THE ROLE OF WEATHER ON THE OCCURRENCE OF COMMON DISEASES IN JOS NORTH LOCAL GOVERNMENT AREA, PLATEAU STATE, NIGERIA

BY

NTEM Golau Isa

(B.Sc. HONS UniJos)

M.SC/SCIEN/05390/2010-2011

A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVRESITY, ZARIA, NIGERIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN GEOGRAPHY

DEPARTMENT OF GEOGRAPHY,

FACULTY OF SCIENCE,

AHMADU BELLO UNIVERSITY, ZARIA,

NIGERIA.

AUGUST, 2015.

DECLARATION

I hereby declare that the work in this thesis titled “The role of weather on the Occurrence of some common Diseases in Jos North Local Government Area, Plateau State” was carried out by the researcher, Ntem Isa Golau, under the supervision of Dr. B. A. Sawa and Dr. J. O. Folorunsho. All the information obtained from literature has been acknowledged in the text as well as the list of references. No part of this thesis has been previously presented for any degree or any diploma at any University.

-----------------------------------	-------------------------	---------------------------
Ntem Isa Golau	Signature	Date

CERTIFICATION

This thesis titled "The Role of Weather on the Occurrence of some Common Disease in Jos North Local Government Area, Plateau State", meets the regulations governing the award of degree for master in Science, in Ahmadu Bello University, Zaria. It is also approved for its input to knowledge and literary presentation.

-- --------------------------- ----------------------

Dr. B.A. SAWA

Chairman, Supervisory Committee Signature Date

-- -------------------------- -----------------------

Dr. J.O. FOLORUNSHO

Member, Supervisory Committee Signature Date

-- -------------------------- -----------------------

Dr. I.J. MUSA

Head of Department, Signature Date

--- -------------------------- -----------------------

Prof. A.Z. HASSAN

Dean, School of Postgraduate Studies. Signature Date

DEDICATION

This research work is first and foremost dedicated to the Almighty God who has been my source of inspiration and strength and to my Late Parents, Baba Golau Ntem and Mama Ladi Golau, the memory of your love and care still remain very fresh in my mind and to all men and women whose health have been threatened by weather elements.

ACKNOWLEDGEMENTS

My entire being is full of gratitude to the Father, Son and Holy Ghost, without whom nothing is possible.

I owe a lot of thanks to Dr B. A Sawa and Dr J. O. Folorunsho whose support, criticisms, advice and commitment have put me through in this work. I am particularly grateful for the time and attention you gave me, most importantly for the wonderful comments and the corrections of every detail which you both made to enrich this work. Words will not be enough to express my gratitude to you.

Profound gratitude to my beloved wife, Faith Isa whose financial and moral support gave me the courage to forge ahead when I almost gave up at the early stage of this programme. I appreciate my children who bore with my absence sometimes for several weeks in school to ensure that this research work is completed.

Special thanks go to Mr. and Mrs. Abel Sunday, Mr. and Mrs. Suji Golau. The kind gesture you have extended to ensure that I succeed in this work is highly appreciated. Your labour of love will never go unrewarded. Time and space will not permit the history of the very many people who played a role in this work. I may miss some whose contributions were no less. Permit it to be so now. God bless you all.

