographic lift). Radiational cooling occurs due to the emission of infrared radiation, either by the air or by the surface underneath (Glossary of Meteorology, 2009). Evaporative cooling occurs when moisture is added to the air through evaporation, which forces the air temperature to cool to its wet-bulb temperature, or until it reaches saturation (Robert, 2004).

Robert (2002) opined that the main ways water vapor is added to the air are wind convergence into areas of upward motion, precipitation or virga falling from above (National weather service, 2009), transpiration from plants (Krishna and Brad, 2002), cool or dry air moving over warmer water (National weather service, 2008), and lifting air over mountains (Michael, 2008). Water vapor normally begins to condense on condensation nuclei such as dust, ice, and salt in order to form clouds. Elevated portions of weather fronts force broad areas of upward motion within the Earth's atmosphere which form clouds decks such as altostratus or cirrostratus (David, 2006). Stratus is a stable cloud deck which tends to form when a cool, stable air mass is trapped underneath a warm air mass. It can also form due to the lifting of advection fog during breezy conditions (Finnish Meteorological Institute (FMI), 2007).

2.1.1.2 Temperature

According to FMI (2007), Temperature is how hot or cold a thing is. To measure temperature more accurately, a thermometer is used. Thermometers use a temperature scale to record how hot or cold something is. The scale most often used is in degrees Celsius (°C), sometimes called centigrade. In the USA, degrees Fahrenheit (°F) are more often used while scientists mostly use Kelvin (K) to measure temperature because it never goes below zero.

Michael (2008) stated that scientifically, temperature is a physical quantity which describes how quickly molecules are moving inside a material. In solids and liquids the molecules are vibrating around a fixed point in the substance, but in gases they are in free flight and bouncing off each other as they travel. In a gas the temperature, pressure and volume of the gas are closely related by a law of physics.

Ati (2002), described temperature as the degree of sensible heat or cold within the atmosphere, Temperature is also important in weather and climate. It is related to the amount of heat energy in the air. Isotherm maps are used to show how temperature is different across an area. Temperature will be different during different times of day, different seasons and in different places. It is affected by how much heat reaches the place from the sun rays (insolation), how high the place is above the level of the sea, and how much heat is brought to the place by the movement of winds and ocean currents(planet guide, 2011).

2.1.1.3 Relative humidity

According to Glossary of meteorology (2000b), Relative humidity is the ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at a given temperature. Perry and Green (2005) argued that relative humidity depends on temperature and the pressure of the system of interest. It requires less water vapor to attain high relative humidity at low temperatures; more water vapor is required to attain high relative humidity in warm or hot air. The relative humidity of an air–water mixture is defined as the ratio of the partial pressure of water vapor in the mixture to the equilibrium vapor pressure of water over a flat surface of pure water at a given temperature (Perry and Green, 2005).

Cornel (2009) stated that relative humidity is normally expressed as a percentage; a higher percentage means that the air–water mixture is more humid. Humans are sensitive to high humidity because the human body uses evaporative cooling, enabled by perspiration, as the primary mechanism to rid itself of waste heat. Perspiration evaporates from the skin more slowly under humid conditions than under arid. Because humans perceive a low rate of heat transfer from the body to be equivalent to a higher air temperature (Cornel, 2009). The body experiences greater distress of waste heat burden at high humidity than at lower humidity, given equal temperatures. For example, if the air temperature is 24 °C and the relative humidity is zero percent, then the air temperature feels like 21 °C (Cornel, 2009). If the relative humidity is 100 percent at the same air temperature, then it feels like 27 °C. In other words, if the air is 24 °C and contains saturated water vapor, then the human body cools itself at the same rate as it would if it were 27 °C and at 20% relative humidity (an unstated baseline used in the heat index). The heat index and the humidex are indices that reflect the combined effect of temperature and humidity on the cooling effect of the atmosphere on the human body.

Lide (2005) opined that in cold climates, the outdoor temperature causes lower capacity for water vapor to flow about. Thus it may be snowing and at high humidity relative to its temperature outdoors, once that air comes into a building and heats up, its new relative humidity is very low, making the air very dry, which can cause discomfort and can lead to ill health. Although, dry air is good for those suffering from some lung disorders (Lide, 2005).

According to the university of Rochester medical centre, Low humidity causes tissue lining nasal passages to dry, crack and become more susceptible to penetration of Rhinovirus cold viruses. Low humidity is a common cause of nosebleeds. The use of a humidifier in homes, especially

bedrooms, can help with these symptoms. Indoor relative humidity should be kept above 30% to reduce the likelihood of the occupant's nasal passages drying out (Arundel, Sterling, Biggin and Sterling, 1986).

Gilmore (1972) opined that Humans can be comfortable within a wide range of humidities depending on the temperature, from thirty to seventy percent. Ideally, between 50%and 60% (Engineering toolbox, 2013). Very low humidity can create discomfort, respiratory problems, and aggravate allergies in some individuals. In the winter, it is advisable to maintain relative humidity at 30% or above (Washington State Department of Health, 2003). Extremely low (below 20%) relative humidity may also cause eye irritation (Arundel, *et.al*, 1986).

2.2 A review of Common Diseases

2.2.1 Malaria

According to Carabolla (2014), Malaria is a mosquito-borne infectious disease that affects humans and other animals. Malaria causes symptoms that typically include fever, tiredness, vomiting, and headaches. In severe cases it can cause yellow skin, seizures, coma, or death. Symptoms usually begin ten to fifteen days after being bitten by an infected mosquito. If not properly treated, people may have recurrences of the disease months later. In those who have recently survived an infection, reinfection usually causes milder symptoms. This partial resistance disappears over months to years if the person has no continuing exposure to malaria (WHO, 2014).

2.2.1.1 Transmission of malaria

The disease is most commonly spread by an infected female Anopheles mosquito (WHO, 2014). The mosquito bite introduces the parasites from the mosquito's saliva into a person's blood, the parasites travel to the liver where they mature and reproduce (Carabolla, 2014). Five species of Plasmodium can infect and be spread by humans. Most deaths are caused by *P. falciparum*because *P. vivax*, *P. ovale*, and *P. malariae* generally cause a milder form of malaria. The species *P. knowlesi* rarely causes disease in humans. Malaria is typically diagnosed by the microscopic examination of blood using blood films, or with antigen-basedrapid diagnostic tests. Methods that use the polymerase chain reaction to detect the parasite's DNA have been developed, but are not widely used in areas where malaria is common due to their cost and complexity (Nahjim and Behrens, 2012).

2.2.1.2 Symptoms of malaria

The symptoms of malaria typically begin 8–25 days following infection (Fairhurst and Wellems, 2010) but may occur later in those who have taken antimalarial medications as prevention (Nahjim and Behrens, 2012). Initial manifestations of the disease common to all malaria species are similar to flu-like symptoms and can resemble other conditions such as sepsis, gastroenteritis, and viral diseases (Batolloni and Zarmmachi, 2012). The presentation may include headache, fever, shivering, joint pain, vomiting, hemolytic anemia, jaundice, hemoglobin in the urine, retinal damage, and convulsions (*Beare, Taylor, Harding, Lewallen and Molyneux, 2006*).

The classic symptom of malaria is paroxysm, a cyclical occurrence of sudden coldness followed by shivering and then fever and sweating, occurring every two days (tertian fever) in *P. vivax* and *P. ovale* infections, and every three days (quartan fever) for *P. malariae*. *P. falciparum*

infection can cause recurrent fever every 36–48 hours, or a less pronounced and almost continuous fever (Ferri, 2009).

Severe malaria is usually caused by *P. falciparum* (often referred to as falciparum malaria). Symptoms of falciparum malaria arise 9–30 days after infection. Individuals with cerebral malaria frequently exhibit neurological symptoms, including abnormal posturing, nystagmus, conjugate gaze palsy (failure of the eyes to turn together in the same direction), opisthotonus, seizures, or coma (Batolloni and Zarmmachi, 2012).

2.2.1.3 Seasonality of Malaria

WHO (2006) recommended that Malaria is likely the vector-borne ailment most touchy to long haul environmental change. Malaria fluctuates occasionally in profoundly endemic regions. The connection among malaria and outrageous climatic occasions has for quite some time been the subject of concentrate in the Indian subcontinent. Right off the bat in the twentieth century, the Punjab locale experienced intermittent pestilences of malaria. Inundated by five waterways, this topographical fields district outskirts the Thar Desert. Investigations by Bouma and van der Kaay, (1996) have demonstrated that malaria plague chance increments around five-crease in the year after an El Niño occasion. Evengard and Sauerborn (2009) opined that Malaria is known to be endemic in the tropic. Its common symptoms are headaches, weakness, fever, aches, pains, high body temperature, bitterness of the mouth, loss of appetite, nausea and vomiting. It is a serious disease affecting children and adults but its consequences are graver among children and pregnant women (UNICEF, 2000; Van-Geertruyden, Thomas, Erhart and Alessandro, 2004). According to the Federal Ministry of Health (2001), Available records show that at least 50% of the population of Nigeria suffers from at least one episode of malaria each year and malaria

accounts for over 45% of all out-patients visits. It was reported that malaria prevalence (notified cases) in 2000 was about 2.4 million (Federal Ministry of Health, 2001) and responsible for an estimated average annual reduction of 1.3% in economic growth for the countries with the highest burden, Nigeria inclusive (Onwujekwe, Chima and Okonkwo, 2000). Therefore, it imposes a great burden on the country in terms of pains and trauma suffered by its victims as well as loss in outputs and cost of treatments (Onwujekwe, Hanson and Fox-Rushby, 2004). The spread of infectious diseases such as malaria is multicausal but could be influenced by global climate change or climatic variability directly or indirectly (Evengard and Sauerborn, 2009).

The findings of the study of Ceccato, Ghebremeskel, Jaiteh, Graves and Levi (2007) in part of Eritrea and that of Guofa, Minakawa, Andrew, Githeko and Guiyun, (2004) study in East Africa Highland were both similar where they observed a relationship between malaria incidence and climatic anomalies (temperature and rainfall). Weather and climate can influence host defenses, vectors, pathogens and habitat, nevertheless, disease such as malaria could be spread even without excessive rainfall and temperature but extreme rainfall and temperature increases the likelihood of its high morbidity (Bate, 2004). Nevertheless, examining climatic variables associated with infectious diseases will go a long way in anticipating associated future risks and direct our attentions at observations (Epstein, 2002).

A topic of growing concern, and debate, is the role of climate change in variability and trends in malaria, (Hunter, 2003). Several countries and regions have reported emerging or growing threat of malaria due to change in climate (Caminade, Ndione, Kebe, Jones and Danuor, 2010). While deaths due to malaria depend on a number of factors like vector control, access to adequate medical facilities and immunological history of the people, infections can be considered to

depend primarily on abundance of mosquito vector and exposure of the host to bites and rate of transmission (Snow, Craig, Deichmannle and Sueur, 1999).

Davidson and Zahar (1973) suggests that a quantitative delineation of the role of weather variables in malaria load can enable the design of pro-active mitigation based on vector control; implementation of such pro-active vector control is becoming increasingly important in view of reported resistance of mosquitoes to insecticides. At the same time, such quantitative relations between weather variables and malaria can enable reliable projection of vulnerability in a changed climate.

According to Paaijmans, Imbahale, Thomas and Takken (2010), the importance of meteorological variables in genesis and survival of mosquito have been known for a long time, although the relative roles of these variables and various aspects are still being investigated. However, fairly sharp and well defined ranges of meteorological variables, especially temperature, are required for genesis and survival of malaria vector, although these thresholds also depend on the mosquito species. For example, there are well known thresholds of minimum and maximum of temperature for vector genesis and survival. Each weather variable has a range in which it affects the mosquito genesis and survival; a temperature above 16°C is required for breeding and development of the aquatic stages of Anopheles mosquitoes in the Tropics. Similarly, experiments indicate a threshold of minimum temperature between 16°C and 19°C for the development of *Plasmodium falciparum* (PF) malaria parasite.

Gillet (1974) established that temperature affects the rate of reproduction of the pathogens, and thus plays important role in the survival and transmission the vector. Temperature is also known to affect the gonotrophic cycle (physiological process consisting of digestion of blood-meal and

development of ovaries), and longevity. However, other weather variables like rainfall and Humidity also play important roles (Blanford, Crane, Mann and Paaijmans, 2013). For example, amount, intensity as well as duration of rainfall all play important roles in the dynamics of vector population. Besides, other environmental variables like land use and land cover also affect vector dynamics, (Paaijmans and Thomas, 2011; Paaijmans, Imbahale, Thomas and Takken, 2010).

Rainfall can significantly reduce the vector survival by flushing the larval mosquitoes out of their aquatic habitat, (Paaijmans, Wandago, Githeko and Takken, 2007). It can be logically assumed that reduced larval survival will also lead to a smaller population of adult mosquitoes. Both dryness and rainfall can influence larval survival significantly, as shown by experiments with simulated dry conditions, (Koenraaadt, Paaijmans, Githeko, Knols and Takken 2003; Paaijmans, Imbahale, Thomas and Takken, 2010). Similarly, transmission can be inhibited by development time of the pathogen larger than the life span of the insect. Higher temperature, on the other hand, can lead to quicker maturity leading to higher number of off springs during the transmission period, (Paaijmans, Imbahale, Thomas and Takken, 2010). Thus vector abundance can be assumed to be primarily determined by the climate (average weather regime) and the weather (variability around the climate) of the region (Paaijmans and Thomas, 2011). It is also known that the effect of environmental parameters on vector population can be highly location-specific. The phenology and population dynamics of mosquito can vary significantly with altitude; a study based on weekly rainfall intensity in the Lake Victoria basin showed significant differences in larval abundance with altitudes, (Imbahale, Paaijmans, Mukabana, Lammeren and Githeko, 2011). It was found, for example, that for northern Australia, determination of the periodicity and the amplitude of mosquito population (abundance peaks) required consideration of the frequency and the amplitude of the tides, a flood plain or a forested region is likely to

require very different considerations. Over India, several studies have shown relationship between weather variables and malaria, (Dash, 2008).

Tiwari, Ghosh, Ojha, Dash and Raghavendra (2010) opined that India, with its complex climatic heterogeneity, growing population, land-use and urbanization poses a unique challenge to identify role of climate change in malaria load. In particular, a region can experience both decrease and increase in malaria prevalence as the meteorological variables move in or out of the genesis window. A robust and reliable assessment of vulnerability to malaria due to climate change require quantitative, validated models of malaria epidemiology that involve all the relevant weather variables; assessments based on the trend of a single meteorological variable do not have much relevance. Parham and Michael, 2010; Hoshen and Morse (2004) stated that while the role of meteorological variables in malaria has been well recognized, and several attempts have been already made to use weather-driven models for malaria, , most methods have used only a single meteorological variable or time-averaged (weekly/monthly mean) values to assess impact of climate change on malaria. However, dynamics of mosquito population (genesis as well as mortality) depends on daily variability of the weather variables, (Paaijmans, Imbahale, Thomas and Takken, 2010); in general, this daily variability will be much higher than that in monthly-averaged variables. Thus, vector abundance, and hence impact of malaria, is likely to depend on the number of daily genesis windows.

Patz, Graczyk, Geller and Vittor, (2000) suggested that large changes in temperature can lead to reduction in the duration of gonotrophic cycle and in the extrinsic incubation period of malaria parasite and affect the rate of transmission,. Similarly, possible changes in the immunology profile of a people due to factors like migration may also become important in the long term. However, most of the processes in the post-larval stages become less important if vector

sanitation is carried out at the genesis sites. The framework and the methodology are quite generic and can be applied in any geographical location with required calibration. In practice, several species of mosquito are responsible for malaria in India, (Sharma, Tyagi, Padhan, Adak and Subbarao, 2004). The genesis and survival criteria may vary somewhat from species to species; similarly, the effects of local environmental conditions like run-off, land use and water stagnation may affect mosquito dynamics. Githeko and Ndegwa, (2001) compared monthly climate and malaria data in highland Kakamega and found a close association between malaria transmission and monthly maximum temperature anomalies over three years (1997–2000). A strong correlation was found between both annual rainfall and the number of rainy days and the incidence of malaria in most districts of Rajasthan and in some districts in Gujarat (Akhtar and Michael, 1996). Hartman, Ebi, McConnell, Chang and Weyant, (2002) used 16GCM future scenarios to study their effect on climate suitability for malaria in Zimbabwe. Using the MARA/ARMA model of climatic limits on Anopheles mosquitoes and Plasmodium parasites, the authors mapped the change in geographical distribution of endemic malaria. For all scenarios the highlands become more suitable for malaria transmission while the lowlands show varying degrees of change.

2.2.2 Meningitis

Meningitis is an acuteinflammation of the protective membranes covering the brain and spinal cord, known collectively as the meninges (*Sáez-Llorens and McCracken, 2003*). The most common symptoms are fever, headache, and neck stiffness (CDC, 2014). Other symptoms include confusion or altered consciousness, vomiting, and an inability to tolerate light or loud

noises. Young children often exhibit only nonspecific symptoms, such as irritability, drowsiness, or poor feeding. If a rash is present, it may indicate a particular cause of meningitis; for instance, meningitis caused by meningococcal bacteria may be accompanied by a characteristic rash (CDC, 2014).

The inflammation may be caused by infection with viruses, bacteria, or other microorganisms, and less commonly by certain drugs (*Ginsberg, 2004)* Meningitis can be life-threatening because of the inflammation's proximity to the brain and spinal cord; therefore, the condition is classified as a medical emergency. A lumbar puncture, in which a needle is inserted into the spinal canal to collect a sample of cerebrospinal fluid (CSF), can diagnose or exclude meningitis (*Tunkel, Hartman, Kaplan, Kaufman, Roos, Scheld and Whitley, 2004).*

Some forms of meningitis are preventable by immunization with the meningococcal, mumps, pneumococcal, and Hib vaccines. Giving antibiotics to people with significant exposure to certain types of meningitis may also be useful (CDC, 2014). The first treatment in acute meningitis consists of promptly giving antibiotics and sometimes antiviral drugs. Corticosteroids can also be used to prevent complications from excessive inflammation (Tunkel *et al.* 2004). Meningitis can lead to serious long-term consequences such as deafness, epilepsy, hydrocephalus, or cognitive deficits, especially if not treated quickly (*van de Beek and Wijdicks, 2006).*

In 2015, meningitis occurred in about 8.7 million people worldwide. This resulted in 379,000 deaths down from 464,000 deaths in 1990. With appropriate treatment the risk of death in bacterial meningitis is less than 15%.[1] Outbreaks of bacterial meningitis occur between December and June each year in an area of sub-Saharan Africa known as the meningitis belt

(*GBD, 2015).* Smaller outbreaks may also occur in other areas of the world. The word meningitis comes from the Greek μῆνιγξ *meninx*, "membrane", and the medical suffix *-itis*, "inflammation" (*Mosby, 2010).*

Sawa (2007) stated that Cerebrospinal meningitis is a noteworthy general medical issue in nations in the purported meningitis belt of Africa, a zone that extends over the center of the mainland from the Atlantic Ocean in the West to the Red Sea in the East, for quite a while now, this zone has dependably seen plagues bringing about high passing rate, leaving a trail of visual impairment, deafness and paralysis. These zones include Mauritania, Senegal, Mali, Burkina Faso, Ghana, Togo, Benin, Nigeria, Cameroon, Central Africa Republic, Chad, Ethiopia and other countries in this zone (Meningitis Belt).

CHRR (2008) established that the outbreaks are caused by meningococcus (a bacterium); the ailment is related with hot, dry atmosphere conditions, poor natural conditions and low financial principles. Without brief treatment, the casualty rate is high.

Several micro-organisms have been isolated causing cerebrospinal meningitis. These are meningococcus, pneumococci, Haemophilus influenae, staphylococcus, streptococci, and some strains of viruses. Generally, there are three types of cerebrospinal meningitis. These are bacterial meningitis, viral meningitis, tuberculosis meningitis (CHRR, 2008).

2.2.2.1 Symptoms of Meningitis

In adults, the most common symptom of meningitis is a severe headache, occurring in almost 90% of cases of bacterial meningitis, followed by neck stiffness (the inability to flex the neck forward passively due to increased neck muscle tone and stiffness) (*van de Beek and Wijdicks,*

2006) The classic triad of diagnostic signs consists of nuchal rigidity, sudden high fever, and altered mental status; however, all three features are present in only 44–46% of bacterial meningitis cases (*Attia, Hatala, Cook, and Wong, 1999).* If none of the three signs are present, acute meningitis is extremely unlikely. Other signs commonly associated with meningitis include photophobia (intolerance to bright light) and phonophobia (intolerance to loud noises). Small children often do not exhibit the aforementioned symptoms, and may only be irritable and look unwell (*Sáez-Llorens and McCracken, 2003).* The fontanelle (the soft spot on the top of a baby's head) can bulge in infants aged up to 6 months. Other features that distinguish meningitis from less severe illnesses in young children are leg pain, cold extremities, and an abnormal skin color (CDC, 2014).

Attia, *et al*. (1999) suggested that Nuchal rigidity occurs in 70% of bacterial meningitis in adults. Other signs include the presence of positive Kernig's sign or Brudziński sign. Kernig's sign is assessed with the person lying supine, with the hip and knee flexed to 90 degrees. In a person with a positive Kernig's sign, pain limits passive extension of the knee. A positive Brudzinski's sign occurs when flexion of the neck causes involuntary flexion of the knee and hip. Although Kernig's sign and Brudzinski's sign are both commonly used to screen for meningitis, the sensitivity of these tests is limited (*Thomas, Hasbun, Jekel, and Quagliarello, 2002)*. They do, however, have very good specificity for meningitis: the signs rarely occur in other diseases. Another test, known as the "jolt accentuation maneuver" helps determine whether meningitis is present in those reporting fever and headache. A person is asked to rapidly rotate the head horizontally; if this does not make the headache worse, meningitis is unlikely (Attia, *et al.* 1999).

Other problems can produce symptoms similar to those above, but from non-meningitic causes. This is called meningism or pseudomeningitis.

Meningitis caused by the bacterium *Neisseria meningitidis* (known as "meningococcal meningitis") can be differentiated from meningitis with other causes by a rapidly spreading petechial rash, which may precede other symptoms (CDC, 2014). The rash consists of numerous small, irregular purple or red spots ("petechiae") on the trunk, lower extremities, mucous membranes, conjuctiva, and (occasionally) the palms of the hands or soles of the feet. The rash is typically non-blanching; the redness does not disappear when pressed with a finger or a glass tumbler. Although this rash is not necessarily present in meningococcal meningitis, it is relatively specific for the disease; it does, however, occasionally occur in meningitis due to other bacteria (*Sáez-Llorens and McCracken, 2003)*. Other clues on the cause of meningitis may be the skin signs of hand, foot and mouth disease and genital herpes, both of which are associated with various forms of viral meningitis (*Logan and MacMahon, 2008)*.

Beniston (2002) seen that Cerebro-spinal Meningitis (CSM) is mostly a climate stress illness; it demonstrates an extraordinarily regular character. The perpetually start with drier and colder climate towards the end of November and achieve its top in March and April and Subsides quickly in May at the beginning of the rainy season. It has been recommended that they are identified with the dry breeze, dust, heat which is the normal for climate in Northern Nigeria at this season; yet the meteorological parameter which most intently parallels them is the mean minimum temperature, which is at its most minimal in December and January. At the point when the scourge starts and rises steeply until May, pursue intently the curve of week by week warning drops abruptly. A conceivable clarification of this may lie in the way that amid the colder climate

the Northern inhabitants will in general group together in entryways amid the Night, rather than resting outside as they do in the more blazing season on account of neediness six to ten individuals approach a solitary room along these lines making it packed. Involvement in Northern Nigeria has demonstrated that vicinity and congestion are cardinal factors in the transmission of the ailment. Some help is loaned to the climatic speculation by the way that all through the Northern Nigeria the sickness happens in yearly waves tops in the time of February to May (Beniston, 2002).

2.2.3 Diarrhea

According to WHO (2013), Diarrhea is the condition of having at least three loose, liquid, or watery bowel movements each day. It often lasts for a few days and can result in dehydration due to fluid loss.Signs of dehydration often begin with loss of the normal stretchiness of the skin and irritable behaviour. This can progress to decreased urination, loss of skin color, a fast heart rate, and a decrease in responsiveness as it becomes more severe.[2] Loose but non-watery stools in babies who are exclusively breastfed, however, are normal.