ABSTRACT

Weather parameters play a role in the occurrence of diseases outbreak all over the world. The aim of this study is to examine the relationship between weather elements (temperature, rainfall and relative humidity) and the occurrence of malaria, pneumonia and meningitis in Jos North Local Government Area of Plateau State. The objectives of the study include; establishing the trend in the weather parameters and the selected diseases, assessing the relationship between the weather parameters and the selected diseases and determining the seasons of occurrence of the selected diseases. A ten year (2002-2011) meteorological data were sourced from the meteorological unit of the University of Jos and medical records of in- and out- patients treated for the three diseases in Jos North LGA were collected from the Jos University Teaching Hospital (JUTH) and Plateau Specialist Hospital for the purpose of the study. The data were analyzed using time series graphs in order to determine trends in the weather parameters and the selected diseases. Ordinary least square estimates of the multiple regression models was used to established relationship between the weather parameters and the diseases under study. This model was used so as to determine the relationship between the selected weather parameters and the diseases and to as well determine how much of variations in the reported cases of the diseases are accounted for by the weather parameters. Multiple bar graphs were plotted to determine the seasons of occurrence of the selected diseases. The trend in the weather parameters within the ten years of study revealed that temperature has a positive trend that is, it was increasing from year to year which was explained by the trend equation $Y = 0.019x + 24.21$. Both rainfall and relative humidity exhibit a negative trend; meaning that, on the average, rainfall and relative humidity were decreasing from year to year throughout the period of study which was supported by the trend equations $Y = -10.66x - 1313$ and $y = - 119.5x + 578.9$ respectively. Trends in the reported cases of the selected diseases revealed that malaria incidence has a negative trend that is, the number of people suffering from malaria decrease from year to year. The decrease is justified by the trend equation; $Y = -119.5x + 3033$. The trend for pneumonia and meningitis showed a positive trend, that is, the number of people suffering from the two diseases increase from year to year as indicated by the trend equations $Y = 25.79x +61.36$ and $Y = 2.578x +37.26$ respectively. Malaria showed a significant relationship with rainfall. Rainfall was positively related to pneumonia at 1% level of probability while relative humidity was found to be negatively related to pneumonia at 5% level of probability. Rainfall was found to be negatively related to meningitis at 5% level of probability while temperature was found to be positively and significantly related to meningitis at 1% level of probability. The three diseases under study all exhibited seasonal patterns in their occurrence. Malaria and pneumonia incidence are more prevalent during the cold and wet seasons with 282 highest reported cases of malaria in June and 21 reported cases of pneumonia in August. Whereas, the occurrence of meningitis was more prevalent during the warm and wet season with the highest peak mean of 7 reported cases in April. The study concluded that weather elements play a role in the incidence of diseases in Jos North LGA especially malaria pneumonia and meningitis. Therefore, climatic factors are important predictors of diseases incidence and should be considered along with other factors in mitigating the spread of weather sensitive diseases in the study area.

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION

CHAPTER TWO: LITERATURE REVIEW

CHAPTER THREE: THE STUDY AREA AND METHODOLOGY

CHAPTER FOUR: RESULTS AND DISCUSSION

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

DEFINITION OF TERMS AND ABBREVIATIONS

Climate: The atmospheric condition of a place over a long period of time.

Direct effects of weather elements on Health: This involves the transmission of diseases or discomfort which does not need a vector or a causative agent.

Indirect effects of weather elements on Health: The transmission of diseases or discomfort through a vector or causative agent.

Vector – borne diseases: - These are those diseases that require a host (most often arthropods or rodents) to transmit a pathogen.

Weather: The atmospheric condition of a place over a short period of time.

C.D.C: Centre for Diseases Control.

E.N.S.O: El Nino Southern Oscillation.

I.P.C.C: Inter – Governmental Panel for Climate Change.

R.V.F: Rift Valley Fever.

W.H.O: World Health Organization.

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Most vector – borne diseases exhibit a distinct seasonal pattern, which clearly suggest that they are weather sensitive. Rainfall, temperature, relative humidity, wind, cloud cover, and sun shine affect in many ways both the vectors and the pathogens they transmit. For example, high temperatures can increase or reduce survival rate, depending on the vector, its behavior and many other factors (Gubler et al, 2001). Thus the probability of transmission may or may not be increased by higher temperatures.

Ojo (1977) found out in his study that weather parameters such as temperature, rainfall and relative humidity influence the incidences of diseases in two major ways. Firstly, they affect the resistance of the human body making it more susceptible to diseases. Secondly, weather parameters influence the growth, propagation and spread of some diseases like malaria, pneumonia and meningitis. This presupposes that weather parameters have a profound relationship with the incidences of diseases.

A study was carried out by Sawa and Buhari (2011) on the effect of temperature variability on the outbreak of malaria and measles in Zaria. Their study revealed that temperature has a positive relationship with the incidence of malaria and measles. That is the reported cases of malaria and measles in Zaria increase significantly with increase in temperature.

The tremendous growth in international travel increases the risk of importation of vector-borne diseases, some of which can be transmitted locally under suitable circumstances at the right time of the year. Demographic and sociological factors also play critical roles in determining disease occurrence. It is likely that these diseases will cause major epidemics in the developing world if the health facilities are not improved.

According to McMicheal, Patz, and Kovats (1989), there is a profound connection between the natural world and the human economy. There can be no sustainable development without a healthy natural environment. In other words, human well being and health depend fundamentally upon the goods and services provided by the natural world and the human economy.

Researchers such as Kenneth, Thomas, Rebecca and Edward (2008) have attempted to explore this important aspect of human life: health and how the weather elements of a place could be a major determinant of the state of health of the people. Some of these effects are positive while others are negative, some are direct and some indirect. These clearly indicate the nature of relationship that exists between weather and disease variables.

Climate variability and its impacts on human health are areas of research that have been receiving very much attention from scientists and policy makers all around the world over the last decade or so. The subject of climate change and variability is older than the subject of its impacts (Chen and Taylor, 2002). Climatic factors influence the emergence and reemergence of infectious diseases in addition to multiple human, biological, and ecological determinants. Climatologists have identified upward trends in global temperatures and now estimate an unprecedented rise of 2.0 degrees centigrade by the year 2100. Of major concern is that these changes can affect the introduction and dissemination of many serious infectious diseases (Patz, Epstein, Burke and Balbus, 1996).

The global climate is changing at an unprecedented rate, with rising temperatures, increase in precipitation, seasonality, rising sea levels, and extreme events such as drought and flooding. The question about disease incidence and spread and its possible health consequences command increasing attention. It has become evident that climate variability will continue to alter the pattern of average climatic conditions although trends within specific geographic regions remain uncertain (IPCC, 2007).

Heat wave is another major health problem in some regions of the world. It was estimated to have killed 29,817 to 30,617 people in Europe through heat stroke, exacerbated cardiovascular and respiratory diseases (Haines, Kovats, Cambell-Lendrum and Corvalan, 2006). A large portion of these deaths occurred among the elderly and socially isolated. These categories of the population are more susceptible to extreme heat. Increased frequency of high rainfall has also been associated with an increase in severity of floods, landslides, debris and mudflows. This has been witnessed in parts of Bangladesh, Nepal and India. Increases in sea surface temperature have caused an increase in tropical cyclone intensity leading to an increase in the height of storm surges (Luber and prudent, 2009).

Patz, et al (2001) described the direct health impacts of natural disasters as mostly injuries and death while secondary health effects may also occur, this may involve changes in ecological systems and public health infrastructures, such as bacterial proliferation and the availability of safe drinking water. They also discovered that exposure to particulate matter can aggravate respiratory and cardiovascular disease, alter the body’s defense systems against foreign materials, damage long tissue and may cause cancer and premature death. Furthermore, they discovered that exposures to carbon monoxide, sulphurdioixide and nitrogen dioxide can cause visual impairment, reduced work capacity, aggravation of existing cardiovascular diseases, affect breathing, respiratory illness, lung irritation and alterations in the lung’s defense systems.

Climate variability will continue to alter the pattern of average climatic conditions, although trends within specific geographic regions remain uncertain (IPCC, 2007). There are unresolved questions about how climate variability may affect the outbreak and transmission of vector borne disease and to what extent the empirical evidence of short term climate variation and diseases transmission can be applied to the estimation of future impacts of climate variability.

It has been observed that less effort have been made in empirical research by climatologist to identify the role play by weather parameters in the outbreak of common diseases in Jos North Local government Area such as malaria, pneumonia and meningitis. It is pertinent therefore that a research in this field of study be carried out so as to enable health planners to consider climatic factors along other factors in mitigating the spread of diseases that are weather sensitive.

1.2 Statement of the Research Problem

Climate affects health through the spatial and temporal distribution of climate- sensitive infectious and parasitic diseases (WHO, 2004). Climate variability seems to be the primary cause of ill health and mortality in the study area and at global level, where many millions die annually from the combine effects of malnutrition and preventable diseases (WHO, 2008).

Kaplan (2009) carried out a research on the effects of weather patterns on headache as well as investigating whether or not patients could predict their own sensitivity to weather and which weather patterns were most significant. Interestingly, of the migraine sufferers affected by weather, it was clear that they were sensitive to a combination of temperature and relative humidity changes. The study findings demonstrate that there is a relationship between weather and migraine. Climate and Health Resource Room (CHRR) 2008, also carried out studies on the occurrences of some diseases (malaria and meningitis), in Africa and their results showed that the two diseases exhibit seasonal pattern which suggest very clearly that they are weather sensitive.

Jos North local Government area is located on the Jos-Plateau which receives high rainfall and low temperature due to its altitude than the surrounding area on the same latitude; the relative humidity is low during the dry season and increases during the rainy season. The high rainfall receive collect into mining ponds which serve as breeding grounds for mosquitoes and other vectors that transmit diseases. The low temperature in the area provides some level of comfort but also trigger respiratory tract infections and the occurrence of diseases that are sensitive to cold such as pneumonia. Hot period in Jos LGA aggravates the outbreak of diseases that are sensitive to high temperatures such as meningitis and measles.

The direct impacts of climate variability can influence change on urban population, including slum dwellers, flooding from sea level rise, food, water and public health insecurity (WHO, 2008). Although less visible than extreme events, such as outbreak of killer diseases, the indirect impact of climate uncertainty is an equally serious impediment to development (Hansen and Beltina, 2004).