The most common cause is an infection of the intestines due to either a virus, bacteria, or parasite, a condition also known as gastroenteritis. These infections are often acquired from food or water that has been contaminated by feces, or directly from another person who is infected. The three types of diarrhea are: short duration watery diarrhea, short duration bloody diarrhea, and persistent diarrhea (lasting more than two weeks). The short duration watery diarrhea may be due to an infection by cholera, although this is rare in the developed world. If blood is present it is also known as dysentery (WHO, 2013). A number of non-infectious causes can result in

diarrhea. These include lactose intolerance, irritable bowel syndrome, non-celiac gluten sensitivity, celiac disease, inflammatory bowel disease, hyperthyroidism, bile acid diarrhea, and a number of medications (*Basem and John, 2013).* In most cases, stool cultures to confirm the exact cause are not required (*DuPont, 2014).*

WHO (2013) opined that Diarrhea can be prevented by improved sanitation, clean drinking water, and hand washing with soap. Breastfeeding for at least six months and vaccination against rotavirus is also recommended. Oral rehydration solution (ORS) clean water with modest amounts of salts and sugar is the treatment of choice. Zinc tablets are also recommended. These treatments have been estimated to have saved 50 million children in the past 25 years (WHO, 2013). When people have diarrhea it is recommended that they continue to eat healthy food and babies continue to be breastfed. If commercial ORS are not available, homemade solutions may be used (*Crockett and Keystone, 2012).* In those with severe dehydration, intravenous fluids may be required (WHO, 2013). Most cases; however, can be managed well with fluids by mouth.Antibiotics, while rarely used, may be recommended in a few cases such as those who have bloody diarrhea and a high fever, those with severe diarrhea following travelling, and those who grow specific bacteria or parasites in their stool. Loperamide may help decrease the number of bowel movements but is not recommended in those with severe disease (*DuPont, 2014).*

GBD (2015) revealed that about 1.7 to 5 billion cases of diarrhea occur per year. It is most common in developing countries, where young children get diarrhea on average three times a year (WHO, 2013). Total deaths from diarrhea are estimated at 1.26 million in 2013 down from 2.58 million in 1990 (GBD, 2013). In 2012, it was the second most common cause of deaths in children younger than five (0.76 million or 11%) (CDC, 2013). Frequent episodes of diarrhea are

also a common cause of malnutrition and the most common cause in those younger than five years of age (WHO, 2013). Other long term problems that can result include stunted growth and poor intellectual development (CDC, 2013).

2.2.3.1 Symptoms of Diarrhea

As indicated by a WHO (2007) estimate, each child under 5 years old in the creating scene experiences a normal, a few scenes of looseness of the bowels a year, in the initial 2 years of life upwards of 20 for every 1,000 may die from acute diarrhea. Acute diarrhea occurs all over the world however, it is an intense issue in developing nations. All inclusive, it influences a large number of infants consistently, and a large number of these kids die. It is a main source of death among youngsters underneath the age of 5 years. Diarrhea is the most widely recognized distress of voyagers to developing nations happening in 20% to 50% of those heading out to goals in tropics and subtropical region of Latin American, Africa, and Southern Asia. Indeed, even inside the developed world, extreme or transitory sewage framework disappointments of flooding may taint water supplies and diarrhea disease may result.

Trop (1963) depicted the side effects of diarrhea to incorporate failure to drink fluids due to regurgitating, parchedness, discharging little measures of dim pee, blood in the motion, discharge in the motion, laziness dry bodily fluid film and thirst, increment measure of free stools, Nausea, spewing, cold sweats, stomach torment, stomach spasms and distension. In developing nations of the world, infectious diarrhea kills around 4 million individuals for each year. In the United States, it is assessed that children more youthful than 5 years old experience in excess of 20 scenes of diarrhea (ailment every year) with around 400 deaths per year credited to such scene (Trop, 1963).

Luper and Prudence (2009) completed an investigation In the Village of Imesi, Nigeria, and opined that Diarrhea is most common as breastfeeding comes to an end and proceeds for something like 3 months subsequent to weaning. This is the season of most noteworthy dietary hazard and numerous kids get infected with diarrhea. The investigation has likewise appeared while looseness of the bowels is similarly as successive amid the early weaning time frame, when the tyke is as yet being bosom nourished, it is the adjust period, when bosom bolstering has recently halted, that mortality is so high. In their report they expressed that diarrheal malady in young children has been and keeps on being the scourge of tropical land in the mild zone and in more in fact developed nations. Luper and judiciousness (2009) anyway opined that independent of atmosphere it is progressively common in the lower monetary strata where neediness runs connected at the hip with numbness, stuffing, poor cleanliness, restricted sustenance supply and deficiently risky frequently unclean drinking water.

2.2.4 Typhoid

According to Wain, Hendrekson, MikoleitKeidi and Ochiai (2015), Typhoid fever, also known simply as typhoid, is a bacterial infection due to *Salmonella typhii* that causes symptoms. Symptoms may vary from mild to severe and usually begin six to thirty days after exposure. Anna (2014) opined that there is often a gradual onset of a high fever over several days. Weakness, abdominal pain, constipation, and headaches also commonly occur. Diarrhea is uncommon and vomiting is not usually severe. Some people develop a skin rash with rose-colored spots. In severe cases, there may be confusion. Without treatment, symptoms may last

weeks or months. Wain, *et al.* (2015) argued that other people may carry the bacterium without being affected; however, they are still able to spread the disease to others. Typhoid fever is a type of enteric fever along with paratyphoid fever.

Anna (2014) established that the cause is the bacterium *Salmonella typh*i, also known as *Salmonella enterica* stereotype *Typhii*, growing in the intestines and blood. Typhoid is spread by eating or drinking food or water contaminated with the feces of an infected person (WHO, 2008). Risk factors include poor sanitation and poor hygiene (Anna, 2014). According to WHO(2008), those who travel to the developing world are also at risk and only humans can be infected. Diagnosis is by either culturing the bacteria or detecting the bacterium's DNA in the blood, stool, or bone marrow (Crump, Mintz and Wain, 2010). It was established by Allan (2013) that culturing the bacterium can be difficult. Crump and Mintz (2010) however suggested that Bone marrow testing is the most accurate Symptoms are similar to that of many other infectious diseases.

2.2.4.1 Causes of typhoid fever

According to CDC (2013), the bacterium that causes typhoid fever may be spread through poor hygiene habits and public sanitation conditions, and sometimes also by flying insects feeding on feaces. Public education campaigns encouraging people to wash their hands after defecating and before handling food are an important component in controlling spread of the disease. According to statistics from the United States Centers for Disease Control and Prevention (CDC), the chlorination of drinking water has led to dramatic decreases in the transmission of typhoid fever in the United States

2.2.4.2 Symptoms

Merrian (2013) was of the opinion that the course of untreated typhoid fever is divided into four distinct stages, each lasting about a week. Over the course of these stages, the patient becomes exhausted and emaciated. In the first week, the body temperature rises slowly, and fever fluctuations are seen with relative bradycardia (Faget sign), malaise, headache, and cough. A bloody nose (epistaxis) is seen in a quarter of cases, and abdominal pain is also possible. A decrease in the number of circulating white blood cells (leukopenia) occurs with eosinopenia and relative lymphocytosis; blood cultures are positive for *SalmonellaTyphi* or *S. paratyphi*. The Widal test is usually negative in the first week (Kumar and Kumar, 2016). In the second week, the person is often too tired to get up, with high fever in around 40 °C and bradycardia (sphygmothermic dissociation or Faget sign), classically with a dicrotic pulse wave. Delirium is frequent, often calm, but sometimes agitated. This delirium gives to typhoid the nickname of "nervous fever". Rose spots appear on the lower chest and abdomen in around a third of patients. Rhonchi are heard in lung bases.

The abdomen is distended and painful in the right lower quadrant, where borborygmi can be heard. Diarrhea can occur in this stage: six to eight stools in a day, green, and comparable to pea soup, with a characteristic smell. However, constipation is also frequent. The spleen and liver are enlarged (hepatosplenomegaly) and tender, and liver transaminases are elevated. The Widal test is strongly positive, with anti O and anti H antibodies. Blood cultures are sometimes still positive at this stage.(The major symptom of this fever is that the fever usually rises in the afternoon up to the first and second week.)In the third week of typhoid fever, a number of complications can occur:

1. Intestinal haemorrhage due to bleeding in congested Peyer's patches; this can be very serious, but is usually not fatal.
2. Intestinal perforation in the distal ileum: this is a very serious complication and is frequently fatal. It may occur without alarming symptoms until septicaemia or diffuse peritonitis sets in.
3. Encephalitis
4. Respiratory diseases such as pneumonia and acute bronchitis
5. Neuropsychiatric symptoms (described as "muttering delirium" or "coma vigil"), with picking at bedclothes or imaginary objects.
6. Metastatic abscesses, cholecystitis, endocarditis, and osteitis
7. The fever is still very high and oscillates very little over 24 hours. Dehydration ensues, and the patient is delirious (typhoid state). One-third of affected individuals develop a macular rash on the trunk.
8. Platelet count goes down slowly and risk of bleeding rises.

2.2.4.3 Seasonality of Typhoid

Machault, Vignolles, Borchi, Vounatsou, Pages, Briolant, Lacaux, and Rogier (2011) established that typhoid is a serious disease, and is caused by a bacterium called *Salmonella typhii*. Typhoid causes high fever, loss of appetite, and sometimes a rash. If not treated, it can kill up to 30% of people who are infected. Typhoid in Africa is present in both rural and urban areas, though the risk is lower in the larger cities. Bedi and Zhang (2004) stated that this disease occurs with the change in temperature each year, viruses keep on modifying genetically and the virus is different every year leading to increase in frequency of vomiting and diarrhea. 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, Reiter, Ebi, Yap, Nasci and Patz, (2001) listed a range of possible mechanisms whereby changes in temperature impact on the risk of transmission of vector borne diseases:

1. Increase or decrease in survival of vector.
2. Changes in rate of vector population growth.
3. Changes in feeding behavior.
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.

Crowther, Kay and Wyer (2001) established that the impacts of heavy rainfall events, flooding, and increased temperature are also associated with high counts of indicator bacteria in river waters and marine waters. Typhoid and paratyphoid fever (TPF) has been controlled effectively in Europe and North America, but it remains a serious public health problem in Asia, Africa, and Latin America (Vollaard, Ali, Van Asten, Widjaja, Visser and Surjadi, 2004). Ingestion of contaminated water and food is the most common route of TPF transmission (Maskalyk, 2003), for example, heavy rainfall has been associated with an increase in outbreaks of enteric pathogens, usually due to the contamination of water.

Kelly-Hope, Alonso, Thiem, Canh do, Anhand Lee (2007) opined that many social factors, especially economic development level, health facilities, and living conditions may influence the incidence of TPF. Shuman (2010) also argued that environmental factors, such as climate, have

also been investigated to assess their influence on water/food-borne infections. Many meteorological factors can affect bacterial contamination of food and/or water. For example, McMichael, Woodruff and Hales (2006) opined that heavy rainfall has been associated with an increase in outbreaks of enteric pathogens, usually due to the contamination of water supplies. As contaminated water or food is the most common mode of TPF transmission, meteorological factors may influence the incidence rate and contribute to outbreaks of TPF (Zhang, Bi and Hiller, 2010). Typhoid fever which is otherwise known as enteric fever is a disease prevalent in the world over and continues to be a major public health concern in most developing countries of the world, especially Africa (Mizel and Bates, 2010).

2.2.5 Pneumonia

According to McLuckie, Leach and Richard (2009), Pneumonia is an inflammatory condition of the lung affecting primarily the small air sacs known as alveoli. Typically symptoms include some combination of productive or dry cough, chest pain, fever, and trouble breathing (Ashby, Bonnie; Turkington and Carol, 2007). McLuckie and jeffrey, (2010) argued that Pneumonia is usually caused by infection with viruses or bacteria and less commonly by other microorganisms, certain medications and conditions such as autoimmune diseases. NHLBI, (2016) opined that risk factors include other lung diseases such as cystic fibrosis, asthma, diabetes, heart failure, a history of smoking, a poor ability to cough such as following a stroke, or a weak immune system. Diagnosis is often based on the symptoms and physical examination (NHLBI, 2016). Chest X-ray, blood tests, and culture of the sputum may help confirm the diagnosis. The disease may be classified by where it was acquired with community, hospital, or health care associated

pneumonia (NHLBI, 2011). Vaccines to prevent certain types of pneumonia are available. Other methods of prevention include hand washing and not smoking. Treatment depends on the underlying cause (NHLBI, 2011). Pneumonia believed to be due to bacteria is treated with antibiotics. If the pneumonia is severe, the affected person is generally hospitalized. Oxygen therapy may be used if oxygen levels are low (NHLBI, 2011).

Pneumonia affects approximately 450 million people globally (7% of the population) and results in about 4 million deaths per year (Ruuskanen and Murdoch, 2011) (Lodha, Kabra and Pandey, 2013). Pneumonia was regarded by William Osler in the 19th century as "the captain of the men of death"(Osler and William, 2007). With the introduction of antibiotics and vaccines in the 20th century, survival improved (Ruuskanen and Murdoch, 2011). Nevertheless, in developing countries, and among the very old, the very young, and the chronically ill, pneumonia remains a leading cause of death (Ruuskanen and Murdoch, 2011). Pneumonia often shortens suffering among those already close to death and has thus been called "the old man's friend"(Eddy, 2005).

2.2.5.1 Causes

Ruuskanen and Murdoch (2011) stated that Pneumonia is due to infections caused primarily by bacteria or viruses and less commonly by fungi and parasites. Although there are more than 100 strains of infectious agents identified, only a few are responsible for the majority of the cases. Mixed infections with both viruses and bacteria may occur in up to 45% of infections in children and 15% of infections in adults.

Snydman, editors, Raleigh, Bowden, Per Ljungman and David (2015) established that the term *pneumonia* is sometimes more broadly applied to any condition resulting in inflammation of the

lungs (caused for example by autoimmune diseases, chemical burns or drug reactions); however, this inflammation is more accurately referred to as pneumonitis.

Conditions and risk factors that predispose to pneumonia include smoking, immunodeficiency, alcoholism, chronic obstructive pulmonary disease, asthma, chronic kidney disease, and liver disease (Nair and Niederman, 2011). The use of acid-suppressing medications such as proton-pump inhibitors or H2 blockers is associated with an increased risk of pneumonia (Eom, Jeon, Lim, Cho, Park and Lee, 2011). The risk is also increased in old age (Nair and Niederman, 2011).

2.2.5.2 Symptoms

People with infectious pneumonia often have a productive cough, fever accompanied by shaking chills, shortness of breath, sharp or stabbing chest pain during deep breaths, and an increased rate of breathing (Hoare and Lim, 2006). In the elderly, confusion may be the most prominent sign (Hoare and Lim, 2006).

The typical signs and symptoms in children under five are fever, cough, and fast or difficult breathing (Singh and Aneja, 2011). Fever is not very specific, as it occurs in many other common illnesses, may be absent in those with severe disease, malnutrition or in the elderly. In addition, a cough is frequently absent in children less than 2 months old (Singh and Aneja, 2011). More severe signs and symptoms in children may include blue-tinged skin, unwillingness to drink, convulsions, ongoing vomiting, extremes of temperature, or a decreased level of consciousness (Nair and Niederman, 2011). Bacterial and viral cases of pneumonia usually

present with similar symptoms (WHO, 2012). Some causes are associated with classic, but non-specific, clinical characteristics. Pneumonia caused by *Legionella* may occur with abdominal pain, diarrhea, or confusion (Darby and Buising, 2008), while pneumonia caused by *Streptococcus pneumoniae* is associated with rusty colored sputum (Ortqvist, Hedlund and Kalin, 2005), and pneumonia caused by *Klebsiella* may have bloody sputum often described as "currant jelly" (Tintinalli and Judith, 2010). Bloody sputum (known as hemoptysis) may also occur with tuberculosis, Gram-negative pneumonia, and lung abscesses as well as more commonly with acute bronchitis (Nair and Niederman, 2011). *Mycoplasma* pneumonia may occur in association with swelling of the lymph nodes in the neck, joint pain, or a middle ear infection. Viral pneumonia presents more commonly with wheezing than does bacterial pneumonia (WHO, 2012). Pneumonia was historically divided into "typical" and "atypical" based on the belief that the presentation predicted the underlying cause (Ortqvist, *et al.* 2005). However, evidence has not supported this distinction, thus it is no longer emphasized (Murray and Nadel, 2010).

2.3 Literature Review

2.3.1 Climate and Diseases

The impact of climate change on human health was first mentioned briefly in the first IPCCAR1 (IPCC, 1990). In the second report (IPCC, 1996) a whole chapter was dedicated to health (McMichael *et al*., 2003). Since then there has been a plethora of research and policies on how climate change will affect infectious diseases, particularly malaria, dengue, diarrhoeal diseases, cholera and meningitis. Most of these studies have focused on developed countries (Kelly-Hope and Thomson, 2008). However, in the past decade, a number of these studies have been carried out in African countries (e.g., De Magnay *et al*., 2012; Fernendez *et al*., 2009; Thomson *et. al*., 2006; Yaka *et al*., 2008). (Grasso *et al*., 2012) suggested that more quantitative studies in

specific regions that use long-term reliable data and consider non-climatic factors need to be carried out in Africa. They are particularly urgent in countries that have been neglected by such studies, like Nigeria, which has a large population, high regional political relevance, a high burden of infectious diseases, and faces a potential risk of climate change (Kelly-Hope and Thomson, 2008).

The relationship between disease and climatic factors can be quantified by using either statistical or process-based modelling approaches. These will subsequently form the basis for future predictions of disease outbreaks (WHO, 2005). Before this can be achieved, however, it is necessary to ensure that both disease incidence data and climate data are available at appropriate spatial and temporal resolutions and for a sufficient period. The choice of analytical approach is informed by the nature of data and diseases under scrutiny and the availability of information about them. Basu and Samet (2002) opined that the statistical approach essentially involves explaining the predictant (e.g., meningitis cases) based upon predictor(s) such as temperature and humidity, and additional potential risk factors such as vaccination. Statistical models are the mostly widely used approach in investigating relationships between climate and infectious diseases.

Several studies have been carried out using various analytical techniques with the objectives of identifying, quantifying and assessing the roles of climate and the environment in the risk factors of infectious diseases. Statistical techniques that have been widely used in climate disease modelling are the linear and non-linear models; these techniques are used for predicting the occurrence of disease epidemics. Chaves and Pascual (2007) investigated the suitability of both

linear and non-linear methods for disease prediction in a study they conducted using historical data of monthly leishmaniasis diseases time series from Costa Rica between 1991 and 2001. Performances of all models were assessed based on their R^2 coefficient and fit based on independent data that was not included during models fit.

Thomas *et al.* (2006) studied potentials of environmental models to predict meningitis epidemics in Africa, he used soil and land cover type, aerosol index, vegetation greenness, cold cloud duration and rainfall as variables. The researcher discovered that the most consistent predictants of anomalies in meningitis incidence were anomalies in rainfall and anomalies in dust. Sultan *et al.* (2005) examined the influence of climate upon the meningitis onset in West Africa taking large scale atmospheric circulation into cognizance. They found out that there is a strong relationship between climate and the seasonal pattern of meningitis. There was also a strong correlation between the winter maximum and epidemic onset.

Forgo, *et al.* (2007) studied influence of climatic factors on the incidence of meningitis in Northern Ghana using Relative humidity, temperature, number of haze days and rainfall as variables, they found out that temperature and airborne dust shows a clear association. Meningitis risks are highest at the hottest time of the year when dust exposure has already been accumulated for weeks. In the similar study, Yaka, *et al.* (2008) studied the relationship between climate and year to year variability in meningitis outbreaks in Burkina Faso and Niger they correlated wind velocity, surface temperature, sea level pressure and relative humidity against the meningitis occurrence and found out that the relationship between these elements is clear in Niger and weak but significant in Burkina Faso.

Abdulsallam (2014) explored climate influences on infectious diseases in Nigeria, he also predicted diseases outbreak over time. The researcher employed the use of statistical models (Atmosphere-Ocean Global Climate Models), the result showed the significant roles of both meteorological and socioeconomic factors on incidence of diseases. Prediction results suggest that future temperature increase due to climate change has the potential to significantly increase cases in all seasons and time slices.

Sawa and Bukhari (2011), studied temperature variability and the outbreak of meningitis and measles in Zaria LGA, and observed that there is a causative significant relationship between temperature and the outbreak of CSM. According to him, the hotter months recorded more cases of CSM. Ogbaji (2006) studied the role of temperature in the distribution of malaria in Zaria. His result shows that there is a positive relationship between temperature extremes and the prevalence of malaria.

Ntem (2014) studied the role of weather on the occurrence of common diseases in Jos North LGA, the researcher correlated rainfall, temperature and humidity with malaria, typhoid and pneumonia. The researcher opined that the weather elements have a significant role in the occurrence of the selected diseases and that there is seasonal variation in the occurrence of common diseases in the study area.

Akinbobola and Omotosho (2004) assessed the relationship between meteorological variables and the occurrence of malaria, measles, chicken pox, meningitis and pneumonia in Ikeja, Akure and Kaduna. Logarithmic transformation was applied to malaria incidence and the

meteorological parameters and homogeneity of variance of the residuals, Autoregressive Integrated Moving Averages (ARIMA) models and cross correlation were used to evaluate the relationship between weather factors and monthly malaria incidence, the result showed that there is a relationship between diseases and the seasons. It showed that malaria and pneumonia are associated with the rainy season while measles, chicken pox and meningitis are common during hot periods.

Omonijo, Matzarakis, Oguntoke and Adeofun(2011) carried out a study on the influence of weather and climate on malaria occurrence based on human bio-meteorological methods in Ondo State, Nigeria. They used meteorological and malaria dataset in the state for the period from 1998 to 2008. In addition, sea surface temperatures (SSTs) over equatorial Pacific Ocean were integrated in the analysis. The study showed that there is significant association between wind speed, sea surface temperatures, air temperature, solar radiation, mean radiant temperature, physiologically equivalent temperature and universal thermal climate index and malaria cases for the eleven years examined. Malaria transmission in the two eco-climatic zones of Ondo State, Nigeria for the period 1998 to 2008 is high and occurs all-year round but more prevalence at the beginning of rainy season.

Oluleye and Akinbobola (2010) studied malaria and pneumonia occurrence in Lagos, Nigeria; Role of temperature and rainfall, they expounded the relationship between malaria, pneumonia, rainfall and air temperature over Lagos. Significant climate change was detected in both rainfall and temperature, they concluded that climatic parameters, rainfall and air temperature have profound influence on both malaria and pneumonia occurrence and are responsible directly for intractable increase of the diseases.

Bako (2012) investigated the influence of some weather elements on the occurrence of some common diseases in Kafanchan, Kaduna State using correlation and regression analysis. The researcher observed that malaria showed a significant relationship with both rainfall and relative humidity and also that there is a significant relationship between typhoid fever and rainfall and relative humidity and that the occurrence of typhoid fever is higher during the rainy season.

Anumonye (2016) investigated the effects of some weather elements on the occurrence of malaria, typhoid and tuberculosis in Onitsha North Local Government Area, Anambra state Nigeria. The research showed that malaria and typhoid are the most common diseases in the study area. The relationship between malaria, typhoid and the weather elements was high while that of tuberculosis was relatively moderate with relative humidity having the most significant effect on the diseases.

Several studies have used linear regression models (e.g., Besancenot *et al*., 1997; Thomson *et al.*, 2006; Stocco *et al*., 2010; Yaka *et al*., 2008) using different data resolutions and span for example, Molesworth *et al*. (2003), using gridded-based environmental variables, developed a spatial forecasting model for epidemics of meningitis in Africa. 3,281 districts were identified and grouped into similar seasonal profiles; logistic regression was used to identify the association within districts; and then stepwise multiple regressions were used for the modelling. All variables appeared to be independently associated with epidemic locations, but humidity and land cover profiles came out to be the best predictors in the final model. In what is seemingly a similar but more statistically robust study, Thomson *et al*. (2006) explored the potential of environmental and climatic factors in predicting the probability of meningitis epidemic occurrences. Separate land cover models were developed using stepwise multiple regression:

savannah areas showed the strongest correlation. Other studies adopt the use of Poisson and logistic regression techniques for their investigations (e.g., Chou *et al*., 2010; Lindsay *et al*., 2002; Mueller *et al*., 2008; Paz, 2009). For example Lindsay *et al*. (2002) used the Poisson regression technique, taking account of population increase and the disease incubation period, to model the relationship between climatic variables and meningitis notification in Auckland, New Zealand during a disease epidemic. Temperature was the best predictor in the final model.