Ogbaji (2006) studied the role of temperature in the distribution of malaria in Zaria. The study covered a period of ten years (1996-2005). He correlated the independent variable (temperature) with the dependent variable (reported cases of malaria) and his 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 record more cases.

Akinbobola and Omotosho (2004) carried out a research on the relationship between meteorological variables and the occurrence of malaria, measles, chicken pox, meningitis and pneumonia in Ikeja, Akure and Kaduna (Nigeria) for the period of sixty years (1944-2003). Multiple regression analysis was used to establish the relationship between the meteorological variables and the incidences of the selected diseases and their results showed that there is a relationship between outbreak of the 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 the hot periods.

Weather elements affect the timing or intensity of the outbreak of diseases that are sensitive to weather in the study area which the people are ignorant of and this seem to be the quite reason for ill health, increased hospitalization and death rate in the locality which the forgoing literatures have not addressed.

It is on this backdrop that the study sought to examine the relationship between temperature, relative humidity and rainfall and the occurrence of malaria, meningitis, and pneumonia in Jos North Local Government Area of plateau State.

This study addressed the following questions:

i. What are the trends in the weather parameters (temperature, relative humidity and rainfall) and incidence of malaria, meningitis and pneumonia in the study area over the time of study (2002-2011)?

ii. What season of the year is linked to resurgence of malaria, meningitis and pneumonia in the study area?

iii. What is the relationship between the selected weather parameters and the incidence of malaria, meningitis and pneumonia in Jos North L.G.A.?

1.3 Aim and Objectives of the Study

The aim of this research is to examine the relationship between temperature, relative humidity and rainfall parameters and the occurrence of malaria, meningitis and pneumonia in Jos North Local Government Area of Plateau State. To achieve this aim, the following specific objectives were pursued which are to:

i. establish the trend of the selected weather parameters (temperature, relative humidity and rainfall) and incidence of malaria, meningitis and pneumonia in the study area.

ii. determine the season of occurrence and spread of malaria, meningitis and pneumonia in the study area.

iii. examine the relationship between temperature, relative humidity and rainfall variability and the incidence of the selected malaria, meningitis and pneumonia in the study area.

1.4 Hypothesis

The working hypothesis of this study is: there is no significant relationship between the selected climatic parameters and outbreak of malaria, meningitis and pneumonia in Jos North local government area of Plateau state.

1.5 Scope of the Study

The purpose of this study is to establish the relationship between temperature, relative humidity and rainfall variables and the occurrence of malaria, meningitis and pneumonia in Jos North Local Government Area. The areal scope of the research is limited to Jos North Local Government Area of Plateau State. Jos Norht LGA was chosen because its location on the Jos-plateu gives it distinct climate characteristics of higher rainfall and a reduced temperature.

Moreover, easy accessibility to data especially the meteorological records also formed the basis of my choice of the study area. The study covers the period of 2002-2011 because it is the period with continuous records of patients treated for malaria, pneumonia and meningitis in the study area.

This study intends to cover the two major hospitals in the study area namely: Jos University Teaching Hospital (JUTH) and Plateau Specialist Hospital. The two hospitals are selected because of their spatial location in the study area and are well equipped with modern treatment facilities where most people patronize them for treatments. Moreso, the two hospitals are tertiary hospitals where records are kept for research purposes.

1.6 Justification of the Study

The justification of this research is based on the role played by temperature and rainfall on the outbreak and spread of climate-sensitive diseases like malaria, cholera, meningitis and pneumonia.

Jos North Local Government Area is located on the Jos-Plateau whose climate is characterized by a reduced temperature and higher rainfall than the surrounding lowland areas on the same latitude like Bauchi and Minna due to its elevation. It is on this note that temperature and rainfall parameters are chosen among other elements of weather in this study. The modified climate has been observed among other factors to have effect on the occurrence and spread of certain diseases such as malaria, meningitis and pneumonia. It is on this note that this research sought to investigate the relationship between these climatic parameters and the occurrence of the above mentioned diseases in Jos North Local Government Area of Plateau State.

The findings of this research will help Jos North L.G.A., Plateau State as well as the Federal Government to adopt measures that will mitigate the occurrence of these diseases. In addition, the research work serves as a reference material and a guide to future researchers.

1.7. Organization of the Study

This study which is segmented into five chapters is written and organized as follows: A background to the study, statement of the problem, aim and objectives, hypothesis, scope of the study and justification of the study are discussed in chapter one. Chapter two deals with the conceptual framework where major concepts in the study such as direct and indirect effects of weather elements on human health, weather parameters (temperature, rainfall and relative humidity) and weather sensitive diseases (malaria, pneumonia and meningitis) are defined and highlighted. Moreso, relevant literatures on weather and its effects on human health and modes of diseases transmission are reviewed. Chapter three discusses the study area, in which case the description of the environment of Jos North Local Government Area is taken into consideration including the location, historical development of the study area, nature of climate, relief and drainage, geology, soil and vegetation, economic activities and ecological problems. Also, the methodology involved in .this study which includes types of data, sources of data and data analysis including time series analysis, correlation, regression and the construction of multiple charts are discussed. The data analysis, result of findings and the discussion of results are all discussed in chapter four. Finally, the summary, conclusion and recommendations of the study are presented in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This segment of the study is dedicated to reviewing relevant literatures so as to bring to lime light the important concepts employed in this study. Therefore, the contributions of many scholars on the relationship between weather elements and the occurrence of weather-sensitive diseases are reviewed in this study.

Moreso, issues which are central to this study such as the direct and indirect effects of weather elements on human health are extensively reviewed. Furthermore, literatures on the modes of transmission and the environmental factors that favour the spread of the selected diseases in this study are reviewed. The definitions of the weather elements which the occurrence of the selected diseases in this study largely depend upon such as the rainfall, temperature and relative humidity as discussed by other scholars are also reviewed.

2.2 Direct Effects of Weather Elements on Health

According to the new encyclopedia of Africa the sensitivity of infectious diseases to climate is complex, as climate is only one factor among many that can influence the occurrence of infectious diseases, particularly in Africa. Many human diseases in Africa are affected directly or indirectly by weather and climate. Climate affects the spatial distribution of diseases, in the other hand weather affects the temporal or the seasonality of diseases outbreak. Where the transmission of diseases or discomfort does not need a vector or a causative agent, it is said to be a direct effect of weather elements. Luber and Prudent (2009) described global temperature increase as due to the effect of human activities and population increase. According to them, urban built environment is a major cause of Urban Heat Island (UHI). The UHI can add between 2- 10^0C ambient air temperature. The built up structures absorbs heat during the day and radiates it out at night, raising night time temperatures, which have been epidemiologically linked with mortality.

2.3 Indirect Effects of Weather Elements on Health

Global assessment of the potential impacts of anthropogenically – induced climate change on vector- borne diseases suggests an increase in extent of the geographical areas susceptible to transmission of malarial plasmodium parasites, *dengne flavivirus* and *schistosoma* worms (Martens, Spoof and Jackson,1997). The vector-borne disease studied is highly sensitive to climate changes on the periphery of the currently endemic areas and at higher altitudes within such areas. Their findings vis-à-vis the present endemic areas indicate that the increase in the epidemic of malaria and dengue transmission may be estimated at 12-27% and 31-47% respectively, while in contrast, schistosomiasis transmission potential may be expected to exhibit a 11-17% decrease. Moreso, a study carried out by climate and Health Resource Room (CHRR, 2008) on climate and malaria showed that where malaria is not adequately controlled, its distribution and seasonality are closely related to seasonal characteristics of the weather. And when there are cases of anomalies, malaria which is seasonally endemic becomes epidemic in warm semi arid region of Africa during the dry season. They typically coincided with period of very low humidity and dusty conditions and disappear with the onset of the rains.

According to Lindsay and Birly (1996), there is a consensus among climatologists that our planet is experiencing a progressive rise in surface “green house” gases. Some of the possible consequences of elevated temperature on malaria transmission were then examined. A simple mathematical model is first used to examine the effect of temperature on the ability of Anopheles maculipennis to transmit vivax malaria. This indicates that small increases at low temperatures may increase the risk of transmission substantially. This is important, since vulnerable communities, poorly protected by health services, in areas of unstable or no material are likely to be at risk of future outbreaks. In contrast, areas of stable transmission may be little affected by rising temperature. It is true that global warming will lead to coastal flooding, changes in precipitation and indirectly, changes in land use. Just how these changes will affect transmission of malaria, cholera, meningitis, pneumonia and measles at a regional level requires an understanding of the ecology of local vectors, since environmental changes which favour certain vectors may reduce the survival of other vectors in another place.

Adebayo (2001), quoted by Sawa and Buhari (2011), noted that variability in weather and climate has been shown to have an impact on meningitis, diarrhea, cholera and measles outbreak and spread. For example, increase in cases of diarrhoea is often associated with extreme flooding events while recent researches link cholera outbreak with warmer temperatures. The outbreak and spread of diseases such as Murray valley, Encephalitis, Blue tongue, Rift valley fever, African Horse sickness, Rose River virus disease and malaria have all been associated with variability of climate. The seasonal nature of outbreaks of several human and animal diseases suggests that climate plays an important role in their occurrences. These show that climate anomalies have a demonstrated impact on increased disease transmission.