Driscoll (1971) correlated daily mortality for Chicago with weather conditions in January, April, July and October and found that large diurnal variations in temperature, dew-point and pressure were associated with many high mortality days. In addition, hot humid weather with concomitant high pollutant concentrations was also contributory mechanisms. Ericsson (2010) argued that other studies do not attribute large variations in mortality to extreme events, but rather to the normal seasonal changes in weather.

Gagge (1979) stressed that Climate has potential to alter the average exposure of human populations to vector borne diseases by changing the geographical distribution of condition that is suitable for the vector and diseases pathogen. An increase in global temperature will result in an expansion of warm temperature regiment into higher altitude and latitudes. Any associated changes in rainfall in tropical and subtropical zones will also render habitats more or less suitable for vector. In addition, the implications of the asymmetrical increase of temperature with global warming for the epidemiology of victor-borne disease need to be clarified. Greater effects of low temperatures on vectors survival, behavior, and disease transmission in cold limited climates than from smaller and less frequent increases in extreme maximum temperatures. These changes

would make temperature environments more receptive to many tropical vector-borne diseases while having less negative efforts on tropical environments.

Ayoade (1982) opined that several specific body disorders such as heat stroke occur only under particular climatic conditions. Likewise, the outbreak of several illnesses and diseases are induced by climate, indeed, the periodic or seasonal nature of outbreaks of some human diseases suggest that weather conditions play important role. In addition, many important diseases are highly sensitive to changing temperatures and precipitation. These include common vector-borne diseases such as malaria, cholera, typhoid and dengue as well as other major killer diseases such as malnutrition and diarrhea. Healthscout (2010) agreed that climate change already contributes to the global burden of diseases, and this contribution is expected to grow in the future.

Hore (1979) stressed that weather and climate have affected human health for millennia. Now, climate change is altering weather band climate patterns that previously have been relatively stable. Climate experts are particularly confident that climate change will bring increasingly frequent and severe heat waves and extreme weather events, as well as a rise in sea levels. These changes have the potential to affect human health in several direct and indirect ways, some of them severe. Heat exposure has a range of health effects; from mild heat rashes to deadly heat stroke Heat exposure can also aggravate several chronic diseases, including cardiovascular and respiratory diseases. The results can be severe and result in both increase illness and death. Ilemona (1983) established that heat also increases ground-level ozone concentrations, causing

direct lung injury and increasing the severity of respiratory diseases such as asthma and chronic obstructive pulmonary diseases.

The world's climate is showing signs of a shift, becoming warmer, with more precipitation and weather extremes. Potential effects of this climate influence are lively to include more variable weather, stronger and longer heat waves more frequent heavy precipitation events, more frequent and severe droughts, extreme weather events such as flooding and tropical cyclones, rises in sea level and increased air pollution (Kalkstein and Valimont, 2008). The variation from year to year in the general character of a particular season is reflected in the degree of severity of the outbreak of certain diseases. Kaplan (2009) opined that every facet of human life is under the constant influence of the atmospheric environment, through the nature, occurrence and variability of its critical characteristics. Weather more than any other element of the environment exercises considerable influence on man.

Despite the recognition of the incidence of climate on human physiological processes and outbreak of disease, relatively very little, research have been directed at studying the actual health consequences of influence of weather on health especially in Ankpa LGA of Kogi State, Nigeria.

2.3.2 Relationship between Weather Elements and Common Diseases

2.3.2.1 Relationship between Temperature and Common Diseases

Lindsay and Birley (1996) established that extreme temperatures often are lethal to the survival of disease-causing pathogens but incremental changes in temperature may exert varying effects. Where a vector lives in an environment where the mean temperature approaches the limit of physiological tolerance for the pathogen, a small increase in temperature may be lethal to the

pathogen. Alternatively, where a vector lives in an environment of low mean temperature, a small increase in temperature may result in increased development, incubation and replication of the pathogen. Gubler, Reiter, Ebi, Yap, Nasci and Patz (2001) argued that temperature may modify the growth of disease carrying vectors by altering their biting rates, as well as affect vector population dynamics and alter the rate at which they come into contact with humans. Finally, a shift in temperature regime can alter the length of the transmission season.

Epstein (1993) stated that increasing temperatures may lengthen the seasonality or alter the geographical distribution of water-borne diseases. In the marine environment, warm temperatures create favourable conditions for red tides (blooms of toxic algae) which can increase the incidence of shellfish poisoning. Colwell (1996) agreed that increasing sea surface temperatures can indirectly influence the viability of enteric pathogens such as Vibriocholerae by increasing their reservoir's food supply. Ambient air temperatures also have been linked to hospital admissions of Peruvian children with diarrhoeal disease (Checkley *et al*. 2000). Disease carrying vectors may adapt to changes in temperature by changing geographical location. An emergence of malaria in the cooler climates of the African highlands may be a result of the mosquito vector shifting habitats to cope with increased ambient air temperatures (Cox, Craig, Le Seieur and Sharp 1999). Another possibility is that vectors undergo an evolutionary response to adapt to increasing temperatures.

There is recent evidence to suggest that the pitcher-plant mosquito (Wyeomiasmithii) can adapt genetically to survive the longer growing seasons associated with climate change. Bradshaw and Holzapfel, (2001) demonstrated this by documenting a change in the photoperiodic response

between two different time periods in two populations of pitcher-plant mosquitoes. The change in response was correlated to a marked genetic shift within the mosquito species. A greater degree of micro evolutionary response was associated with mosquito populations inhabiting higher latitudes. The hypothesis is that because these populations have greater selection pressure they have also a greater ability to evolve genetically. Although the study was limited to one specific species of mosquito, it suggests that other mosquitoes, perhaps disease carrying vectors, may undergo an analogous microevolution which would allow adaptation to altered seasonal patterns associated with global climate change.

2.3.2.2 Relationship between precipitation and common Diseases

According to Ko, Reis, Cibele, Dourado, Johnson Jr, Riley, and the Salvador Leptospirosis Study Group (1999), Variability in precipitation has direct consequences on infectious disease outbreaks. Increased precipitation may increase the presence of disease vectors by expanding the size of existent larval habitat and creating new breeding grounds. In addition, increased precipitation may support a growth in food supplies which in turn support a greater population of vertebrate reservoirs. Unseasonable heavy rainfalls may cause flooding and decrease vector populations by eliminating larval habitats and creating unsuitable environments for vertebrate reservoirs. Alternatively, flooding may force insect or rodent vectors to seek refuge in houses and increase the likelihood of vector-human contact. Epidemics of leptospirosis, a rodent-borne disease, have been documented following severe flooding in Brazil. In the wet tropics unseasonable drought can cause rivers to slow, creating more stagnant pools that are ideal vector breeding habitats.

Parmenter, Yadav, Parmenter, Ettestad and Gage (1999) stressed that heavy rains can contaminate watersheds by transporting human and animal faecal products and other wastes in the groundwater. Evidence of water contamination following heavy rains has been documented for cryptosporidium, giardia, and E.coli. This type of event may be increased in conditions of high soil saturation due to more efficient microbial transport (Rose, Epstein, Lipp, Sherman, Bernard and Patz, 2001). WHO (1999) opined that at the other extreme, water shortages in developing countries have been associated with increases in diarrhea disease outbreaks that are likely attributed to improper hygiene.

2.3.2.3 Relationship between Relative Humidity and common Diseases

According to Hales, de Wet, Maindonald and Woodward (2002), Humidity can greatly influence transmission of vector-borne diseases, particularly for insect vectors. Mosquitoes and ticks can desiccate easily and survival decreases under dry conditions. Mount, Haile and Daniels (1997)stressed that saturation deficit (similar to relative humidity) has been found to be one of the most critical determinants in climate/disease models, for example, dengue fever and Lyme disease models.

2.3.3 Predictability of Infectious Diseases using Climate information

Understanding the distribution and seasonality of many infectious diseases allowed the possibility of using climatic and environmental information in the development of models, with the potential to predict disease epidemics. For example, in 1923, Gill developed a statistical model for predicting malaria. He considered rainfall, economic conditions, and epidemic potential (Gill, 1923). Although the model does not define the epidemic threshold, it was used

for epidemic projection until 1942 for 29 districts in Punjab, India. This study and others that followed reveal the expediency and the potential of using climatic and environmental variables to predict disease epidemics.

The improved accuracy of climate prediction and the growing understanding of the relationship between weather and infectious diseases have encouraged the academic community to develop models capable of predicting epidemic-prone infectious diseases (WHO, 2005), using different techniques, and at various spatial and temporal scales e.g. Connor *et al*. (2008). These models are usually designed to give early warning of approaching epidemics, which is extremely useful to government and health workers as it allows them to prepare well to prevent the epidemic. The main aim of disease prediction is to inform policy makers to prepare effective intervention to handle the epidemics and possibly reduce mortality and morbidity. An example of operational disease prediction exercises is that of forecasting high or low malaria incidence anomalies in Botswana and Eritrea (Ceccato *et al*., 2007; Connor *et al*., 2008). The prediction is based on a seasonal time scale using the ensemble from Global Climate Models (GCM) and historical records of clinical malaria incidences. Areas with malaria risk and temporal patterns were identified using Principal Component Analysis, stratification, and non-hierarchical clustering techniques. Although the forecasting skill was low for other seasons, however a good skill was observed in the June, July, August season in the eastern part. In a similar project, the Highland Malaria Project (HIMAL) was put in place for malaria forecasting in Kenya and Uganda (Abeku *et al*., 2004). This project used selected district level disease surveillance and environmental data: good prediction accuracy was also reported from this exercise.

Recently, the University Corporation for Atmospheric Research (UCAR), in conjunction with WHO, Meningitis and Environmental Risk Information Technologies (MERIT), research clusters, and some countries from sub-Saharan Africa embarked on a meningitis prediction exercise in five African countries (Chad, Burkina Faso, Nigeria, Togo, and Benin). The aim of this exercise is to use operational weather forecasts and weekly surveillance data of diseases to predict epidemics at district level, on probability of exceeding epidemic threshold over the time scale of 10–15 days, using predictive statistical models. This information is made available in real time to field health workers to help with the effective distribution and dissemination of vaccines (UCAR, 2012). The progress of this exercise was evaluated at the 6th MERIT meeting in Accra, Ghana: health workers from Benin, Chad, and Togo reported a good forecast skill in some districts. In summary, the evaluation revealed that there is no single best model, and that the modelling strategies need to be tailored to individual countries (MERIT, 2013). The importance of including other non-climatic factors was also emphasized. There are also other small-scale attempts at disease prediction using climate information, both at national, regional, and local levels, based on records of historical diseases incidence. Examples of these studies include: cholera (Koelle *et al*., 2005), meningitis (Sultan *et al*., 2005), dengue fever (Bartley *etal*., 2002), in Bangladesh, Mali, and Thailand respectively. Results from these studies are encouraging, and have the advantage of being region specific (Grasso *et al*., 2012), based on local meteorological information.

These studies have demonstrated the possibility of predicting some infectious diseases. However, the importance of considering the effects of social risk factors in addition to meteorological conditions in predicting the dynamics of these diseases has been pointed out (e.g., Chou, 2010;

Pascual *et. al*., 2002; Palmgren, 2009). These factors may include migration, sanitary conditions, accessibility of safe drinking water, population density, access to healthcare facilities, and herd immunity developed from previous epidemics (e.g., Ali, 2002; Faruque, 2005). Factors such as migration, vaccination, housing conditions, prevalence of other diseases and previous exposure to infections are also thought to have a reasonable influence on diseases epidemics from small areas to wider spatial scales (WHO, 2005b). In addition, such models need to be scrutinized before bringing them into operational use, in order to ascertain their levels of confidence and accuracy. This could be achieved through evaluating and validating the models using independent data that was not included in the initial model fitting, and by using established validation techniques. Cox and Abeku (2007) pointed out that another important issue that needs to be addressed is the quality of disease surveillance data, most especially in developing countries.

CHAPTER THREE

STUDYAREA AND METHODOLOGY

3.1 The Study Area

3.1.1 Location and Size

Ankpa is the administrative headquarter of Ankpa Local Government Area situated in the eastern part of Kogi state. It lies between latitude $7^{o}16'N$ and $7^{o}41'N$ and longitude $7^{o}22'E$ and $7^{o}51'E$. It is bounded by Omala Local Government Area to the North, to the east by Oturkpo LGA in Benue state, to the west by Ofu and Dekina Local Government Areas and to the south by Olamaboro Local Government Area. The Local Government occupies a total landmass of $1{,}200km^2$ (see fig 3.1).

3.1.2 Climate

Ali (2010) established that the study area falls within the "Aw" climate (wet and dry) type based on "Koppen's classification. It experiences the warm Tropical Savannah climate type. The important feature of the climate is the seasonality of rainfall. The rainfall of the area is highly seasonal. Virtually no rain falls between the end of October and end of March. Furthermore, about 89% of the rain falls in six (6) months; that is, between May and October. The seasonal rainfall comes in form of intense, violent, and convectional down pour of short duration especially at the beginning and end of the rainy season.

Temperature is moderate throughout the year averaging 25°C, though it may occasionally rise. The lowest monthly temperature is experienced in the month of July to September. The mean monthly minimum air temperature however lowest during the period of harmattan, that is November to December (16.7°C) while the highest mean minimum is March to April (21.1°C)

(ADP Report, 1990). The mean maximum temperature ranges between (26.5°C) during the harmattan to (32.7°C) in March and April.

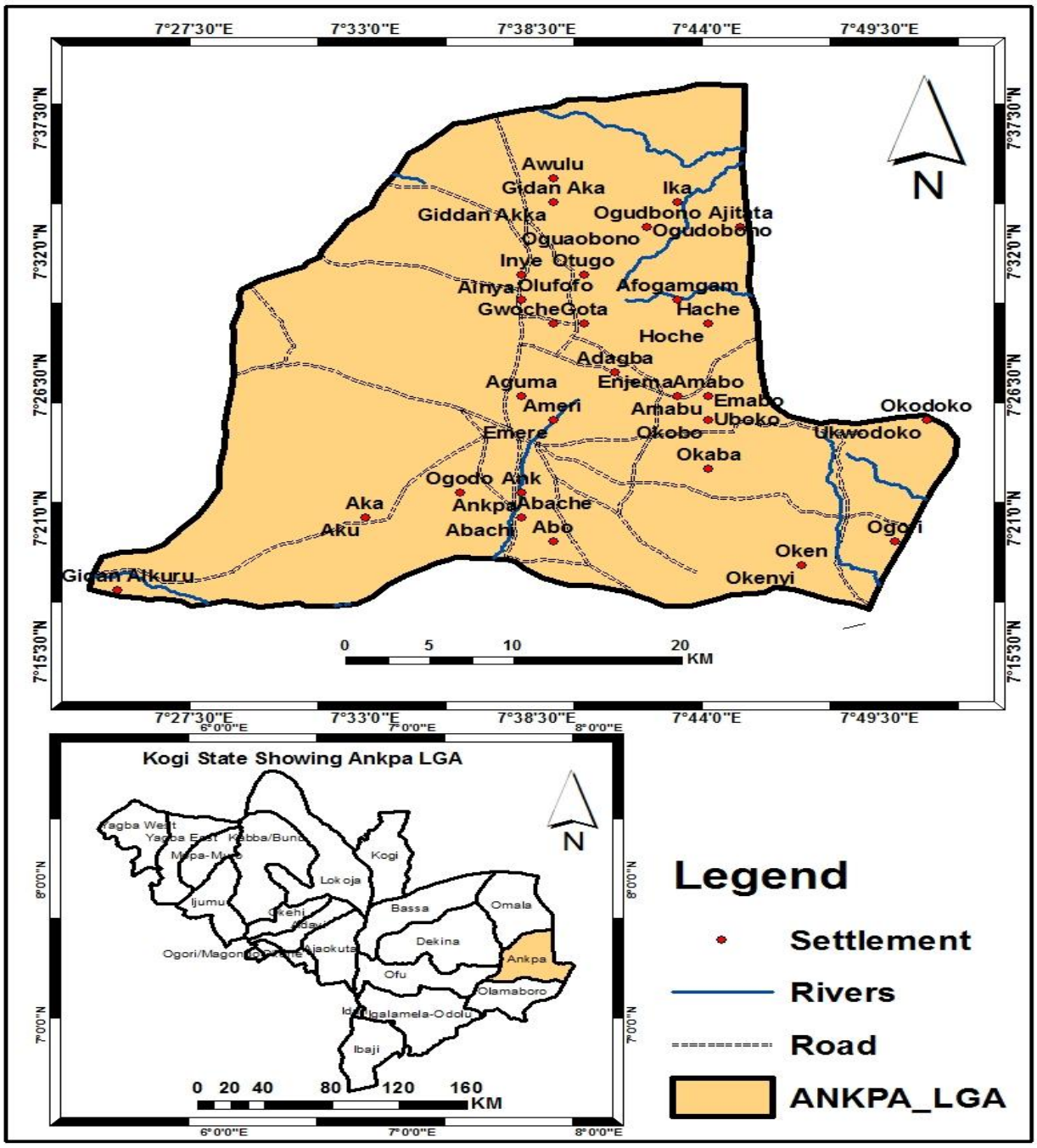


Fig 3.1: Ankpa Local Government Area
Source: Adopted from Administrative Map of Kogi State (2014).

3.1.3 Historical Background

According to KSID (1993),Ankpa was founded in the year 1936 by Abutu Ejeh, the ancestral father of the Igala kingdom. It is the traditional seat of a paramount chief called the '*Onu*' Ankpa, a second class chief in the Igala Traditional Council.

The town at the start of its growth, started as a linear settlement, along the major roads passing through the town and Imabolo River, but as population increased it started to expand outward from the center forming a nuclear settlement. The strategic location of the town coupled with its function as an administrative and commercial center account for its rapid expansion.

3.1.4 Geology of the Area.

Micheal, Johnmark and Victor (2015) opined that the geology of Ankpa is characterized by basement complex, which are a combination of igneous and metamorphic rock. There is an occurrence of loamy soil along the river beds there are also pebbles in the upper course of the river down to the lower course. The town is bounded by a ridge hill on the eastern part of the town behind river *Imabolo* and gentle undulating lowland on the North-western part of the town

3.1.5 Soil

The soil in Ankpa generally relate strongly to the topography, parent material, drainage conditions and vegetation. The soil of the study area belongs to the levisol type (consultant Survey, 1994). The soil is predominantly deep, sandy, derived from alluvium deposits. It is well drained and so the water holding capacity is limited. More so, it has low organic matter content. The soil is generally subjected to the very humid, though seasonal climate (Micheal, *et al.* 2015).

3.1.6 Vegetation

According to Ali (2010), the study area falls in the Southern Guinea Savannah vegetation type. The vegetation is characterized by scattered trees and they rarely occur in clumps, most trees are deciduous. Some of the trees are umbrella shaped creating shade on the ground. However, some tall trees, shrubs, herbs and grasses at different serial stages are found at the bank of the river. Common tree species here include coconut tree (*Cocos nucifera*), Mango tree (*Magnifera indica*), citrus tree (*Citrus* spp), cashew tree (*Anarcandium occidantale*) and palm tree (*Elaeis guinensis*).

3.1.7 Relief

Ali (2010) stated that Ankpa has three levels of topography namely, the high land area extending to over 200m above sea level, the lower intermediate level of 100-200m, and the flood plain of river *Imabolo*. The town itself is a valley settlement badly threatened by erosion menace at different points. The outskirt environment is however of plain land.

3.1.8 Drainage

Micheal, *et al.* (2015) stressed that the study area is drained mainly by river Imabolo and others such as Rivers Ajigbi, Obagu, Otowu, Okwumo etc. apart from river Imabolo, the others are seasonal, and the marked seasonality of the rainfall here produces two regimes. They are the peak flow from August to early October and low from November to May of every year.

There is excessive runoff due to the fact that the town is located in a valley; this excessive flow of water which always concentrates on the same channel gives birth to gully erosion in the town.

3.1.9 Land use Activities

According to Ajewole and Oni (2010), the major land-uses in Ankpa community are residential and agricultural land-uses. Farming is the major activity on land and the principal crops are maize, cassava, yam, palm oil and cashew. The tropical climate of the area impacts the farming activities. However, the people are majorly subsistence farmers. Therefore, farming activities are in small scale. The predominant occupation of the study area is farming and the main crops include maize, cassava guinea corn, yam, palm plantation, vegetables etc. Other food stuff and crops mainly from farm produce constitute over 75% of the traded goods as the town has a busy daily market with the busiest day usually every four days which is regarded as '*Afor*' market day.

3.1.10 People and Population

The population of Ankpa Local Government Area of Kogi State according to the 2006 national census was 267,353 (NPC, 2009). The people in the area are mainly Igalas with few Hausa and Idoma settlers/Immigrants. There are also Igbos in the area for business purposes and Fulanis are nomads.

3.1.11 Healthcare Facilities

The study area houses a number of hospitals and clinics. The healthcare facilities consist of the Government hospitals and some other private hospitals and clinics. The Government hospitals have been well equipped due to the healthcare reforms initiated by the government of the day, state of the art equipments have been acquired to ensure proper and efficient healthcare delivery. The same can be said about the privately owned hospitals in the area. The hospitals in the study area include General Hospital, Madonna Hospital, Bethel Hospital, Living Hope Hospital among others.

3.2 Methodology

3.2.1 Reconnaissance Survey

Reconnaissance survey was carried out in the study area. This was aimed at getting the researcher acquainted with the general knowledge of the study area in terms of geographical landscape and biophysical conditions of the environment. This visit was useful for the establishment of rapport with the officers in charge of data required. The researcher visited the meteorological station of the Kogi State College of Education to ensure availability of the records needed for the study. The researcher also visited all the hospitals in Ankpa local government area to identify and ensure the availability of medical records for the period of 10years (2006-2015). It was during this survey that the researcher came to identify five major hospitals in the study area with available medical records, these hospitals are General hospital, Bethel hospital, living hope hospital, omega hospital and Madonna hospital.

3.2.2 Types of Data Used

For the purpose of this study, secondary data were used, i.e., hospital records on common diseases (malaria, typhoid, meningitis, pneumonia and diarrhea) and weather records (Temperature, Rainfall and Relative humidity) for 10 years. Information was also gathered from relevant literature, such as books, journals, newspapers, maps and previous reports.

3.2.3 Sources of Data

Temperature, Rainfall and Relative humidity records for the 10 years (2006-2015) were obtained from the meteorological station of Kogi State College of Education, Ankpa. The medical records were obtained from the following hospitals:

i. General Hospital Ankpa.

ii. Bethel Hospital Ankpa.

iii. Living Hope Hospital Ankpa.

iv. Omega Hospital Ankpa.

v. Madonna Hospital Ankpa.

The choice of these hospitals was based on the fact that each of them has existed for over ten years and have the records of patients treated for these diseases between 2006 – 2015.

3.2.4 Method of Data Analysis

Objectives 1 and 2 which sought to examine the pattern of the weather elements and occurrence of the selected diseases were achieved by subjecting the mean annual rainfall, mean annual temperature and mean annual relative humidity, and total cases of the diseases for each year to time series analysis in which graphs were drawn. Trend lines and linear trend line equations were fitted on the graphs to show direction of change.

Objective 3: to examine the relationship between the weather elements and the occurrence of the selected disease, the Pearson's product moment correlation coefficient was employed. Rainfall, temperature, humidity were correlated with occurrence of malaria, typhoid, meningitis, pneumonia and diarrhea using IBM SPSS (version 20). This was also used in testing the stated hypothesis (H_o).

Objective 4 which sought to examine the seasonality in the occurrence of the selected diseases, was achieved by getting the overall mean for each of the diseases (malaria, typhoid, meningitis, pneumonia and diarrhea) and weather elements (rainfall, temperature and relative humidity) for

the corresponding years and was calculated by seasons; hot dry (January, February and march), rainy (april, may, june, july, august, September and october) and cold dry (November and december) seasons and the results was presented in bar graphs.

Objective 5 which is to predict the pattern of the weather elements and the occurrence of the diseases from 2016 to 2025 was achieved using regression analysis to predict the trend of the weather elements (rainfall, temperature and relative humidity) and the occurrence of the diseases (malaria, typhoid, meningitis, pneumonia and diarrhea) up to 2025.