It is widely recognized that there are four major health determinants namely, human biology, environment, lifestyle and medical care. Human biology for example greatly influences susceptibility to illness. It includes gender, age and those variables which are genetically inherited. The environment within which an individual can exert slightly more influence, particularly his or her mobility includes numerous aspects of the physical milieu, such as altitude, climate, chemical composition of the soil and quality of drinking water. The social environment or life style, for example includes population density, housing design and construction, agriculture, industrial processes and pollutants. Biological components like viruses, bacteria, pollen and fungal spores greatly influence human health also. Indeed, the incidence of diseases varies geographically at scales from internationally to local.

The relationship between human health and weather has been established through direct results of research findings. Such findings have reported that increases in certain diseases are as a consequence of unusual (otherwise known as extreme and spell events) such as temperature, rainfall, vapour pressure, relative humidity and wind (Oluleye and Akinbobola, 2010). Ebi et al, (2004) found out that between 6 and 13% of those hospitalized for congestive heart failure and stroke among the aged (70 or more years old) are as a result of changes in temperature. In the face of any change in climate, how occurrence and hospitalization for diseases will change remains highly speculative (Reiter, 2001, IPCC, 2001).

Schneider (1990) discovered in his research that the infrared radiation is trapped by greenhouse gases and particles in planetary atmosphere and that the atmospheric carbon dioxide (CO_2) level has increased by some 25% since 1850 because of fossil fuel combustion and landuse. Closely connected to these facts is that global temperature has experienced a rise synchronous with an increasing water vapour attributable to human activities (Willet, Gillet, Jones and Thorne, 2007). Thus the global climate, as measured by increasing positive anomalies of temperature and precipitation, has witnessed certain variability and changes but how these changes have impacted the local communities remain largely unknown especially in the areas related to health. Any change in climate parameter especially temperature is anticipated to cause change in outbreak of certain common diseases such as plasmodium, falciparum which causes malaria and pneumonia.

As reported by Jonathan, Diarmid, Tracey and Jonathan (2005), many prevalent human diseases are linked to climate fluctuations ranging from cardiovascular mortality and respiratory illness due to heat waves, to altered transmission of infectious diseases and malnutrition from crop failures. Persinger (1980) found that some disease occurrences are linked to rainy season but speculated that the change in occurrence of the diseases may be due to development of hospitable climate variability suitable enough for longer breeding period of disease- causing insects (mosquitoes in case of malaria). Linking climate variability or change to outbreak or resurgence of certain diseases remains a challenge because fairly long-term data to assess the relationship between climate parameters and diseases is not available, a fact that has also been echoed by Jonathan, Diarmid, Tracey and Jonathan (2005).

According to the new encyclopedia of Africa, climate is one factor among many that can influence the occurrence of infectious diseases, particularly in Africa. Many human diseases in Africa are affected directly or indirectly by weather and climate. This links may be spatial, with climate affecting temporal distribution, weather affecting the timing of an outbreak, or relate to intensity of an outbreak. There are several causal pathways for outbreaks of vector-borne disease, water and food-borne diseases, air-borne, heat-related diseases, and extreme climate events. However, it should be noted that although these diseases are climate sensitive, human activities also contribute to their spread, particularly for the diseases that require human and livestock hosts.

Ayoade (1988) investigated the water and health situation on a global basis and discovered that 400million cases of intestinal worm infection occur yearly, typhoid 200 million cases every year, malaria 160 million cases every year and cholera 20-40 million cases every year. Some 5 million people are estimated to die every year from climate-induce diseases such as cholera, typhoid, diarrhea, dysentery, malaria and intestinal worm infection.

In the United States, food-borne diseases are estimated to cause 76 million cases of illness; microbiologic agents in water (e.g. viruses, bacteria and protozoa) can contaminate food especially during rainy season. Also, diseases transmitted between humans by blood- feeding anthropods (e.g insects, ticks and mites), such as plague, typhus, malaria, yellow fever and dengue fever were once common in the United States and in Europe when temperatures are higher (Patz et al, 2001).

2.4 Selected Weather Elements Involved in the Study

The weather elements considered in this study include temperature, rainfall and relative humidity.

Ati (2002), described temperature as the degree of sensible heat or cold within the atmosphere. The author described rainfall, as liquid precipitation in the form of drops of diameter greater than 0.5mm. Relative humidity is the ratio of the partial pressure of water to the equilibrium vapour pressure of water at the same time.