The regression model is given as; $y = a + b_1x_1+b_2x_2+b_3x_3$

Where y = predicted dependent variables (Malaria, Typhoid, Meningitis, Pneumonia, Diarrhea)

a= Constant

b= slope

$x_{1=}$ Rainfall

$x_{2=}$ Humidity

$x_{3=}$ Temperature

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Pattern Of Climatic Variables (See Appendix I for computation)

The temporal pattern of occurrence of the climatic variables is discussed in this section. Table I. Appendix I shows their measures of central tendency.

4.1.1 Trends in Rainfall of the Study Area

Figure 4.1 shows the trend in mean annual rainfall in the study area from 2006 to 2015.

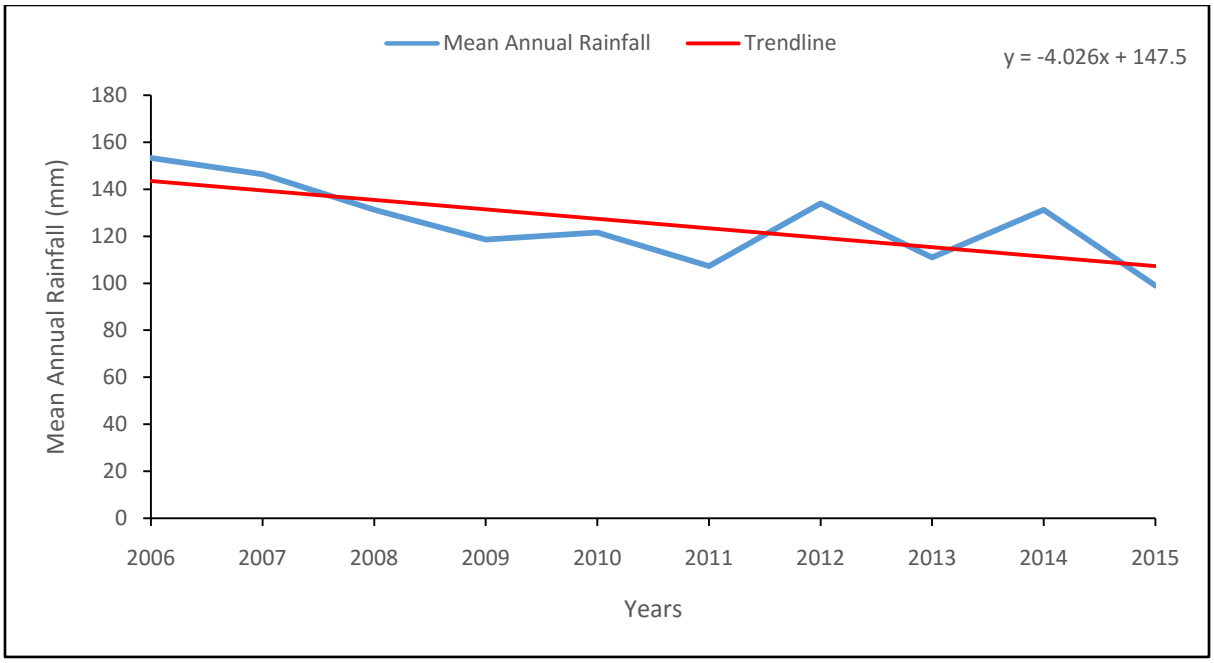


Figure 4.1: Annual Rainfall Trend
Source: Author's Computation, (2017)

The pattern in Figure 4.1 indicates that the annual rainfall in the study area has been fluctuating from 2006 to 2015. There is a decreasing trend of rainfall as indicated by the linear trend line. The linear trend line equation y = -4.0269x + 147.52 indicates that the mean annual rainfall has been decreasing over the time frame in the study area. The peak of the rainfall was in the year 2006 while the lowest rainfall was observed in 2015. The decreasing trend in rainfall may be due

to climate change which is a phenomenon that has been described as a statistical variation in weather elements that persist for an extended period, typically for decades or longer. This is in agreement with the finding of Ntem (2014) that rainfall has been on the decrease in Jos North LGA, Plateau State, Nigeria. Climate change leads to a distortion of seasonal patterns of weather elements and consequently, changes in rainfall patterns (IPCC, 2001).

4.1.2 Pattern of Annual Temperature of the Study Area

Figure 4.2 presents the trend in mean annual temperature in the study area from 2006 to 2015.

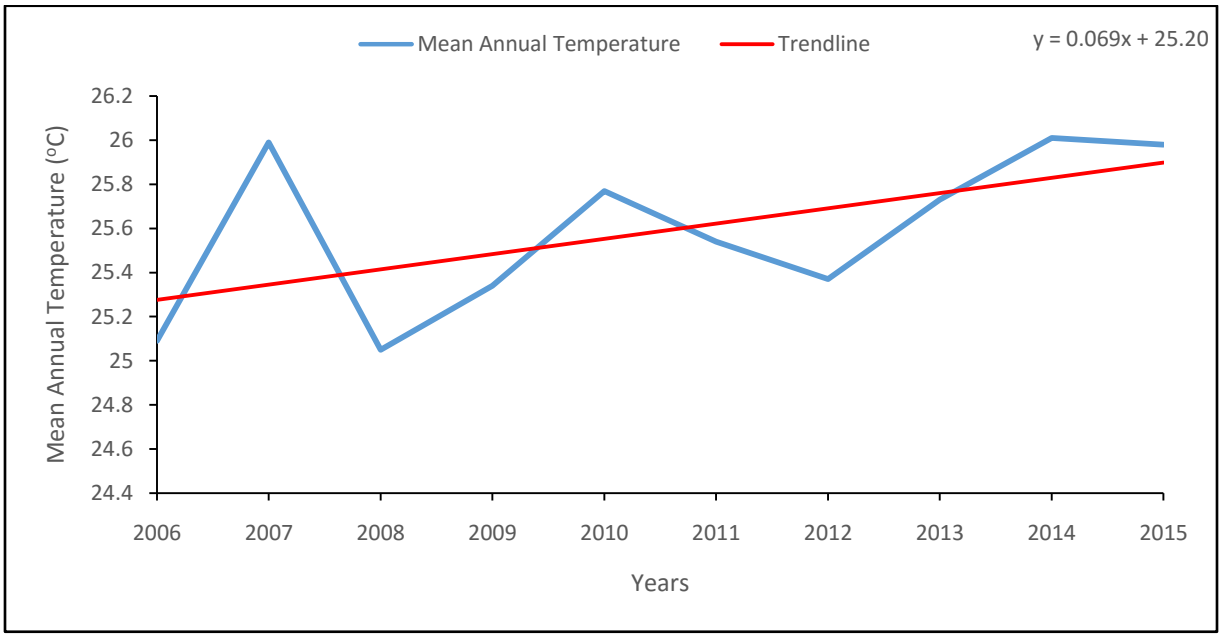


Figure 4.2: Annual Temperature Trend
Source: Author's Computation, (2017)

From Figure 4.2 it can be observed that temperature has been fluctuating much more than rainfall within the study period. The linear trend line equation y = 0.0692x + 25.207 indicates that mean annual temperature has been on the increase. This is also supported by the trend line in Figure 4.2. Increasing trend in temperature has also been associated with global warming. This finding

also agrees with Anumonye (2016) who deduced that temperature has been on the increase in Onitsha North LGA, Anambra State, Nigeria.

4.1.3 Pattern of Annual Relative Humidity in the study area

The Pattern of mean annual relative humidity of the Study Area is presented in Figure 4.3.

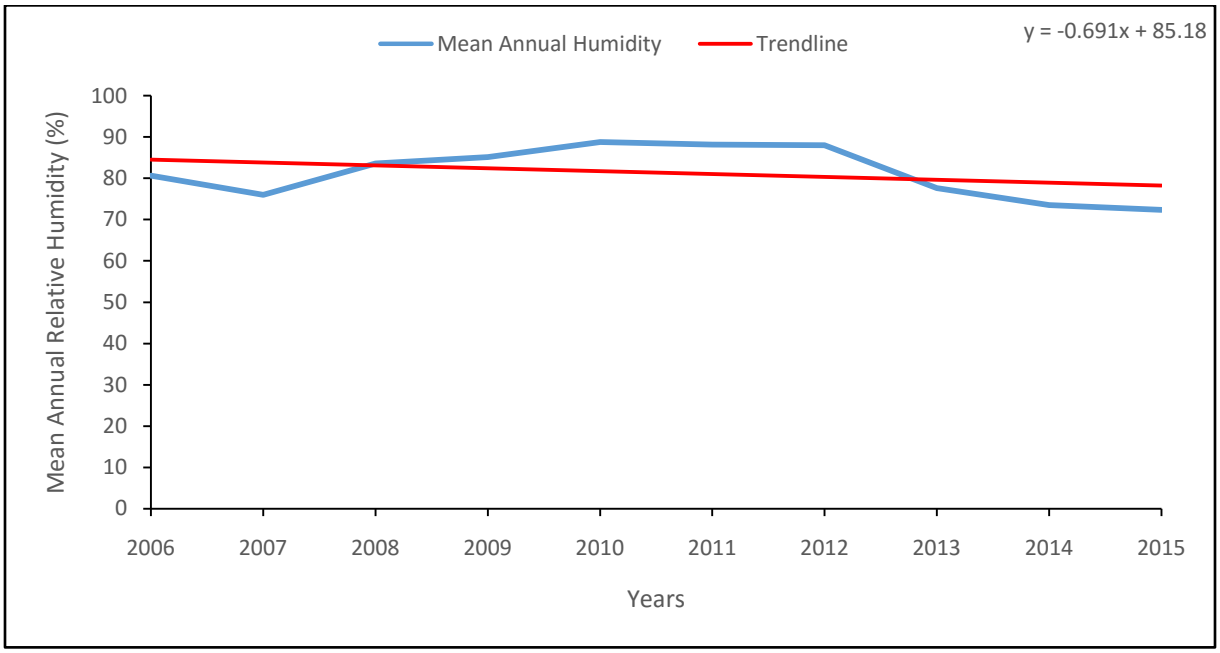


Figure 4.3: Annual Relative Humidity Trend
Source: Author's Computation, (2017)

From Figure 4.3, the highest relative humidity was observed in 2010, while the lowest percentage was in 2015. This trend shows that relative humidity has been fluctuating in the study area. The linear trend line equation is y = -0.6911x + 85.184, indicating that relative humidity has been decreasing over the time frame which might be associated with climate change. This finding disagrees with Bako (2012) who established that relative humidity is on the increase in Kafanchan LGA of Kaduna State, Nigeria, but agrees with the finding of Ntem (2014) and Anumonye (2016) who carried out similar studies in Jos North LGA and Onitsha North LGA respectively.

4.2 PATTERN OF DISEASES OCCURRENCE IN THE STUDY AREA

The pattern of occurrence of diseases is discussed in this section. Table II. Appendix I shows their measures of central tendency.

4.2.1 Pattern of Occurrence of Malaria in the Study Area

Figure 4.4 shows the pattern of occurrence of malaria in the study area from 2006 to 2015

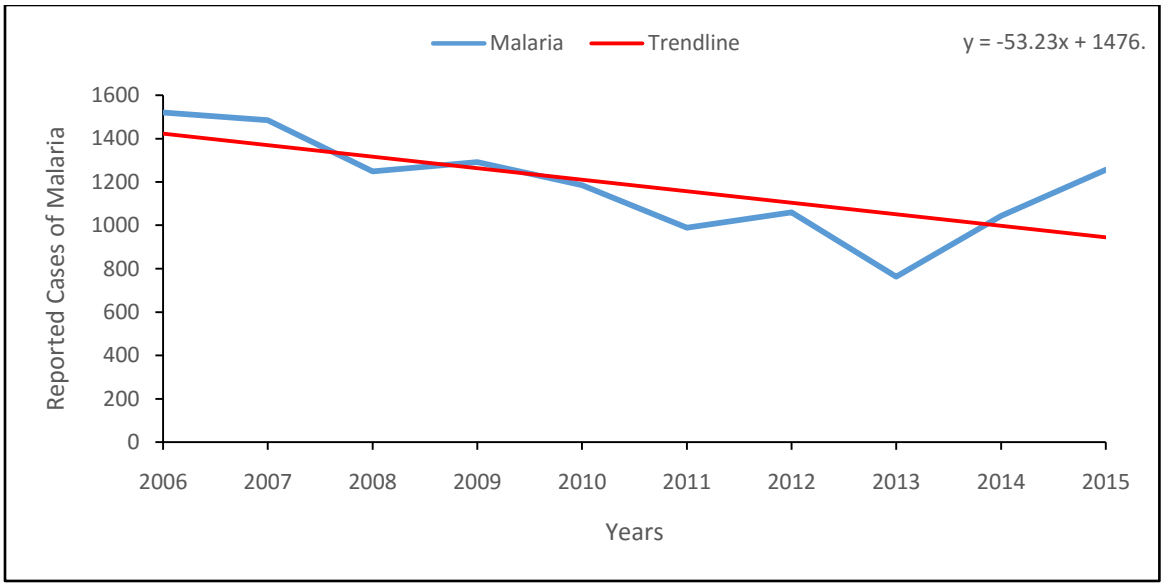


Figure 4.4: Pattern of Malaria Cases
Source: Author's Computation, (2017)

Figure 4.4 shows that Malaria occurrence has been fluctuating in the study area with its peak occurrence in 2006 and the lowest occurrence in 2013. The decrease in the occurrence in 2013 might be attributed to the state government's effort of combating malaria incidence by providing treated mosquito nets to residents. This initiative was discontinued as the government of the state leadership changed in 2015. Hence, the rise of reported cases of malaria in 2015. The occurrence of Malaria is generally high in the study area may be because of the high amount of rainfall received in Ankpa LGA since Malaria is associated with stagnant water which usually occurs when there is high rainfall and poor drainage systems. The trend as indicated by the linear trend

line shows a slight decreasing pattern of occurrence. The linear trend line equation is y = -53.23x + 1476, indicating that the rate of occurrence of malaria has been on the decrease to a small extent which may be due to the increase in National awareness of the use of treated mosquito nets over the time frame. This finding agrees with Anumonye (2016), Ntem (2014), Bako, (2012) and Omonijo, (2010) who carried out similar studies in Onitsha North, Jos North, Kafanchan and Akure LGAs respectively.

4.2.2 Pattern of Typhoid Fever Occurrence in the Study Area

The occurrence of Typhoid fever in the study area within the time frame of the study is given in Figure 4.5.

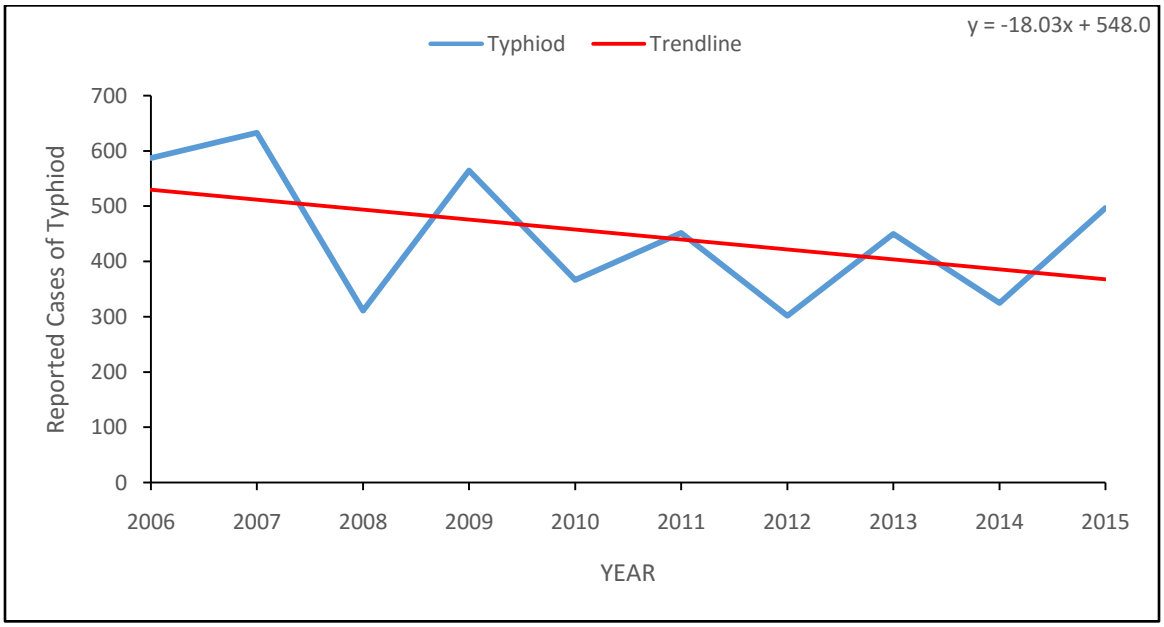


Figure 4.5: Pattern of Typhoid Cases
Source: Author's Computation, (2017)

The trend shows that there have been fluctuations in the occurrence of typhoid fever in the area with the highest occurrence recorded in 2007 and the lowest in 2012. The linear trend line equation y= -18.03+548.0 indicates that the occurrence of typhoid fever in the study area has been on the decline. There is an increasing trend in 2015 which might be associated with poor

quality of drinking water from streams and rivers in the study area as a consequence of low rainfall that year. This finding disagrees with Anumonye (2016) which states that typhoid fever is on the increase in Onitsha North LGA, Anambra State, Nigeria.

4.2.3 Pattern of Occurrence of Meningitis in the Study Area

Figure 4.6 gives the occurrence of meningitis within the time frame of the study in the study area

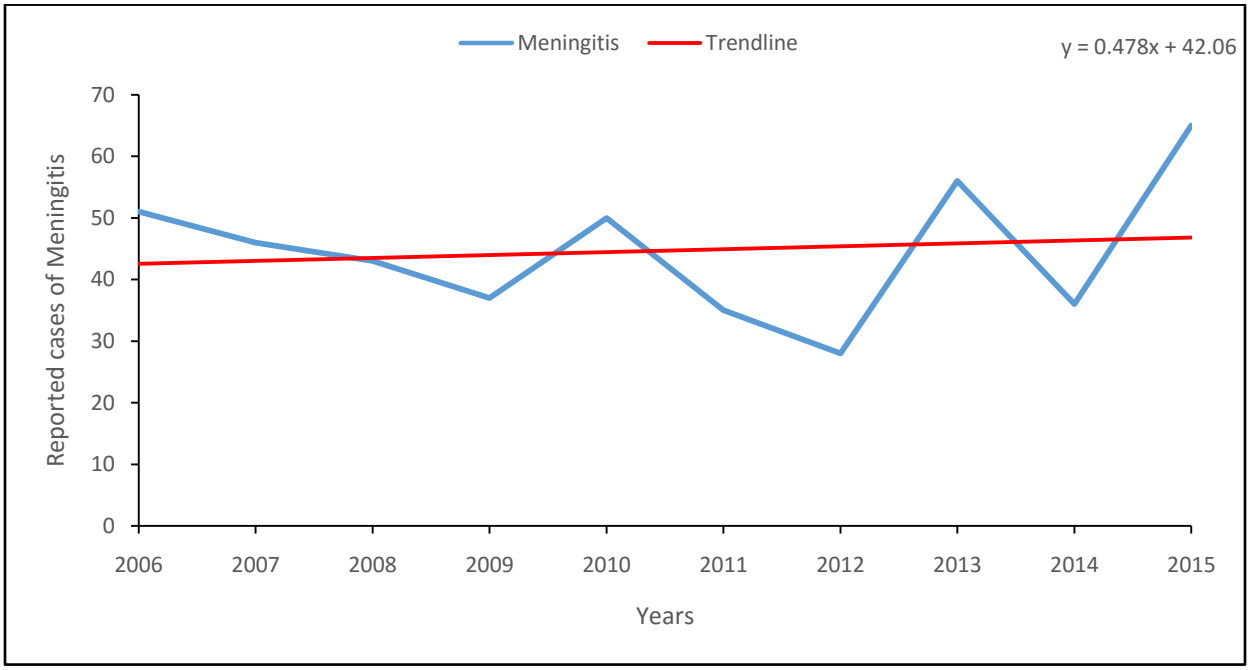


Figure 4.6: Pattern of Meningitis Cases
Source: Author's Computation, (2017)

The trend shows that the occurrence of meningitis has been fluctuating in the study area with 2015 having the highest occurrence and 2012 having the lowest. The trend line shows a slight increasing trend of meningitis within the period of study (2006-2015). This is supported by the trend line equation y = 0.4788x + 42.067 indicating that the occurrence of meningitis in the study area has been on the increase. This finding corroborates the finding of Bako (2012) in Kafanchan

LGA and Abdulsallam (2014) in Northwest Nigeria that established an increasing trend of meningitis in their respective study areas..

4.2.4 Pattern of Pneumonia Occurrence in the Study Area

The occurrence of pneumonia in the study area within the study period is presented in Figure 4.7.

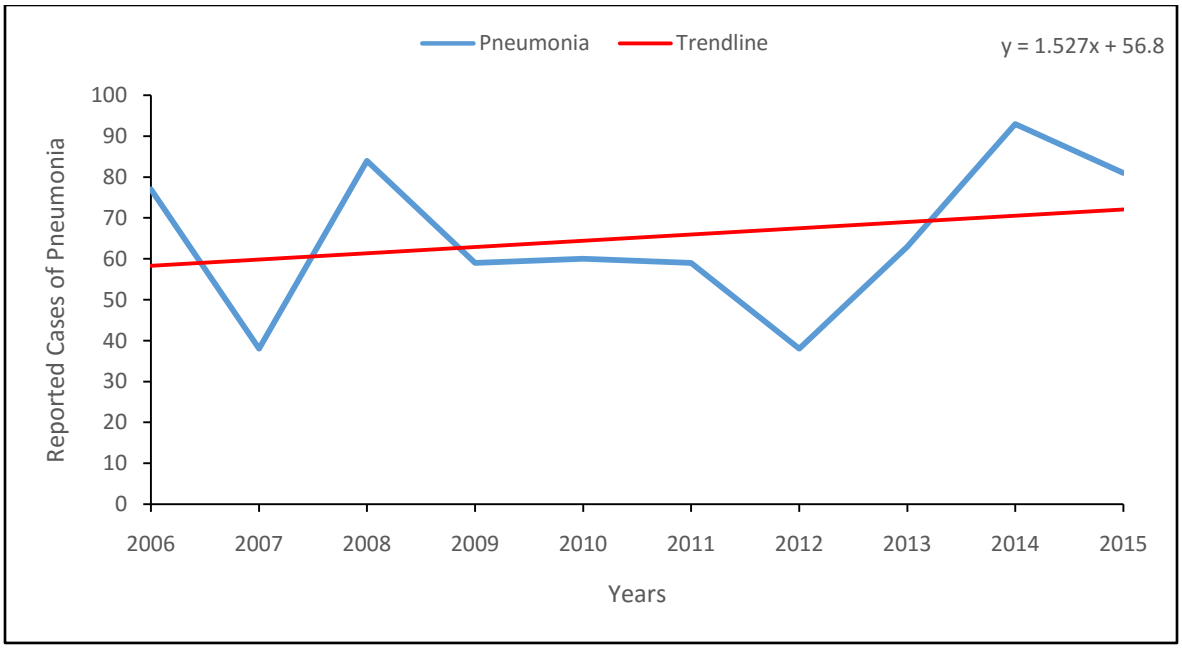


Figure 4.7: Pattern of Pneumonia Cases
Source: Author's Computation, (2017)

There were fluctuations in occurrence of pneumonia with the year 2007 having the lowest occurrence while 2014 have the highest. On a general note, the trend line equation y = 1.527x + 56.8 shows that the occurrence of pneumonia has been on the increase, this can be observed from the trend line. This increase may be attributed to the lack of awareness about the disease. This finding confirms the finding of Ntem (2014). The researcher affirms that pneumonia occurrence has been on the increase in Jos North LGA of Plateau State Nigeria.

4.2.5 Pattern of Occurrence of Diarrhea in the Study Area

Figure 4.8 presents the pattern of occurrence of diarrhea within the study period in the study area.

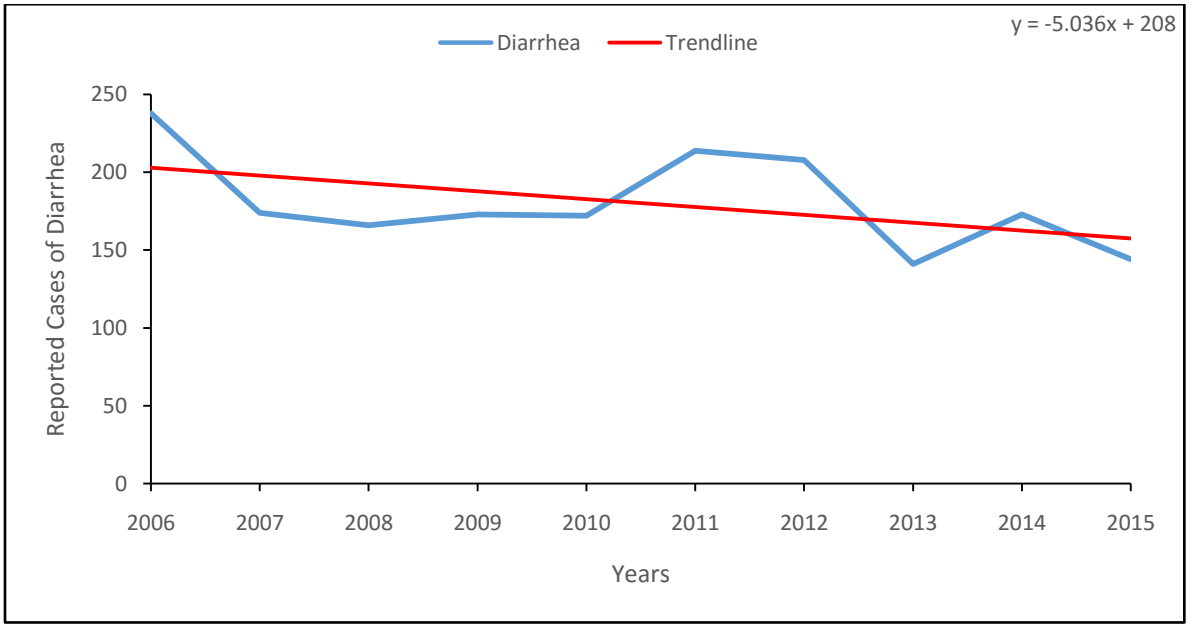


Figure 4.8: Pattern of Diarrhea occurrence
Source: Author's Computation, (2017)

From figure 4.8, it can be observed that diarrhea shows a fluctuating trend of occurrence in the study area within the study period. The year 2006 had the highest occurrence of diarrhea while 2015 had the lowest. The trend line equation y = -5.036x + 208 indicates a decreasing trend of the disease. This can be observed from the linear trend line. This decrease over the years may be associated with more awareness on sanitation and sanitary practices in the study area. This finding goes contrary to the finding of Bako (2012). The researcher opined that Diarrhea has been on the increase over the years in Kafanchan LGA, Kaduna State, Nigeria.

4.3 Relationship between Weather Elements and Occurrence of Diseases

The relationship between the weather elements and the occurrence of the selected common diseases in the study area is presented in Table 4.1 (see appendix II for computations)

Table 4.1: Correlation Matrix of Climatic variables and Diseases

Variables	Rainfall	Temperature	Relative Humidity
Malaria	0.595	-0.214	-0.115
Typhoid	0.167	0.087	-0.297
Meningitis	-0.285	0.305	-0.542
Pneumonia	-0.144	-0.041	-0.438
Diarrhea	0.544	-0.533	0.472

Source: Author's Computation, (2017)

From Table 4.1, it can be seen that rainfall showed a positive relationship with the occurrence of malaria, typhoid and diarrhea, which means that increase in rainfall encourages the occurrence of these diseases. This finding agrees with Ogbaji (2006) in a study carried out in Zaria and Anumonye (2016) in Onitsha North LGA. Rainfall however has a negative relationship with meningitis and pneumonia suggesting that an increase in rainfall will lower the occurrence of meningitis and pneumonia. This finding agrees with Bako (2012) in a study conducted in Kafanchan LGA. The stated hypothesis is rejected for malaria, typhoid and diarrhea while it is accepted for meningitis and pneumonia

Temperature showed a positive relationship with, typhoid and meningitis. This means that an increase in temperature will lead to an increase in the outbreak of these diseases. This is in agreement with the findings of Bako, (2012) in Kafanchan LGA, Sawa and Bukhari (2011) in Zaria and Akinbobola and Omotoso (2004) in Ikeja, Akure and Kaduna. It however showed a negative relationship with malaria, pneumonia and diarrhea which means that an increase in temperature lowers the occurrence of malaria, pneumonia and diarrhea. This is also in agreement

with Akinbobola and Omotoso (2004) Ikeja, Akure and Kaduna. The stated hypothesis is rejected for typhoid and meningitis while it is accepted for pneumonia and diarrhea.

Relative humidity showed a positive relationship with diarrhea. This implies that an increase in relative humidity will lead to an increase in the occurrence of diarrhea. While it showed a negative relationship with malaria, typhoid, meningitis and pneumonia, meaning an increase in relative humidity will not increase the occurrence of these diseases. This confirms the finding of Bako (2012) in a study carried out in Kafanchan LGA. The stated hypothesis was rejected for diarrhea while it was accepted for malaria, typhoid, meningitis and pneumonia.

4.4 SEASONAL PATTERN OF THE OCCURRENCE OF DISEASES

The seasonal pattern of occurrence of the selected diseases from 2006 to 2015 is discussed in this section

4.4.1 Seasonal Pattern of Disease Occurrence in 2006

Figure 4.9 shows the seasonal pattern of occurrence of the selected diseases in the year 2006.

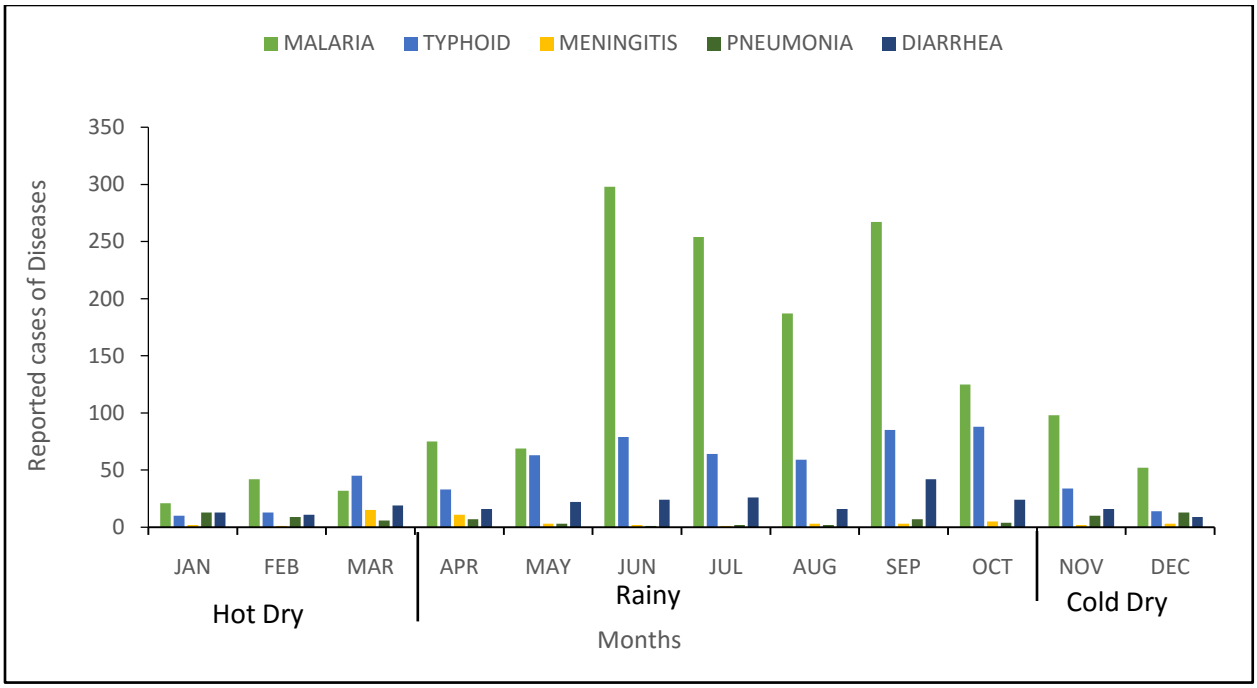


Figure 4.9: Seasonality of Diseases in 2006
Source: Author's Computation, (2017)

From Figure 4.9, it can be seen that the frequency of occurrence of malaria in the study area is very high, with the peak occurring during the rainy season peak (June to September) and its lowest incidence occurring during the hot dry season (January to March). The occurrence of typhoid drastically dropped at the onset of the dry season (November) and remained low during the hot dry season. The frequency of occurrence of Meningitis was at its peak during the end of the hot dry season (March) and the beginning of the rainy season (April). The occurrence of

pneumonia is not as high as typhoid with its peak in the cold dry season (November and December). The occurrence of diarrhea is frequent during the hot dry and rainy seasons; its peak was observed when rainfall was at its peak (September). This finding confirms the finding of Bako (2012) where the researcher affirmed that there is significant variability in the occurrence of common diseases among the various seasons in Kafanchan LGA, Kaduna State, Nigeria.

4.4.2 Seasonal Pattern of Diseases Occurrence in 2007

The seasonal pattern of the selected diseases in the year 2007 is presented in Figure 4.10

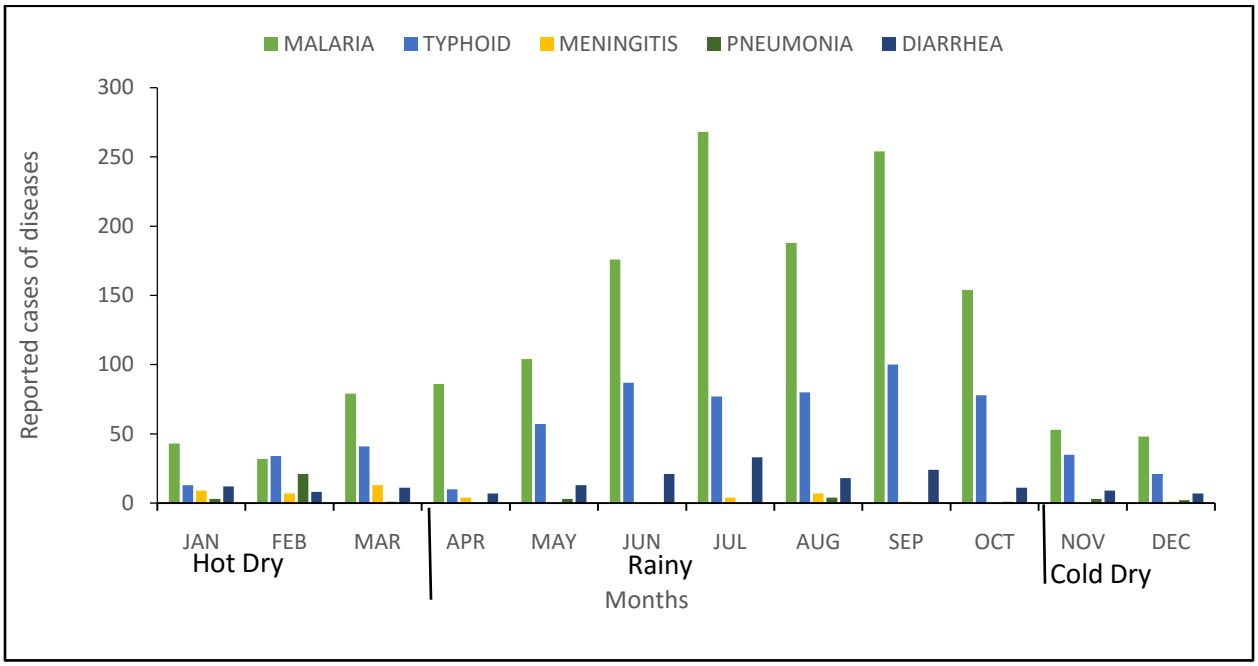


Figure 4.10: Seasonality of Diseases in 2007
Source: Author's Computation, (2017)

From Figure 4.10, it can be observed that the frequency of occurrence of malaria is very high in the study area with its peak occurring during the rainy season (July and September) while the lowest incidence was during the hot dry season (January to March). Typhoid fever occurred

mostly during the rainy season (April to October), with its peak in the month of September and the lowest occurring in April.

Meningitis showed a rather fluctuating trend throughout the year with an increase during the hot dry season (January to March). Its peak is in the month of march while its lowest occurrence was observed in some part of the rainy season (May, June and October) and the cold dry season (November and December). Pneumonia occurred mostly during the cold dry season (November and December).This finding confirms the finding of Bako (2012) where he affirmed that there is significant variability in the occurrence of common diseases among the various seasons in Kafanchan LGA.

4.4.3 Seasonal Pattern of Diseases Occurrence in 2008

Figure 4.11 presents the seasonal pattern of occurrence of the selected diseases in the year 2008.

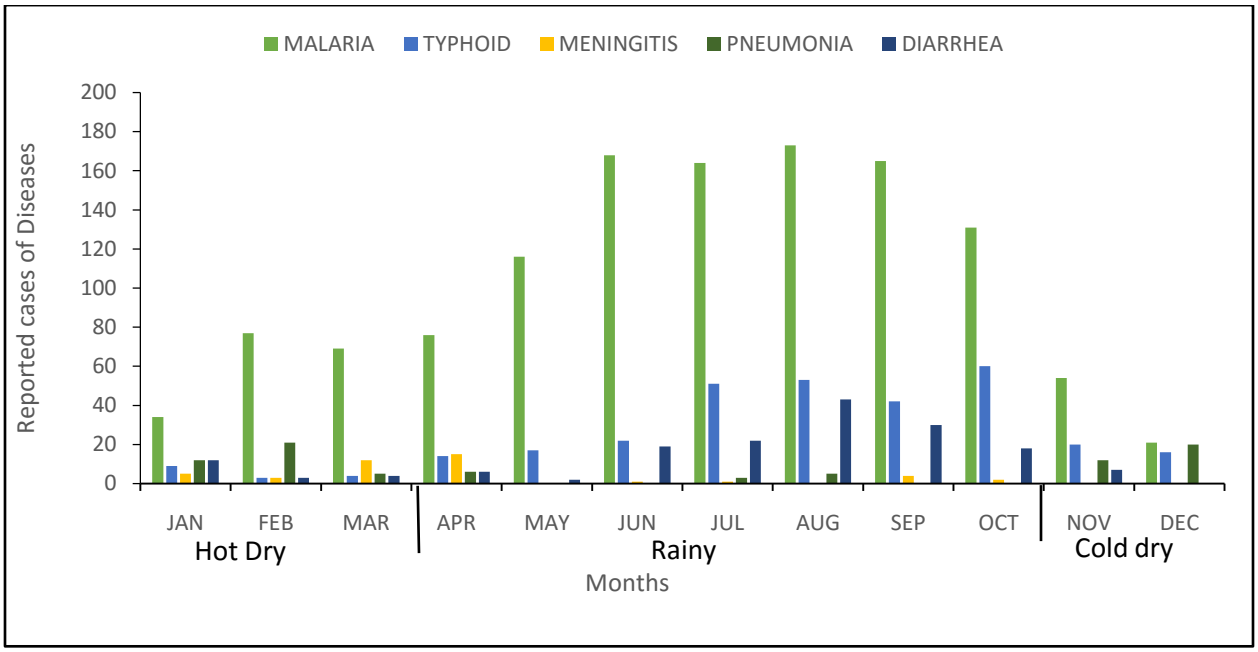


Figure 4.11: Seasonality of Diseases in 2008
Source: Author's Computation, (2017)

The highest case of malaria was recorded in the peak of the rainy season (June to September) with its lowest in the cold dry (December) and hot dry (January) seasons. Typhoid has its highest frequency of occurrence within the rainy season (July to October) while the lowest frequency of occurrence was observed in the hot dry season (February and March). The frequency of occurrence of meningitis is highest during the hot dry season (January to March) and the beginning of the rainy season (April). Pneumonia occurred frequently during the cold dry season (November and December) while diarrhea occurred frequently during the hot dry season (January to March). This finding is in agreement with Akinbobola and Omotosho (2004) suggesting that there is seasonal variation in the occurrences of diseases in Ikeja, Akure and Kaduna.

4.4.4 Seasonal Pattern of Diseases Occurrence in 2009

Figure 4.12 shows that the highest case of malaria was recorded during the peak of the rainy season (July to October) while the disease was recorded less during the hot dry season (January and February). Typhoid had similar pattern as malaria with frequent occurrence in the rainy season (May to October) while its occurrence was less during the hot dry season (January to March). Meningitis was more frequent during the hot dry season (January to March) and the least occurrence was during the rainy season (April to October). Pneumonia recorded highest in the cold dry season (November and December) though it can also be observed that the occurrence was also high in the month of February.

The seasonal pattern of occurrence of the selected diseases in the year 2009 is presented in Figure 4.12.

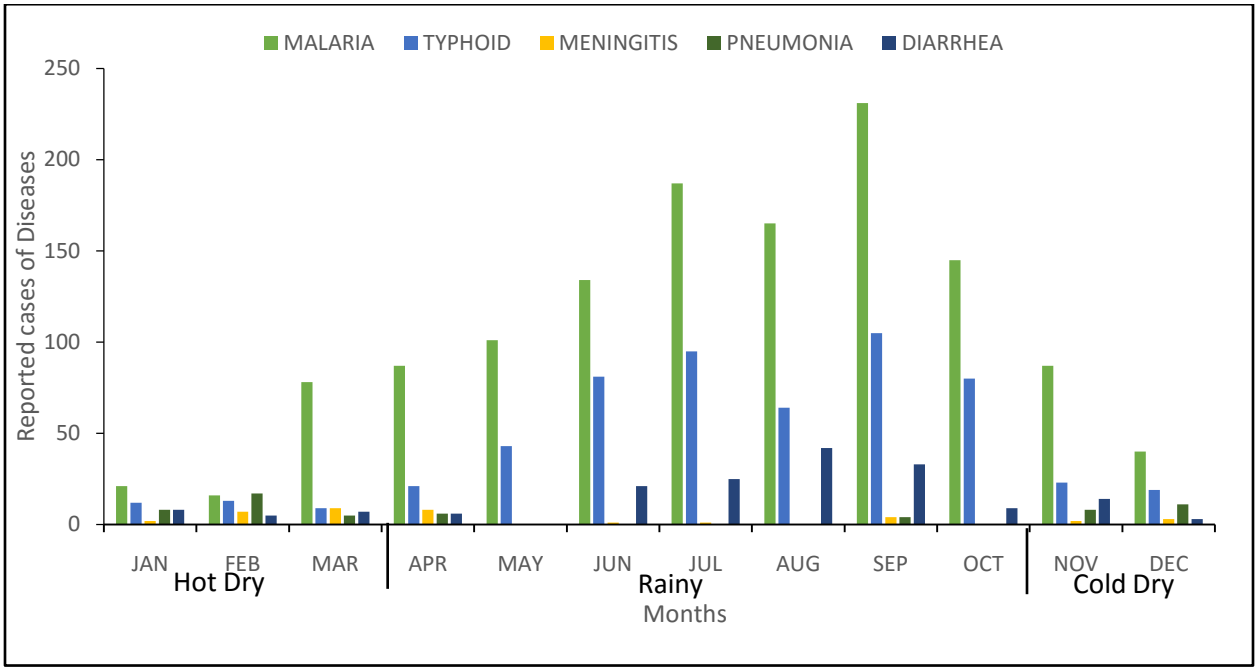


Figure 4.12: Seasonality of Diseases in 2009
Source: Author's Computation, (2017)

It was less frequent during the rainy season (May to October). Diarrhea was more frequent during the rainy season with its highest frequency of occurrence when rainfall was at its peak (May to October) and the lowest occurrence was during the cold dry season (November and December). This is in agreement with Anumonye (2016) arguing that there is seasonal variation in the occurrence of common diseases in Onitsha North LGA.

4.4.5 Seasonal Pattern of Occurrence of Diseases in 2010

The seasonal pattern of occurrence of the selected diseases in the year 2010 is shown in figure 4.13

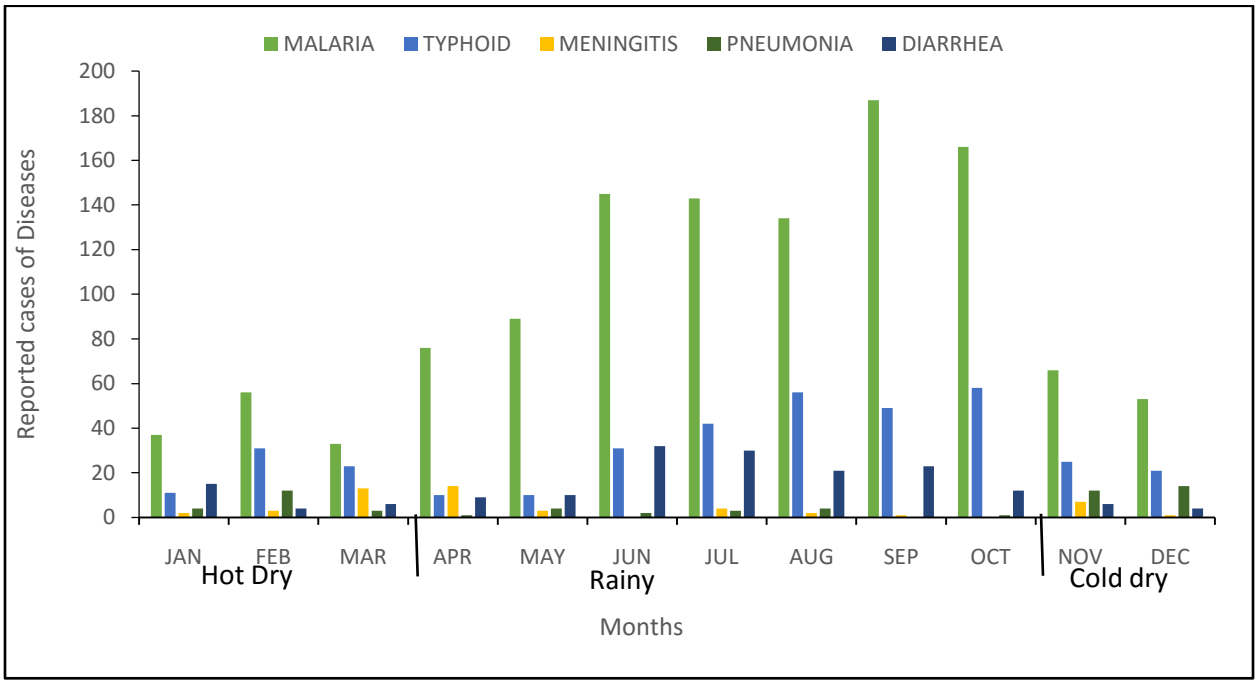


Figure 4.13: Seasonality of Diseases in 2010
Source: Author's Computation, (2017)

From figure 4.13, malaria recorded highest occurrence in the rainy season with its peak in September. The lowest occurrence was recorded during the hot dry season (March). Typhoid occurrence was highest during the rainy season with its peak occurrence in august and October. the occurrence was however lowest during the hot dry season (January). Meningitis occurrence was highest during the end of the hot dry season (January to March) and the beginning of the rainy season (April), its lowest occurrence was in the rainy season and cold dry season. Pneumonia was more prevalent during the cold dry season (November and December) and its lowest occurrence in the rainy season. Diarrhea occurred frequently in the rainy season while its

lowest occurrence was in the cold dry season. This finding is in agreement with Ntem (2014) in Jos North LGA, Plateau State, Nigeria.