2.4.1 Temperature

The concept of thermo reception is involved in temperature sensation, thermal comfort and thermoregulation of the body. Thermoreception is a process in which different levels of heat energy (temperature) are detected by living things. Thermal comfort and temperature sensation can be separated psychologically and physiologically. Temperature sensation is directed towards an objective world, while thermal comfort refers to the subjective, state of the observer. Temperature sensation is verbalized by either warn or cold while thermal comfort uses the term pleasant or unpleasant (Hensel, 1979).

Health is an important criterion in any selection of the environment. Survival to heat or cold stress often plays a more important role than preference of an optimal comfort zone.

2.4.2 Rainfall

Apart from the effects of rainfall on temperature and humidity, that is, reduction in the intensity of sensible heat when it rains and increase humidity, it also affects crop production which could mean malnutrition with little amount of rainfall, this also determines the state of well- being of a person. Also, the rain might provide breeding sites for vector borne diseases. Extreme events could mean flooding in some cases which leads to injury, destruction of lives and properties (Osadare 2011).

To Rose et al (2001), exposure to water borne and food borne pathogens can occur via drinking (associated with fecal contamination), seafood (due to natural microbial hazards, toxins, or waste water disposal) or fresh produce (irrigated or processed with contaminated water). Weather influence the transport and dissemination of these microbial agents via rainfall and run off and the survival and/ or growth through such factors as temperature. Federal and state laws and regulatory programs protect much of the US population from water borne disease, however, if climate variable increases current and future deficiencies in areas such as efficient drainage systems will probably increase the risk of contaminations. Knowledge about transport processes and the fate of microbial pollutants associated with rainfall and snowmelt is a key to predicting risks from a change in weather.

2.4.3 Relative Humidity

Relative humidity refers to the ratio of the observed humidity mixing ratio to that which would saturate the air at the same temperature. Relative humidity is usually higher during the rainy seasons and reduces during the dry season.

Relative humidity affects thermal comfort indirectly by altering the rate of sweat in warm environments. In cold environments low humidity may cause discomfort from dehydration of the skin surface and membrane of eye, nose and throat (Gagge, 1997).

2.5 Selected Diseases for the Study

The diseases to be reviewed in this study include malaria, pneumonia and meningitis.

2.5.1 Malaria

Miller (1977) discovered that vector-borne diseases are the most common climate – influenced human diseases in Africa. Most notable among these vectors are mosquitoes, flies and ticks. New Encyclopedia of Africa (2010). Malaria is a potentially life – threatening disease caused by four related species of the protozoan parasite plasmodium: "plasmodium falciparum," "plasmodium vivax", plasmodium malariae" and "plasmodium ovale". Of these, "plasmodium falciparum" most often causes serious morbidity and intensive mortality and it is highly resistant to anti malaria drugs.

According to the New Encyclopedia of Africa, unlike in other parts of the world, Africa's malaria mosquitoes are almost exclusively human – biters, and this fact enhances the chain of human to –human transmission. It was estimated that in 2005, about 343 million clinical attacks of malaria was a major cause of death (over 950,000 deaths annually) in Africa. It is also a significant indirect cause of deaths in the continent, where malaria – related maternal anemia in pregnancy, low birth weight, and premature delivery cause about 75, 000- 200000 deaths in sub-Saharan Africa. Moreso, ten to fifteen percent of overall HIV infections and as much as twenty five percent of pediatric infections, mainly for the treatment of severe Maria and sickle cell anemia.

2.5.1.1. Mode of transmission

i. Vector transmission: Park (1997) discovered that malaria is transmitted from human to human through the bite of an infected anopheles mosquito. A single infected vector, during her life time, may infect several persons. The mosquito is not infective unless the sporozoites are present in its salivary glands.

ii. Direct transmission: malaria may be induced accidentally by hypodermic intramuscular and intravenous injections of blood or plasma. Blood transfusion poses a problem because the parasites keep infective activity during at least 14 days in blood bottles at 4^0C (Park, 1997)

iii. Congenital transmission: congenital infection of the newborn from an infected mother may also occur (park, 1997).

2.5.1.2. Incubation period

The length of time between the infective mosquito bite and the first appearance of clinical signs is usually not less than 10 days. The duration of the incubation period varies with the species of the parasite, and in natural infections this is 9-14 days of falciparium malaria, 8 -17 days for vivax maria, 18-40 days malariae (park), 1997).