4.4.6 Seasonal Pattern of Occurrence of Diseases in 2011

Figure 4.14 shows the seasonal pattern of occurrence of the selected diseases in the year 2011

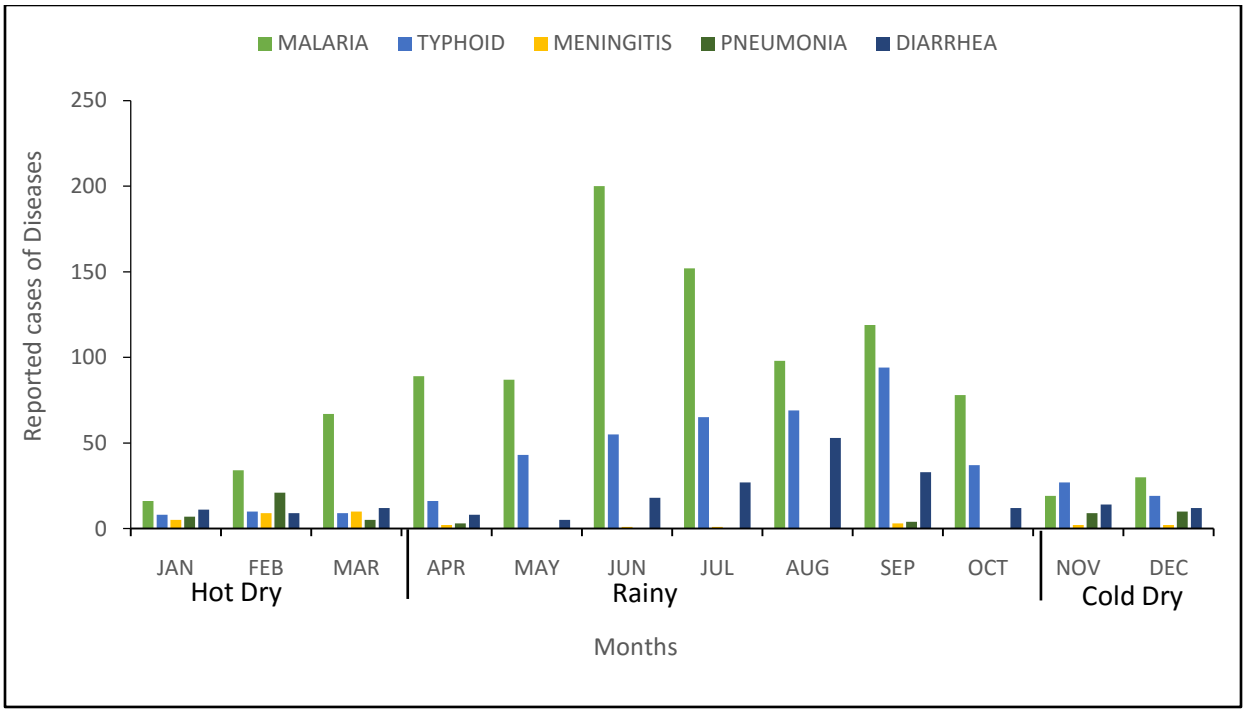


Figure 4.14: Seasonality of Diseases in 2011
Source: Author's Computation, (2017)

From figure 4.14, malaria occurrence can be seen to be all year round but its peak is during the rainy season with the highest record in June. Its lowest occurrence is during the cold dry season. Typhoid followed a similar trend having its highest occurrence during the rainy season while the lowest is at the hot dry season. Meningitis occurred mostly during the hot dry season pneumonia also has its highest recorded cases during the cold and hot dry seasons, the lowest record was recorded during the rainy season. Diarrhea however recorded highest during the rainy season with its peak in august when rainfall intensity is highest in the study area, while it recorded

lowest during the hot dry season. This corroborates with Bako (2012), Ntem (2014) and Anumonye (2016) in Kafanchan, Jos North and Onitsha North LGAs respectively.

4.4.7 Seasonal Pattern of Occurrence of Diseases in 2012

The seasonal pattern of occurrence of the selected diseases in the year 2012 is presented in figure 4.15

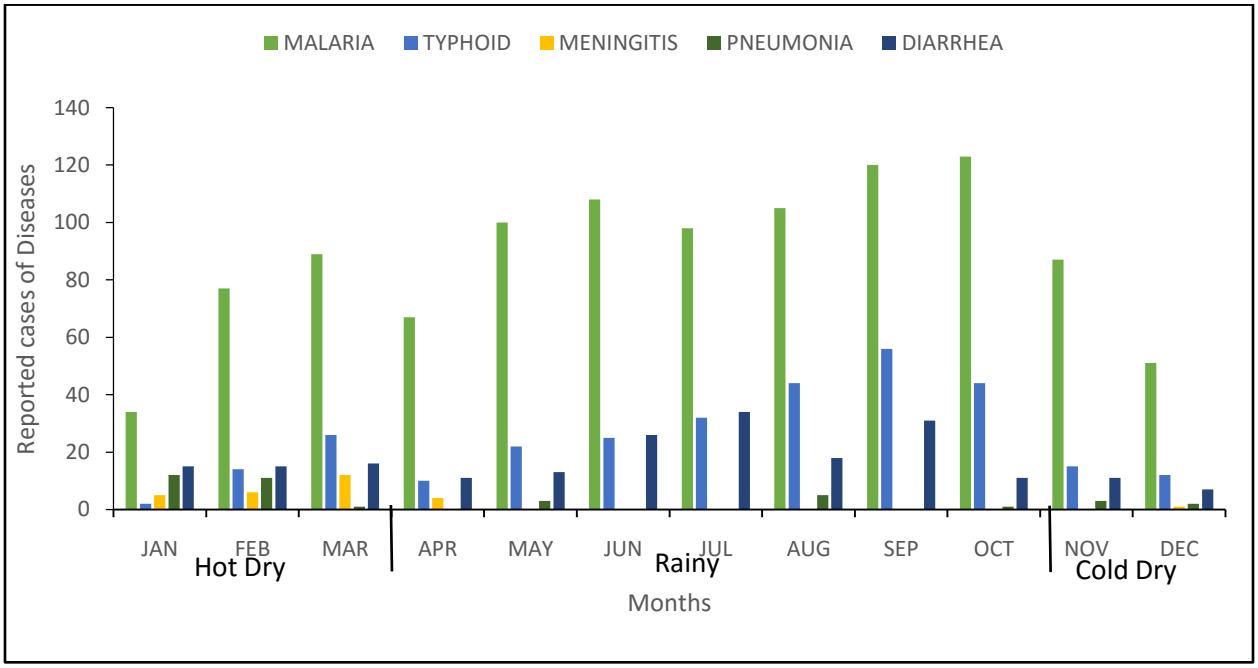


Figure 4.15: Seasonality of Diseases in 2012
Source: Author's Computation, (2017)

In the year 2012, figure 4.15 shows that malaria had a fluctuating occurrence all year round. Occurrence of malaria was generally high throughout the year, although its peak was during the rainy season (April to October) while the lowest was recorded in the hot dry season (January). Typhoid too followed a similar trend, cases were reported all year round but the highest cases were recorded in the rainy season between August and October, the lowest case was recorded in January. Meningitis had the highest frequency of occurrence during the hot dry season (January

to March) while it had the lowest frequency of occurrence during the rainy season. Pneumonia had the highest frequency of occurrence during the hot dry season, unlike the previous years, while the rainy season experienced less frequency of occurrence. Diarrhea occurred frequently during the rainy season with its highest occurring during the peak of the rainy season (August to October) and the lowest recorded for the cold dry season. This finding is in agreement with Akinbobola and Omotosho (2004) in Ikeja, Akure and Kaduna.

4.4.8 Seasonal Pattern of Diseases Occurrence in 2013

Figure 4.16 presents the seasonal pattern of occurrence of the selected diseases in the year 2013

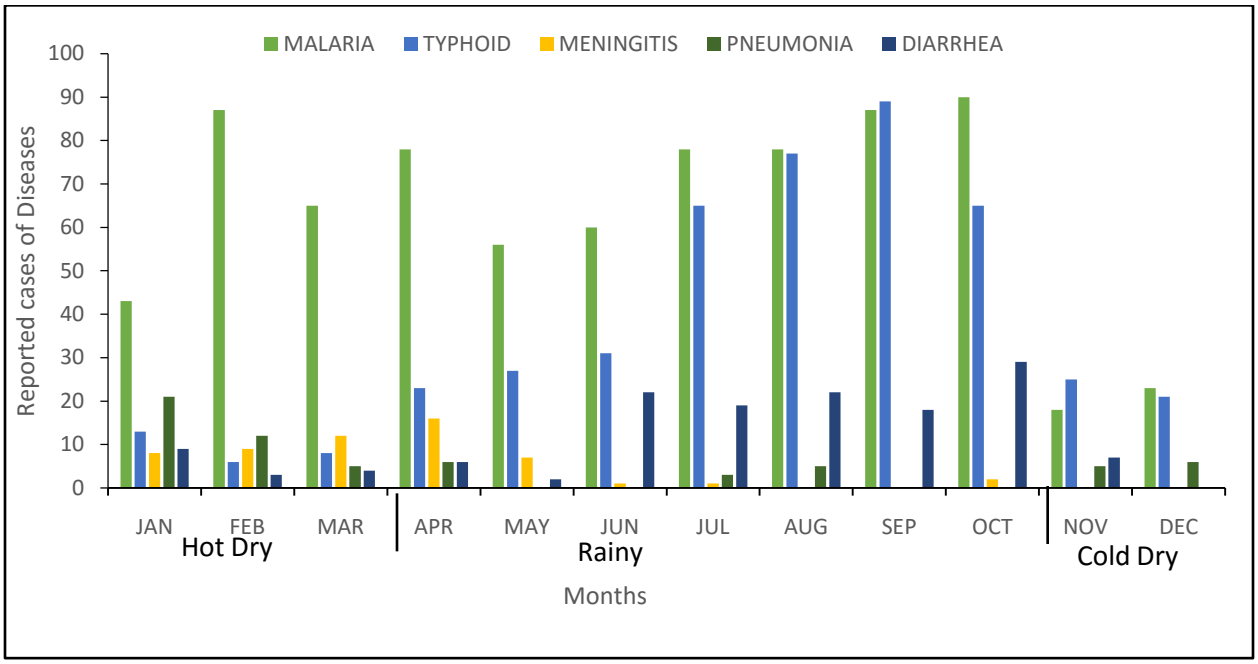


Figure 4.16: Seasonality of Diseases in 2013
Source: Author's Computation, (2017)

Malaria occurrence in the year 2013 was very high. Unlike other years, the highest cases were recorded during the hot dry season (February) followed by the rainy season and the lowest was recorded during the cold dry season (December). The reason for the very high cases of malaria

could be due to the 2012 floods, causing ponds of stagnant water which is a breeding site for mosquitoes. Typhoid has the highest recorded frequency during the rainy season with its peak occurring in September and the lowest frequency during the hot dry season. Meningitis was highest during the hot dry season (January to March) and some months into the rainy season (April and May) while it was at its lowest during the cold dry season (November and December). Unlike other years, pneumonia was highest during the hot and dry season (January to March) and into some months in the rainy season (April and May) and it was lowest during the cold dry season (November and December). Diarrhea has the highest frequency during the rainy season (April to October) while it had the lowest frequency during the cold dry season (November to December).This agrees with the finding of Anumonye (2016) in Onitsha North LGA.

4.4.9 Seasonal Pattern of Diseases Occurrence in 2014

The seasonal pattern of occurrence of the selected diseases in the year 2014 is presented in figure 4.17

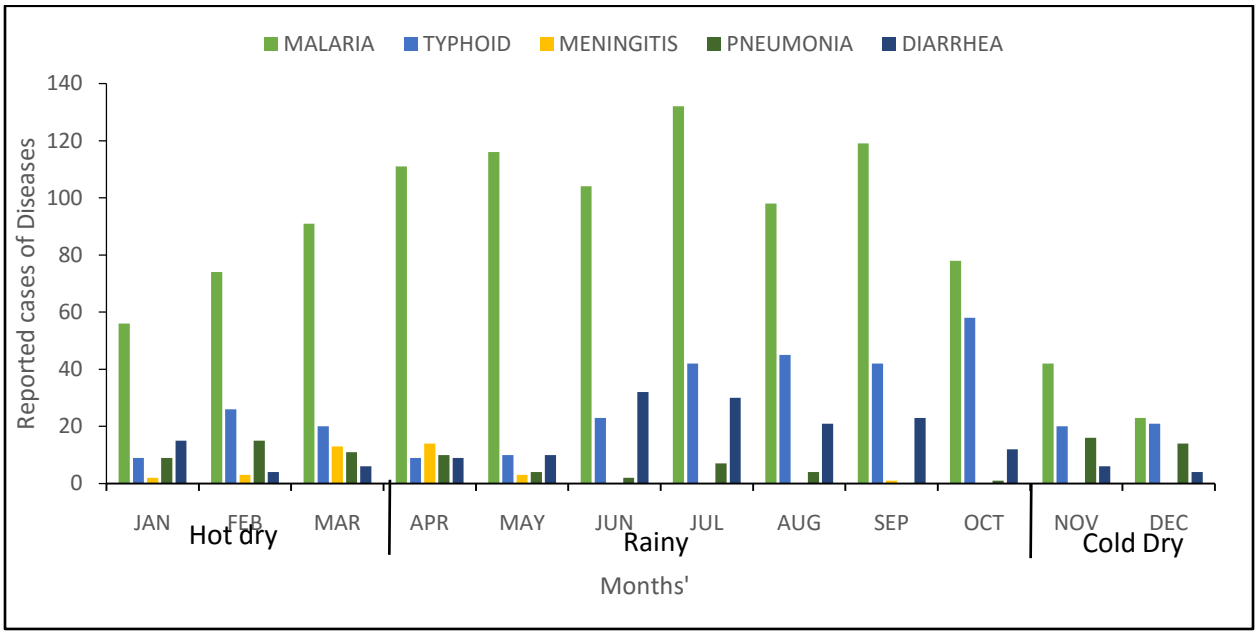


Figure 4.17: Seasonality of Diseases in 2014
Source: Author's Computation, (2017)

Figure 4.17 showed that malaria cases were high throughout the year 2014. This may be due to the fact that the study area received high amount of rainfall in 2014 which led to the creation of ponds of stagnant water. Malaria is highest during the rainy season with its peak in the month of July and the lowest frequency recorded in the cold dry season (November to December). Typhoid recorded highest during the rainy season with the highest in October and lowest in the hot dry season (January to March). Meningitis has the highest frequency of occurrence during the hot dry season (January to March) and the beginning of the rainy season (April), its lowest was during the rainy season (April to October). Pneumonia recorded highest during the cold dry season (November to December) while it was at its lowest during the rainy season (April to

October). Diarrhea was generally high during the rainy season (April to October) and lowest during the cold dry season (November to December). this finding is in agreement with what Bako (2012) found out in Kafanchan LGA.

4.4.10 Seasonal Pattern of Occurrence of Diseases in 2015

Figure 4.18 shows the seasonal pattern of occurrence of the selected diseases in the year 2015

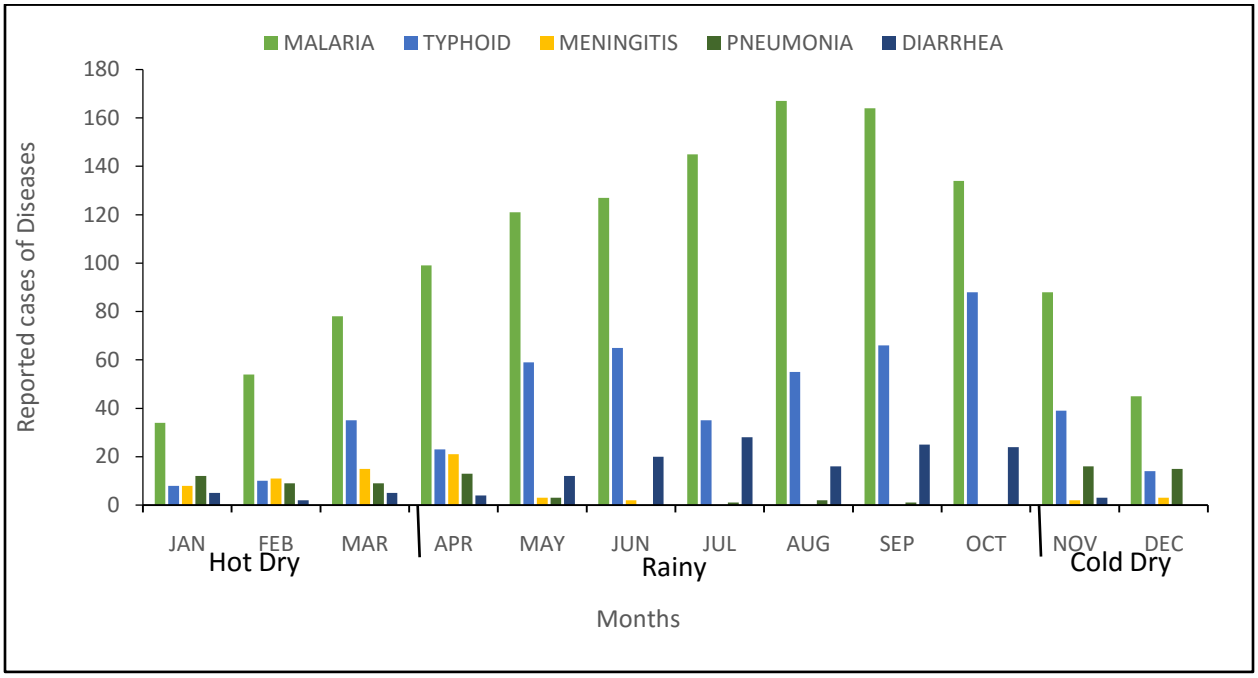


Figure 4.18: Seasonality of Diseases in 2015
Source: Author's Computation, (2017)

As observed from Figure 4.18, malaria had the highest frequency of occurrence during the rainy season (April to October) with its peak in the month of august and September, and it was recorded lowest during the hot dry season (January to March). The highest occurrence of malaria in the year 2015 may be due to the high temperature recorded for that year since mosquitoes thrive well during periods of high temperature.

Typhoid had the highest frequency of occurrence during the rainy season also with its lowest frequency during the hot dry season (January to March). Meningitis occurred most during the hot

dry season while the lowest frequency of occurrence was during the rainy season (April to October). Pneumonia was recorded more during the cold dry season (November to December) and during the beginning of the rainy season while its lowest frequency of occurrence was during the rainy season. Diarrhea in the year 2015 like previous years recorded highest during the rainy season while it recorded least during the cold dry season. This finding is in tandem with the findings of Anumonye (2016), Ntem (2014) and Bako (2012) which affirms that there is a seasonal variation in the occurrence of these common diseases in Onitsha North, Kafanchan and Jos North LGAs respectively.

4.4.11 Seasonality of Diseases Occurrence from 2006 to 2015

Figure 4.19 shows that between 2006 and 2015 malaria had its highest number of reported cases occurring during the rainy season and had its lowest number during the hot dry season. Typhoid occurrence was slightly higher during the rainy season with its lowest occurrence during the hot dry season. The occurrence of meningitis was most prevalent during the hot dry season and was lowest during the rainy and cold dry seasons, pneumonia was most prevalent during the cold dry season and lowest during the hot dry season and lastly diarrhea had the highest reported cases during the rainy season and the lowest reported cases during the cold dry season.

Figure 4.19 presents the mean annual seasonality of the selected diseases from 2006 to 2015 in the study area.

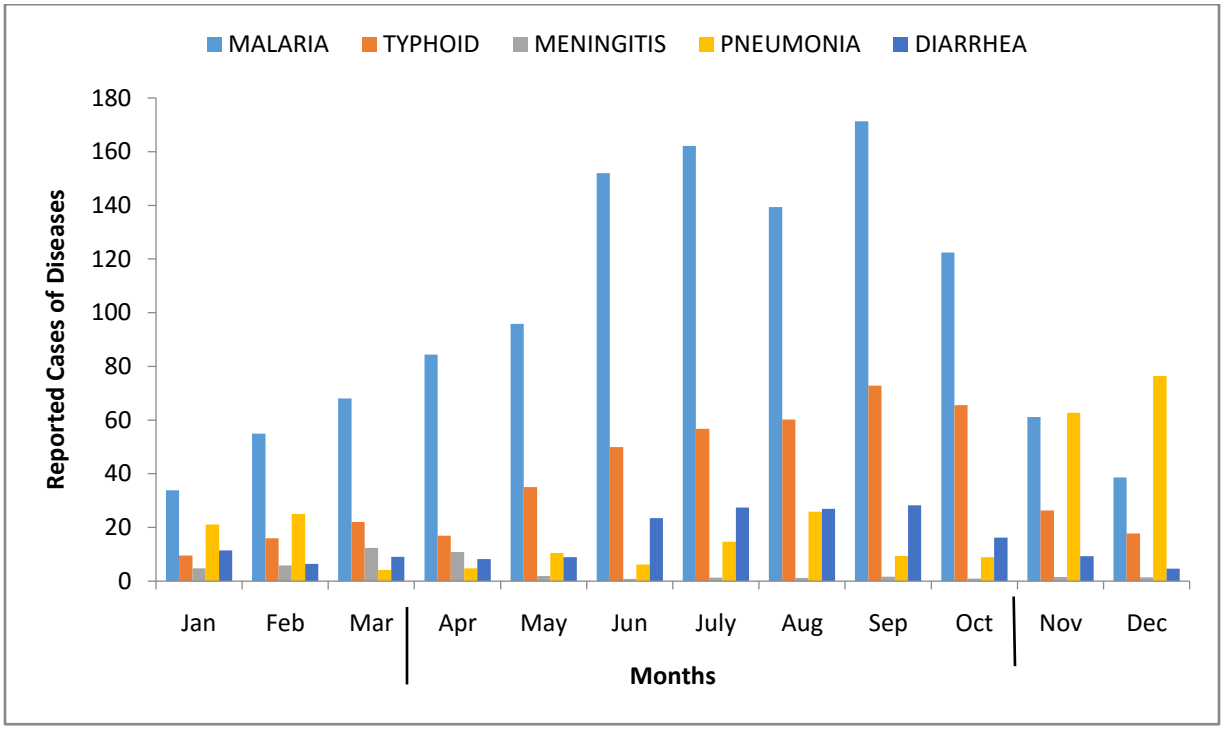


Figure 4.19: Seasonality of Diseases from 2006 to 2015
Source: Author's Computation, (2017)

4.5 Prediction of Weather Elements and Diseases for up to 2025

The predicted temporal pattern of occurrence of weather elements and diseases is discussed in this section. Appendix III shows their measures of central tendency.

4.5.1 Prediction of Mean Annual Rainfall

Figure 4.20 presents the predicted mean annual rainfall up to 2025

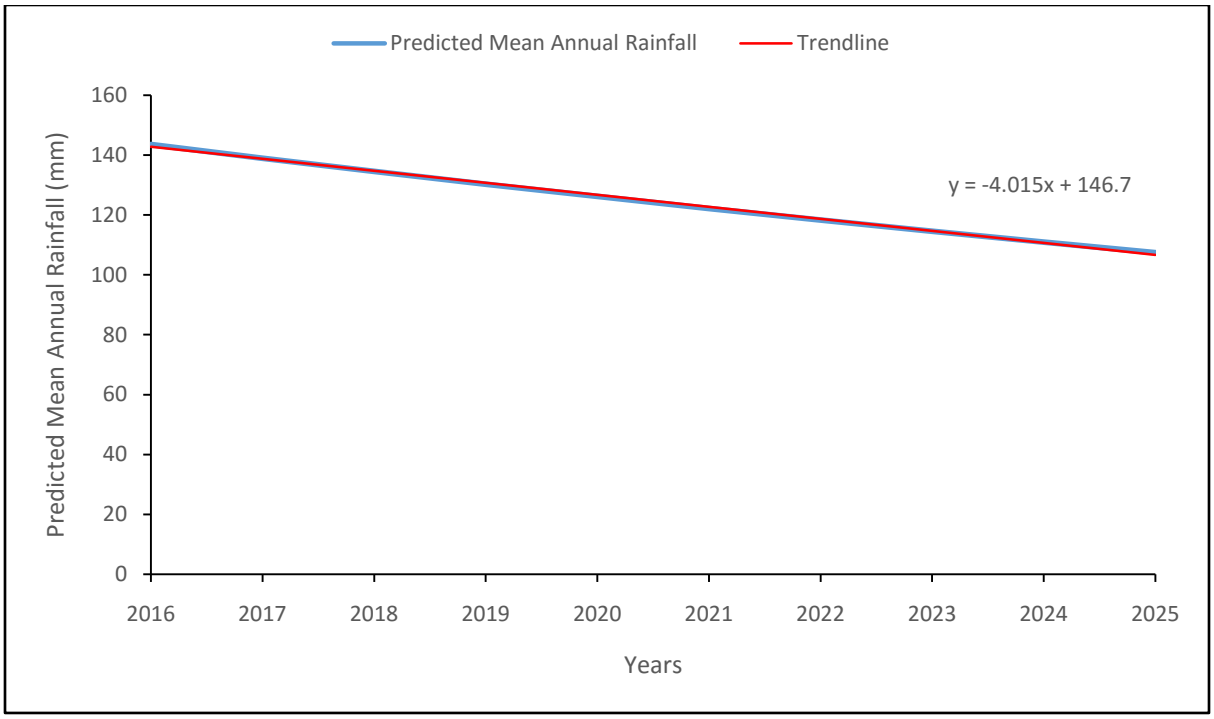


Fig. 4. 20: Predicted Mean Annual Rainfall up to 2025
Source: Author's computation (2017)

It is observed from Table 4.20 that rainfall will have a decreasing trend up to 2025. This is supported by the linear trend line equation y = -4.0152x + 146.79 indicating a decrease in the trend of rainfall within the given period. This may also be due to the increasing aridity in the study area (IPCC, 2007).

4.5.2 Prediction of Mean Annual Temperature

Figure 4.21 shows the predicted mean annual temperature up to 2025

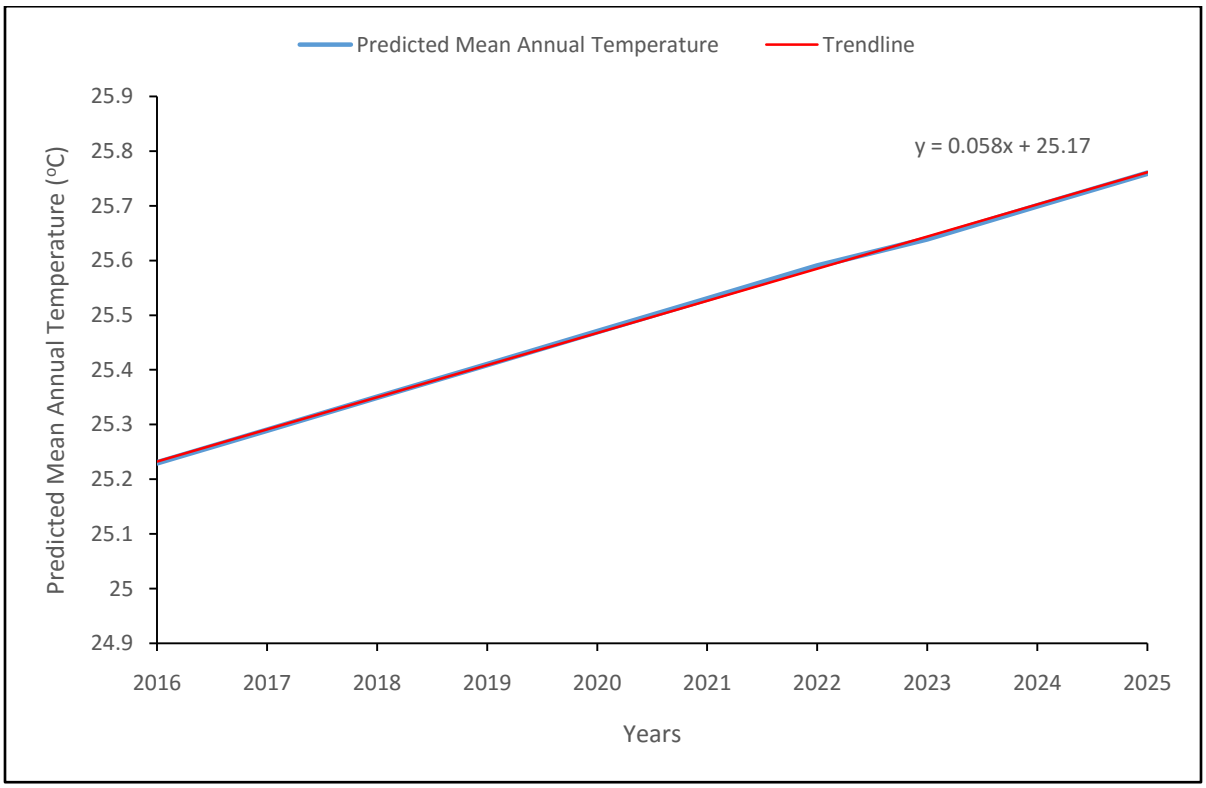


Fig.4.21: Prediction of Mean Annual Temperature up to 2025
Source: Author's Computation (2017)

According to Table 4.21, temperature will be on the increase upto 2025. The trend line equation y = 0.0587x + 25.174 indicates an increasing trend of temperature within the given period of time. This may be due to increasing global warming and climate change as predicted by IPCC (2007) and Abdulsalam (2014).

4.5.3 Prediction of mean annual Relative Humidity up to 2025

The predicted mean annual relative humidity is presented on figure 4.22

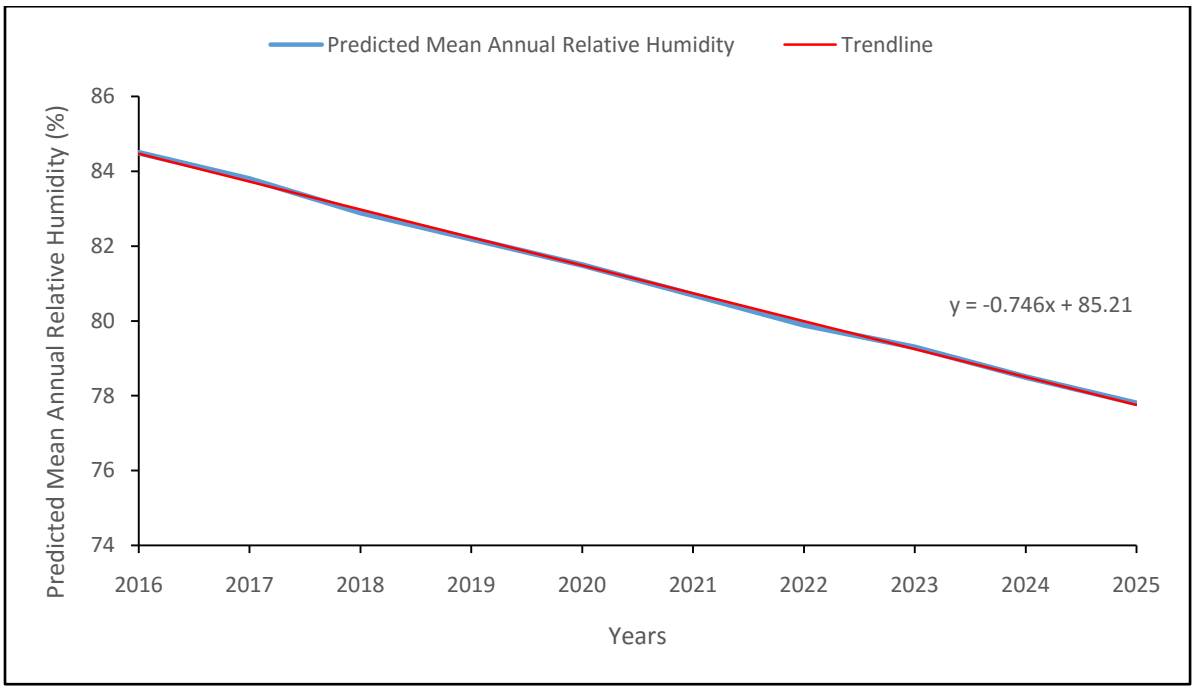


Fig. 4.22: Prediction of Mean Annual Relative Humidity up to 2025
Source: Author's Computation (2017)

The prediction in figure 4.22 shows that relative humidity will be on the decrease from 2016 up to 2025. This is supported by the trend line equation y = -0.7461x + 85. 213 suggesting that relative humidity will have a decreasing trend over the stated period of time. This may be linked with decreasing rainfall and increasing aridity in the study area.

4.5.4 Prediction of Malaria

Figure 4.23 presents predicted cases of malaria up to 2025 for the study area

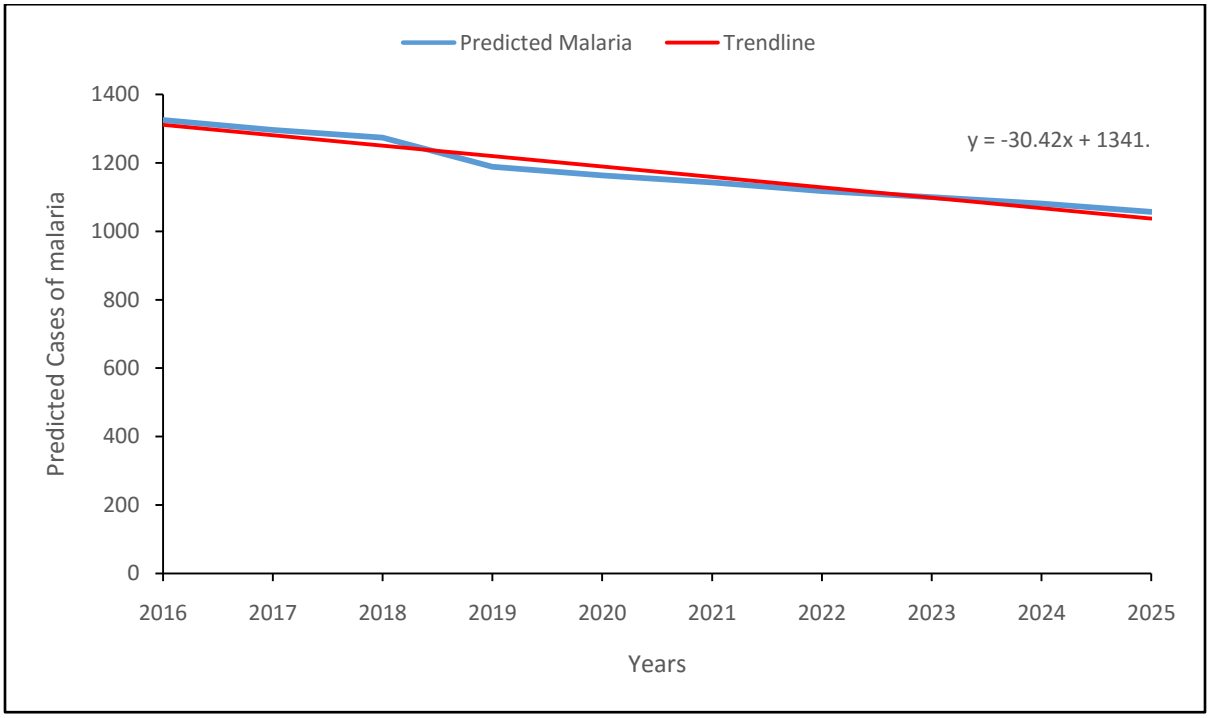


Fig. 4.23: Predicted Cases of Malaria up to 2025
Source: Author's Computation (2017)

From the prediction in figure 4.23, it can be observed that the occurrence of malaria will decrease over time. The linear trend line equation y = -30.424x + 1341.9 indicates that the occurrence of malaria will have a decreasing trend over the given period of time. This is also supported by the linear trend line. The decreases may be due to decrease in relative humidity which will lead to decrease in rainfall and poor breeding conditions for mosquitoes.

4.5.6 Predicted Cases of Typhoid up to 2025

Figure 4.24 shows the predicted cases of typhoid in the study area up to 2025

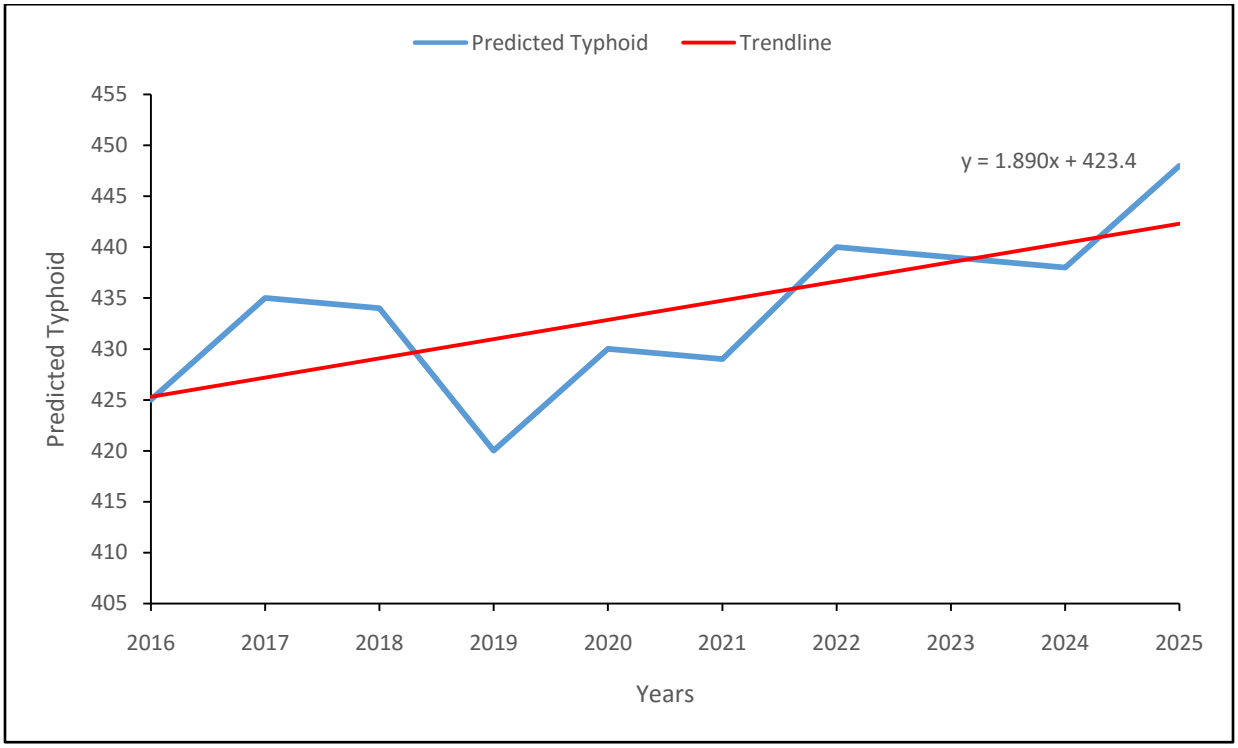


Fig. 4.24: Predicted Cases of Typhoid up to 2025
Source: Author's Computation (2017)

The prediction on figure 4.24 shows that the cases of typhoid will be fluctuating, but it will have an increasing trend during the given period. This can be observed from the linear trend line and also supported by the linear trend line equation y = 1.8909x + 423.4. This may be due to the predicted increase in temperature since the bacteria that causes typhoid (salmonella typhii) thrive well under high temperature.

4.5.7 Predicted Cases of Meningitis Occurrence

Figure 4.25 presents the predicted cases of meningitis up to 2025

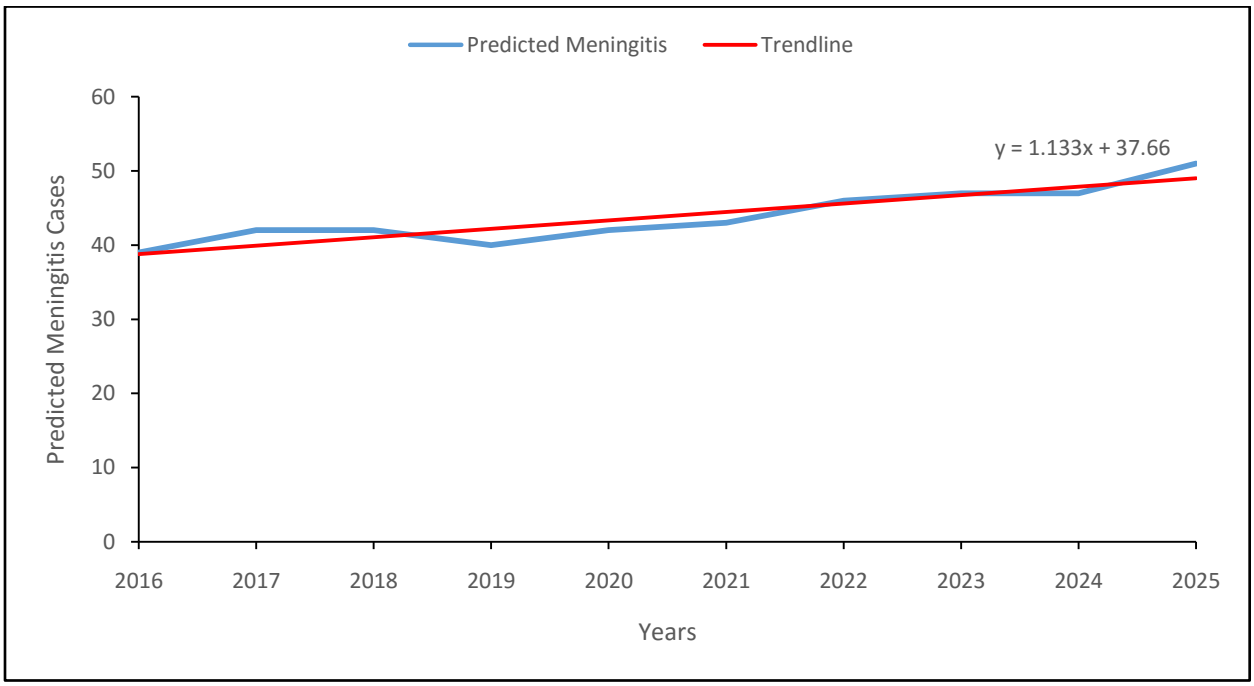


Fig. 4.25: Predicted Cases of Meningitis up to 2025
Source: Author's Computation (2017)

The predicted cases of meningitis show an increasing trend up to 2025. This means that during the given time frame, meningitis will be on the increase. This is observed from the trend line and also supported by the linear trend line equation y = 1.1333x + 37.667.This may be linked to the predicted increase in temperature in the study area since increase in temperature leads to increase in meningitis occurrence.

4.5.8: Predicted Cases of Pneumonia upto 2025

Figure 4.26 shows the predicted cases of pneumonia upto 2025

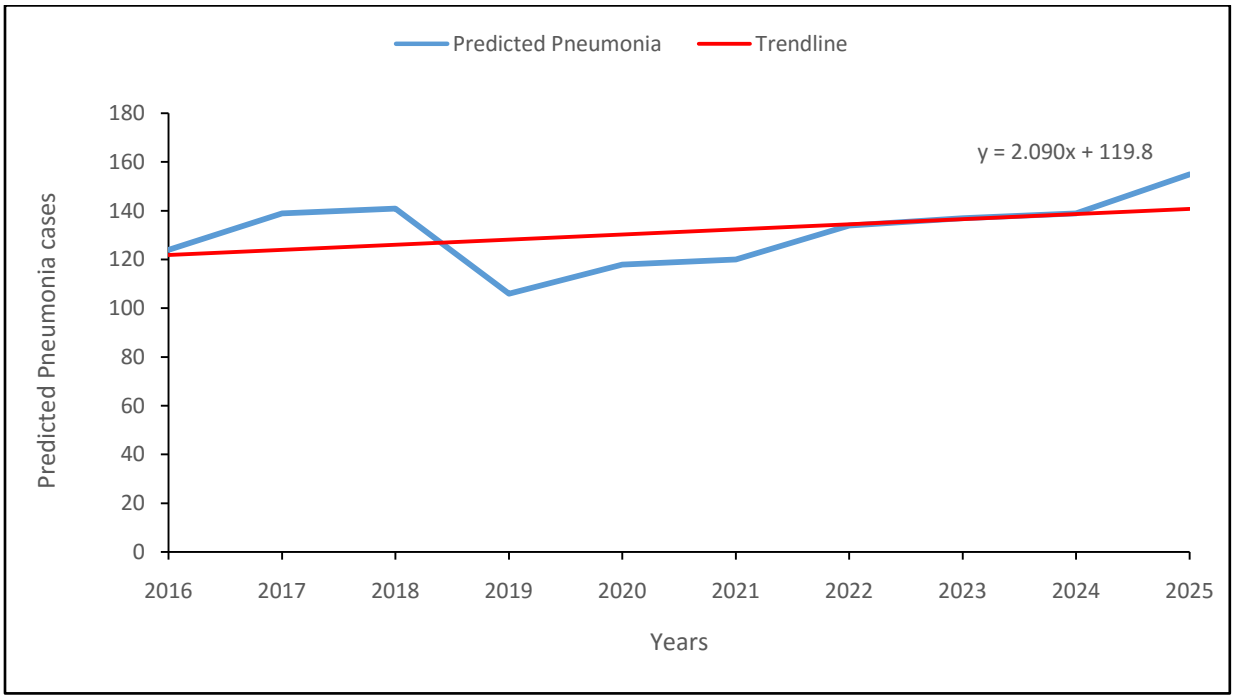


Fig. 4.26: Predicted Cases of Pneumonia
Source: Author's Computation (2017)

It can be observed that pneumonia has an increasing trend for the given period of time. This means that for the period of time predicted, pneumonia will be on the increase. The trend line shows that pneumonia will have an increasing trend, this is also supported by the trend line equation y = 2.0909 +119.8. This may be due to lack of awareness about the disease.

4.5.9: Predicted Cases of Diarrhea up to 2025

The predicted cases of diarrhea up to 2025 in the study area is shown in Figure 4.27.

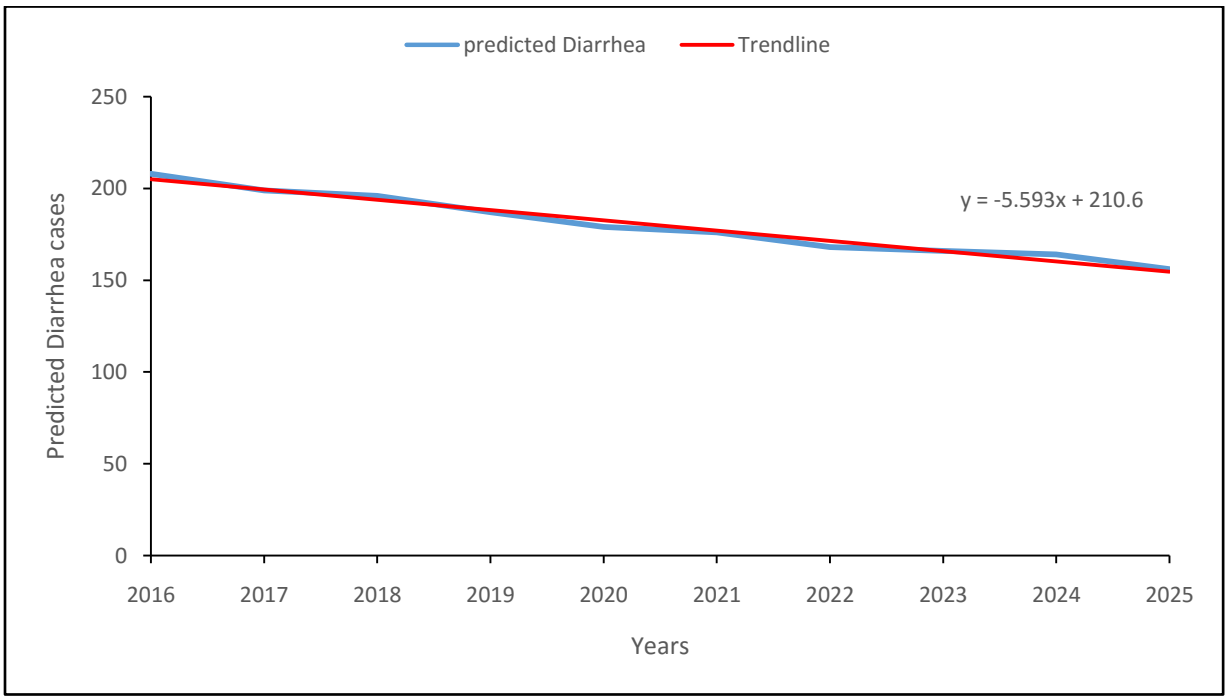


Fig. 4.27: Predicted Cases of Diarrhea
Source: Author's Computation (2017)

The predicted cases of diarrhea on figure 4.27 show that diarrhea will be on the decrease in the study area from 2016 to 2025. The trend line and trend line equation y = -5.5939 + 210.67 indicates that diarrhea will have a decreasing trend in the study area up to 2025. This may be due to the decreasing trend of rainfall observed since a decrease in rainfall would mean a decrease in diarrhea occurrence.

4.6 Discussion

Figs. 4.1 to 4.3 showed that rainfall, temperature, relative humidity have all been fluctuating between 2007-2015. Rainfall and relative humidity exhibited decreasing trends indicating a decrease in the amount received, this may be due to climate change. Temperature indicated an increasing trend which portrays that the average amount of temperature received is increasing for the time frame of study. This fluctuation in Temperature has been attributed mainly to global warming which is an effect of climate change. This finding corroborates with the finding of Anumonye (2016).

Figs 4.4 to 4.8 indicated that the occurrence of malaria, typhoid, meningitis, pneumonia and diarrhea have been fluctuating; this may be attributed to the fluctuations also exhibited by the weather elements. The trend line showed a decrease in the occurrence of malaria, typhoid and diarrhea and an increase in the occurrence of meningitis may be due to and pneumonia. This increased amount of recorded cases of meningitis may be due to increase in temperature and pneumonia may be due to an increased risk in exposure of the population to these diseases especially in terms of rapid increase in population in the study area over time, exposure to cold environments and lack of awareness about these diseases. This finding agreed with Anumonye (2016) but disagrees with the findings of Bako (2012).

From table 4.1, rainfall showed a positive relationship with malaria, typhoid and diarrhea occurrence, while it showed a negative relationship with the occurrence of meningitis and pneumonia. The stated hypothesis was rejected for malaria, typhoid and diarrhea but was accepted for meningitis and pneumonia. Temperature showed negative relationship with malaria,

pneumonia and diarrhea while it showed a positive relationship with typhoid and meningitis thereby corroborating the finding of Bako (2012) and Anumonye (2016). The stated hypothesis was rejected for typhoid and meningitis but accepted for malaria, pneumonia and diarrhea. Relative humidity showed a negative relationship with malaria, typhoid, meningitis and pneumonia occurrence, it however showed a positive relationship with the occurrence of diarrhea. The stated hypothesis was rejected for diarrhea but accepted for malaria, typhoid, meningitis and pneumonia. This finding agrees with Small, Hay and Goetz (2003), which stated that rainfall and relative humidity rather than temperature, was the primary forcing factor in malaria transmission trends in Africa during most of the twentieth century. The finding however disagrees with Ogbaji (2006) which states that there is a positive relationship between temperature extremes and the prevalence of malaria. The study area experiences high rainfall which has a major influence in enhancing mosquito breeding and survival. An increase in rainfall may increase the presence of malaria vectors by expanding the size of the already existing larval habitat as well as creating new breeding grounds; this in turn leads to an increase in the number of malaria cases especially when preventive measures are not taken.

Temperature intensity greatly influences the transmission of vector borne diseases such as typhoid because bacteria breed easily during periods of high temperature (Anumonye, 2016). The study area experiences relatively high amount of temperature all year round and this condition favors the survival of bacteria which increases the likelihood of typhoid cases experienced. Relative humidity however did not show positive relationship with malaria, typhoid, meningitis and pneumonia occurrence in the study area. This finding disagrees with Anumonye (2016).

From the Table 4.1, rainfall and temperature have a positive relationship with the occurrence of typhoid in the study area while relative humidity showed a negative relationship with the occurrence of the disease. This is in disagreement with Anumonye (2016) which states that rainfall and relative humidity has a significant relationship with the occurrence of typhoid. Although it is in agreement with Bako (2012) who observed that, the occurrence of typhoid fever is higher during the rainy season. The occurrence of typhoid is higher during the rainy season and hot dry season due to the high rate of contamination during this season and the fact that the bacterium (*salmonella typhii*) that causes typhoid fever thrives well under a high temperature.

Rainfall shows a negative relationship with the occurrence of meningitis while temperature and relative humidity shows a positive significant relationship with the occurrence of meningitis. This agrees with Sawa and Bukhari (2011) who noted that there is a significant relationship between temperature and the outbreak of CSM. Akinbobola and Omotosho (2004) also observed that the meningitis is common during hot periods. This may be due to the fact that the virus that cause meningitis thrive well during the hot seasons. They metabolize well during hot periods and hence the prevalence of the diseases during this period.

Rainfall, temperature and relative humidity show negative relationship with the occurrence of pneumonia in the study area. This is in disagreement with the studies of Akinbobola and Omotosho (2004) which opined that pneumonia is associated with the rainy season. Furthermore, rainfall and relative humidity shows a positive relationship with the occurrence of diarrhea while temperature shows a negative relationship. This may be due to the fact that for contamination to

occur transportation is needed, and this is facilitated when there is a downpour. When rain falls, contamination of water sources like streams and rivers is high. The diseases will occur more during rainy season. Irrespective of climate, it is more prevalent in the lower economic strata where poverty goes hand in hand with ignorance, overcrowding, poor hygiene, limited food supply and inadequately unsafe often unclean drinking water (Luper and prudence, 2009).

From Figures 4.9 to 4.18, the highest occurrence of malaria cases was recorded in 2006 during the rainy season with an average amount of 290 reported cases, while the lowest amount was recorded in 2008 during the cold dry season with an average amount of 20. It was observed that 2006 in general had the highest number of cases and 2013 had the lowest malaria cases recorded during the time frame of study. In general, malaria occurred most during the rainy season, this may be because female anopheles mosquitoes lay their eggs in stagnant water which is abundant during the rainy season. This goes in agreement with the findings of Akinbola and Omotosho (2004) and Bako, (2012).

The highest frequency of typhoid cases was recorded in 2007 during the rainy season, while the lowest amount was recorded in 2012 during the cold dry season during the time frame of study. It was observed that typhoid occurred most during the rainy season due to the presence of polluted ground water and poor sanitation which increases during the rainy season. Rainfall helps in influencing the transportation and dissemination of the infectious agents that causes typhoid. This finding is also supported by the findings of Bako (2012).

Meningitis cases was recorded most in 2015 with 65 reported cases and had its lowest recorded case in 2012 with 28 reported cases. It is observed that meningitis occurred most during the hot

dry season and it had its lowest occurrence during the cold dry season. This finding corroborates with Akinbobola and Omotosho (2004) which opined that meningitis is common during hot periods

Pneumonia recorded highest in the year 2008 with 84 reported cases and lowest in the year 2007/2012 with 38 reported cases. It was observed that pneumonia occurred most during the cold dry season. This might be associated with the fact that pneumonia causing pathogens thrive well during the cold season, hence the people of the study area are prone to the disease during this period. This finding agrees with Bako (2012).

Diarrhea had its highest frequency of occurrence in 2006 with 238 reported cases while it had its lowest in 2013 with 141 reported cases. In general, it was observed that diarrhea occurred more during the rainy season. Possibly because of contamination of water sources by runoff after a rainfall event. This finding also agrees with Bako (2012).

Figure 4.19 shows that between 2006 and 2015 malaria had its highest number of reported cases occurring during the rainy season with a seasonal average of 133 cases and had its lowest number during the cold dry season with a seasonal average of 50 cases. Typhoid occurrence was relatively uniform across all seasons but was slightly higher during the rainy season. The occurrence of Meningitis was most prevalent during the hot dry season with a reported average of 8 reported cases, followed by the rainy season with a reported average of 3 cases. Pneumonia had its highest number of reported cases occurring during the cold dry season with a reported average of 10 and lastly the Diarrhea had its highest occurrence during the rainy season with a reported average of 19 cases.

From figures 4. 20 to 4.27, it is observed that rainfall and relative humidity will have a decreasing trend from 2016 to 2025, temperature will however be on the increase within the forecasted period. This may be due to climate change. Consequently, malaria and diarrhea will have a decreasing trend up to 2025 while typhoid, meningitis, and pneumonia will have an increasing trend within the stated period. It is noteworthy that the projections result represents only the climatological potential for increased cases due to climate change, assuming that the present prevention strategies remain similar in the future.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5. 1 Summary

This research analyzed the influence of some weather elements and the occurrence of some selected diseases in Ankpa Local Government Area of Kogi State in Nigeria. This was carried out by using weather records of rainfall, temperature and relative humidity for 10 years (2006-2015), collected from the weather station at Kogi State College of Education, Ankpa and the records of reported cases of malaria, typhoid, meningitis, pneumonia and diarrhea obtained from the General Hospital, Bethel Hospital, Omega Hospital, Living Hope hospital and Madonna hospital all in Ankpa town over the same period. The intention was to see the temporal pattern of occurrence of the climatic elements and selected diseases, their relationship, seasonal variation and their future pattern.

Time series analysis was used to determine the trend in the occurrence of the weather elements and selected diseases. Pearson Product moment Correlation Coefficient was used to test the relationship between the variables, simple bar graphs were drawn to check the seasonality of occurrence of the diseases and regression analysis was used to forecast the variables. The following results were observed; rainfall and relative humidity showed decreasing trends with linear trend while temperature showed increasing trend. Malaria, Typhoid and Diarrhea showed a decreasing trend, while pneumonia and meningitis showed an increasing trend.

The result of the research also indicated that these diseases are influenced differently by the different weather elements; rainfall showed a positive relationship with malaria, typhoid and diarrhea and a negative relationship with meningitis and pneumonia. Temperature showed a positive relationship with typhoid and meningitis while it showed a negative relationship with malaria, pneumonia and diarrhea. Relative humidity on the other hand showed a negative relationship with malaria, typhoid, meningitis and pneumonia while it showed a positive relationship with diarrhea.

Seasonal analysis revealed that the rainy season and hot dry season recorded more cases of malaria, typhoid and diarrhea, this may be attributed to the presence of water which enhances the growth and proliferation of some disease pathogens, the hot dry season recorded more cases of meningitis, this may be attributed to overcrowding which makes it easier for people to contact the disease from already infected persons, the cold dry season recorded more cases of pneumonia, this can be attributed to lack of awareness.

The forecasting showed that rainfall and relative humidity will keep decreasing while temperature will have an increasing trend for the next 10 years (2016 - 2025). Consequently, malaria and diarrhea will be on the decrease while meningitis, typhoid and pneumonia will have an increasing trend over the given period of time.

Based on the findings of this study, the null hypothesis which states that there is no significant relationship between rainfall, temperature and relative humidity and the occurrence of malaria, typhoid, meningitis, pneumonia and diarrhea was accepted for relative humidity and temperature but rejected for rainfall in the case of malaria, accepted for relative humidity but rejected for

rainfall and temperature in the case of typhoid, accepted for rainfall and relative humidity but rejected for temperature in the case of meningitis, accepted for temperature, rainfall and relative humidity in the case of pneumonia and finally, it was accepted for temperature but rejected for rainfall and relative humidity in the case of diarrhea in the study area. This implies that different diseases are influenced differently by the weather elements, with some of the weather elements having a positive influence and others having a negative influence.

5.2 Conclusion

The results of the research showed that malaria and typhoid are the two most prevalent diseases in the study area. The relationship between malaria, typhoid, and diarrhea and the weather elements was high while for meningitis and pneumonia, it was relatively moderate. Rainfall had the most significant influence on the diseases. On the seasonal basis, all the three climatic elements were found to influence the occurrence of these diseases based on prevailing season. But the influence varied from one disease to another. It was observed that malaria and typhoid had the highest number of occurrence in all the months. The study showed that rainfall and temperature had a greater influence on the occurrence of malaria and typhoid when compared to the effect of relative humidity. Temperature had more influence on meningitis occurrence, Rainfall and relative humidity have a greater influence on diarrhea, hence malaria, typhoid and diarrhea showed a more positive relationship with the weather elements.

Weather has profound influence on the rate of occurrence for malaria, typhoid, meningitis, pneumonia and diarrhea in Ankpa LGA, the level of the effect varies from one disease to another for most of the study period. The recorded cases was higher in certain particular seasons but

differed on one or two occasions being that the spread of diseases is not merely affected by weather elements alone but may also be affected and induced by other environmental factors such as overcrowding, poor sanitation etc.

5.3 Recommendations

Based on the findings of this research, the following recommendations were made:

1. The State town planning board should ensure proper town planning of the LGA to avoid indiscriminate building of houses in order to improve health and sanitation of the residents.
2. Proper drainage channels should be constructed by the State Ministry of Works to reduce stagnation of water or waterlog after a downpour.
3. The Local Government Authorities should organize sensitization programs to educate the residents on the issue of climate change and how it can influence the occurrences of the common diseases in the area.
4. The State Ministry of Water Resources should make provision for potable drinking water by drilling boreholes in public places for public consumption to curb the use of contaminated water thereby reducing the occurrence of water borne diseases like diarrhea.
5. The State Ministry of Health should make provisions for vaccines for the immunization of these diseases especially pneumonia and meningitis. Residents should also be educated on how to manage these diseases.
6. It was observed from the study that malaria and typhoid are the most prevalent diseases in the study area, the Ministry of Health should make provisions for mosquito nets as this

will help curb the incidence of malaria. The State Ministry of Water resources should make provision of potable drinking water to curb the occurrence of typhoid fever.

7. Pneumonia was reported in the research to be hardly known by the residents, more enlightenment by health workers can help bring down the rate of occurrence considerably.
8. A study of this nature should be carried out on a yearly basis to assess whether the efforts made by government in combating these diseases in the study area are yielding positive result or not, if not, the weaknesses of such efforts should be identified and managed to ensure a sustainable environment.

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APPENDIX I

Table I: Annual Variation of Climatic Variables

Year	Rainfall	temperature	humidity
2006	153.3	25.09	80.61
2007	146.4	25.99	75.9
2008	131.2	25.05	83.6
2009	118.6	25.34	85.1
2010	121.6	25.77	88.8
2011	107.4	25.54	88.2
2012	133.9	25.37	88.0
2013	111.0	25.73	77.6
2014	131.3	26.01	73.5
2015	99.0	25.98	72.325
Mean	**125.4**	**25.6**	**81.4**
SD	**16.28**	**0.35**	**5.94**
CV%	**12.9**	**1.37**	**7.3**

Source: Authors Computation, (2017)

Table II: Occurrence of Diseases

Year	Malaria	Typhoid	Meningitis	Pneumonia	Diarrhea
2006	1520	587	51	77	238

2007	1485	633	46	38	174
2008	1248	311	43	84	166
2009	1292	565	37	59	173
2010	1185	367	50	60	172
2011	989	452	35	59	214
2012	1059	302	28	38	208
2013	763	450	56	63	141
2014	1044	325	36	93	173
2015	1256	497	65	81	144
Mean	**1184**	**449**	**45**	**65**	**160**
SD	**229.7**	**120.8**	**11.2**	**18.6**	**30.8**
CV%	**19.4**	**26.9**	**24.9**	**28.6**	**19.3**

Source: Author's Computation, (2017)

APPENDIX II

CORRELATION FOR RELATIONSHIP BETWEEN WEATHER ELEMENTS AND SELECTED DISEASES

		Malaria	Typhoid	Meningitis	Pneumonia	diarrhoea	Rainfall	Humidity	Temperature
Malaria	Pearson Correlation	1	.575	.151	-.024	.326	.595	-.115	-.214
	Sig. (2-tailed)		.082	.678	.948	.359	.069	.752	.552
	N	10	10	10	10	10	10	10	10
Typhoid	Pearson Correlation	.575	1	.371	-.246	.113	.167	-.297	.087
	Sig. (2-tailed)	.082		.291	.493	.757	.644	.405	.812
	N	10	10	10	10	10	10	10	10
Meningitis	Pearson Correlation	.151	.371	1	.319	-.491	-.285	-.542	.305
	Sig. (2-tailed)	.678	.291		.368	.150	.425	.105	.391
	N	10	10	10	10	10	10	10	10
Pneumonia	Pearson Correlation	-.024	-.246	.319	1	-.191	-.144	-.438	-.041
	Sig. (2-tailed)	.948	.493	.368		.598	.691	.206	.911
	N	10	10	10	10	10	10	10	10
diarrhoea	Pearson Correlation	.326	.113	-.491	-.191	1	.544	.472	-.533
	Sig. (2-tailed)	.359	.757	.150	.598		.104	.168	.112
	N	10	10	10	10	10	10	10	10

Rainfall	Pearson Correlation	.595	.167	-.285	-.144	.544	1	.005	-.329
	Sig. (2-tailed)	.069	.644	.425	.691	.104		.990	.354
	N	10	10	10	10	10	10	10	10
Humidity	Pearson Correlation	-.115	-.297	-.542	-.438	.472	.005	1	-.573
	Sig. (2-tailed)	.752	.405	.105	.206	.168	.990		.084
	N	10	10	10	10	10	10	10	10
Temperature	Pearson Correlation	-.214	.087	.305	-.041	-.533	-.329	-.573	1
	Sig. (2-tailed)	.552	.812	.391	.911	.112	.354	.084	
	N	10	10	10	10	10	10	10	10

Source: Author's Computation, (2017)

APPENDIX III

FORECASTING WEATHER ELEMENTS UP TO 2025

RAINFALL

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	7.95	21.09	67.95	71.78	244.46	125.29	306.66	299.44	436.17	227.1	28.77	3.12
2007	0	14.66	22.84	74.23	207.64	300.65	249.08	355.88	208.65	246.59	70.13	6.88
2008	0	6.95	59.11	149.08	186.1	178.13	226.87	297.51	266.57	187.35	17.11	0
2009	20.1	6.16	30.55	155.17	167.7	175.17	163.73	277.25	135.56	272.08	19.96	0
2010	6.58	33.59	22.74	102.71	154.02	138.65	280.56	293.3	175.69	205.81	37.29	8.21
2011	0	58.08	26.88	69.14	188.07	111.43	207.17	188.77	217.17	203.36	18.14	0
2012	0	22.34	8.04	107.15	221.96	176.05	282.29	217.74	294.74	219.51	47.81	9.55
2013	11	0.49	67.33	186.16	195.01	145.36	172.66	57.44	234.86	172.15	76.5	13.21
2014	5.49	7.24	99.84	147.88	237.94	127.08	168.05	153.35	362.53	167.03	82.46	16.23
2015	3.45	40.75	70.6	37.24	132.74	151.64	166.26	180.18	157.04	215.64	32.5	0

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		

1	(Constant)	2.171	.031		70.589	.000
	VAR00001	-.014	.005	-.705	-2.813	.023

a. Dependent Variable: rainfall

TEMPERATURE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
2006	25.95	26.16	25.57	25.92	25.21	24.88	24.05	23.7	23.88	24.6	24.7	26.5
2007	27.1	27	26.3	27.05	26.97	25.16	24.7	24.4	25.18	25.6	26.27	26.22
2008	24.21	25.3	26.11	26.37	25.8	25.01	24.07	23.85	24.2	24.88	25.71	25.03
2009	25.72	26.06	26.12	26.185	25.88	25.2	24.58	24.01	24.5	24.66	25.43	25.79
2010	25.94	26.8	26.9	26.99	26.58	25.2	24.6	24.8	24.9	25.2	25.7	25.57
2011	24.9	26.3	26.5	26.5	26.4	25.6	24.7	24.5	24.8	25.3	25.9	25.1
2012	25.4	26.1	26.5	26.3	25.7	25.1	24.5	24.3	24.5	25.3	25.8	24.9
2013	25.7	27.6	28	27.6	26.3	25.4	24.5	24.1	24.6	24.1	25.8	25.1
2014	26.7	28.3	28.2	27.5	26.6	25.5	25	24.1	24.4	25	25.6	25.9
2015	25.3	28.6	28.9	28.5	27.5	25.3	24.9	24.7	24.7	25.2	25.6	22.6

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.401	.004		381.800	.000
	VAR00001	.001	.001	.576	1.991	.082

a. Dependent Variable: Temperature

HUMIDITY

year	jan	feb	mar	apr	may	june	july	august	september	october	november	december
2006	71	77.3	82.2	83.3	88.3	87.3	90.9	89.4	90.8	89.4	75.21	42.3

2007	28.9	62.8	76.1	83.5	84.2	88.7	88.3	89.1	87	85.5	77.2	60.5
2008	64.6	53.8	84.8	86.2	87.9	91.1	91.3	91.6	91.2	89.7	89.1	82.1
2009	85.7	88	88.8	89.8	89.6	91.3	92.3	92.6	91.7	90.9	38.1	82.7
2010	79.5	85.9	85.7	90.4	91.2	92.6	91.8	92	91.8	91.5	90.1	83.3
2011	77.4	87.1	88.5	88.9	90.7	91.7	92.8	92.4	92.7	91.3	88.6	76.2
2012	73.6	86.9	87.2	89.1	90.4	91.6	92.1	91.1	92.5	91.5	90.5	80.1
2013	80.3	62.5	69.5	71.6	78.7	84.2	86.2	86.4	86.3	84.5	79.1	62.4
2014	53	50.9	66.4	71.7	78.2	84.3	85.3	86.5	85.9	85.3	79	55
2015	41.6	62.3	61.6	63.7	73.9	86.3	86.8	87.8	88.7	87.8	77.2	50.2

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.931	.023		84.023	.000
	VAR00001	-.004	.004	-.348	-1.051	.324

a. Dependent Variable: Humidity

Table III: Forecasted Weather Elements

Year	Rainfall(mm)	Temperature(oC)	Relative Humidity(%)
2016	143.6	25.23	84.5
2017	139.0	25.29	83.8
2018	134.6	25.35	82.9
2019	130.3	25.41	82.2
2020	126.2	25.47	81.5
2021	122.2	25.53	80.7
2022	118.3	25.59	79.9
2023	114.6	25.64	79.3
2024	110.9	25.70	78.5
2025	107.4	25.76	77.8

Source: Author's Computation, (2017)

FORECASTING SELECTED DISEASES UP TO 2025

Coefficient[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.701	11.058		.516	.625
	TrRainfall	.728	.546	.489	1.331	.231
	TrHumidity	-.492	1.122	-.187	-.438	.677
	TrTemperature	-2.287	6.501	-.159	-.352	.737

a. Dependent Variable: TrMalaria

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.626	17.023		.389	.711
	TrRainfall	.071	.841	.036	.085	.935
	TrHumidity	-1.157	1.727	-.328	-.670	.528
	TrTemperature	-1.370	10.008	-.071	-.137	.896

a. Dependent Variable: TrTyphiod

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.171	13.173		.848	.429
	TrRainfall	-.551	.651	-.300	-.847	.429
	TrHumidity	-2.009	1.337	-.619	-1.503	.183

	TrTemperature	-3.226	7.745	-.182	-.417	.692

a. Dependent Variable: TrMeanigitis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	28.538	15.422		1.850	.114
	TrRainfall	-.896	.762	-.400	-1.176	.284
	TrHumidity	-2.878	1.565	-.725	-1.839	.116
	TrTemperature	-13.757	9.066	-.635	-1.517	.180

a. Dependent Variable: TrPnuemonia

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.323	7.372		.179	.864
	TrRainfall	.587	.364	.486	1.613	.158
	TrHumidity	.876	.748	.409	1.171	.286
	TrTemperature	-1.402	4.334	-.120	-.324	.757

a. Dependent Variable: TrDiarrhea

Table IV: Forecasted Occurrence of Diseases

Year	Malaria	Typhoid	Meningitis	Pneumonia	Diarrhea
2016	1325	425	39	124	208
2017	1296	435	42	139	199
2018	1274	434	42	141	196
2019	1189	420	40	106	187
2020	1163	430	42	118	179
2021	1143	429	43	120	176
2022	1118	440	46	134	168
2023	1100	439	47	137	166
2024	1081	438	47	139	164
2025	1057	448	51	155	156

Source: Author's Computation, (2017)

APPENDIX V

YEARLY HOSPITAL RECORDS FROM 2006 - 2015 ANKPA KOGI STATE,NIGERIA

GENERAL HOSPITAL, ANKPA

DISEASES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Malaria	500	511	442	380	450	467	390	343	562	442
Typhoid	250	344	120	233	141	223	115	218	120	214
Meningitis	22	12	2	4	11	10	3	23	1	33
Pneumonia	34	12	45	20	35	18	15	27	56	49
Diarrhea	100	85	24	38	44	78	122	65	45	22

BETHEL HOSPITAL, ANKPA

DISEASES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Malaria	300	317	204	350	150	112	130	90	85	383
Typhoid	150	100	81	200	85	122	56	118	83	134
Meningitis	4	9	3	2	2	3	8	5	2	4
Pneumonia	10	4	5	2	2	11	2	1	3	3
Diarrhea	50	23	34	28	55	64	21	18	20	25

LIVING HOPE HOSPITAL, ANKPA

DISEASES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Malaria	228	201	140	135	123	60	84	38	82	153
Typhoid	44	65	16	35	38	25	14	16	21	15
Meningitis	3	4	5	2	8	4	3	10	5	6
Pneumonia	8	4	12	12	10	12	2	13	15	5
Diarrhea	23	18	39	29	25	22	19	14	33	47

MADONNA HOSPITAL ANKPA

DISEASES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Malaria	300	256	312	276	311	160	274	138	144	120
Typhoid	83	91	62	51	42	39	89	62	54	75
Meningitis	12	10	11	8	9	13	7	9	12	10
Pneumonia	10	5	6	11	8	10	8	6	11	14

Diarrhea	25	28	34	44	30	29	22	31	39	30

OMEGA HOSPITAL
ANKPA

DISEASES	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Malaria	202	200	150	151	149	190	181	154	171	158
Typhoid	60	33	32	46	61	43	28	36	47	59
Meningitis	10	11	22	21	20	5	7	9	16	12
Pneumonia	15	13	16	14	5	8	11	16	8	10
Diarrhea	40	20	35	34	18	21	24	13	36	20