2.5.1.3. Environmental factors

Walker (1998) studied the environmental factors that favour the spread of malaria and discovered that under warmer conditions mosquito develop faster, and the parasites also multiply more rapidly. However, the role of climate on malaria transmission and epidemics is highly contested. WHO (2004) argued that it is poor malaria control strategies and drug resistance that would be the most determining factors than climate parameters. Nevertheless, it is obvious that temperature and precipitation acting through other socio economic variables are important in explaining the occurrence of malaria in Africa and the world at large.

Three elements must be present for endemic malaria: infected humans, susceptible mosquitoes and a suitable climate. All three occur in parts of Australia and yet this country had always been a region of marginal malaria endemicity. With the exception of a large epidemic in Cairns during the Second World War, most outbreaks have occurred in small, isolated populations of the northern territory. There have been suggestions that future climate change may increase the range of the major vector in Australia, Anopheles mosquitoes and consequently lead to the re-establishment of endemic malaria. The optimum temperature for the development of the malaria parasite in the insect vector is between 20^0C to 30^0C. The parasite ceases to undergo development in the mosquito if the mean temperature is below 16^0C. Temperature higher than 30^0C is lethal to the parasites (park, 1997).

The atmospheric humidity has a direct effect on the length of life of the mosquito. A relative humidity of 60 percent is considered necessary for mosquitoes to live their normal span of life. When the relative humidity is high, mosquitoes are much more active and they feed more voraciously. If the humidity is low, mosquitoes do not live long. Rainfall in general provides opportunities for the breeding of mosquitoes and may give rise to epidemics of malaria. However, heavy rains may flush out the breeding places (Luber and prudent, 2009).

2.5.2. Pneumonia

According to Ilemonia (1983), pneumonia is an acute respiratory tract infection that affects the lower respiratory tract. It implies an acute inflammatory process involving the alveolar walls and spaces of the lung parenchyma. A wide range of bacterial and respiratory viruses are responsible for it. The two common types are the “labar pneumonia” and “broncho pneumonia”.

2.5.2.1 Mode of Transmission

All the causative organisms are normally transmitted after you breathe infected air particles into your lungs. This generally occurs during sleep. Pneumonia can be transmitted during or after a viral upper respiratory infection, such as cold or influenza. It could be as a result of a complication of a viral illness such as measles and chicken pox. Example of times when this can happen are during or soon after a cold or if you have a long term chronic illness such as obstructive pulmonary disease (WHO, 2004).

2.5.2.2. Environmental Factors

Many factors that trigger the outbreak or severity of pneumonia have been identified. They include not only the climatic condition but also the housing, level of industrialization, socio-economic development and poor nutrition (Ilemonia, 1983). The following factors also increase a man's susceptibility to pneumonia: indoor air pollution caused by cooking and heating with biomass fuel (such as wood or dung). Also, living in crowded homes can trigger the spread of pneumonia from one member of the family to the other. Parents that smoke especially mothers can transmit pneumonia to their children.

2.5.3. Meningitis

By Park (1997), meningitis or cerebra-spinal meningitis is an acute communicable disease cause by a bacteria N. meningitides. It usually begins with intense headache, vomiting, and stiff neck, and progresses to comma within few hours. There are two types of meningitis namely: viral meningitis and acute bacterial meningitis.

Viral meningitis: To Wenner (1997), this type of meningitis is characterized by fever, headache, myalgia and stiffness of the neck. It is a common syndrome caused by diverse infectious agents.

Acute Bacterial meningitis: this is an inflammatory disease of the central nervous system cause by the growth of bacteria in and adjacent to the leptomeninges. The infecting bacteria usually reach the leptomeninges by the blood stream. Occasionally however, infections extend to the meninges directly from other intracranial foci, or results from traumatic inoculation of extradural bacteria. Its spread may be exceedingly rapid (Wenner, 1997).

2.5.3.1. Mode of Transmission

The disease is primarily transmitted through droplet infection by bacteria or virus depending on the type of meningitis. The incubation period is usually 3 to 4 days, but may vary from 2 to 10 days depending on the type of infection (Wenner, 1977).

2.5.3.2. Environmental Factors

To Park (1997), the seasonal variation in the outbreak of meningitis is more frequent in the dry and hot periods of the year. The incidence is also greater among groups of people living under poor housing conditions.

2.6 Effect of Weather Elements on Some Diseases

According to the new Encyclopedia of Africa, Outbreaks of rift valley fever (RVF) in Africa are characterized by distinct spatial and temporal patterns that are largely influenced by climatic parameters. Heavy rains and flooding are particularly associated with onset of the disease, and outbreaks are positively associated with warm El Nino southern oscillation (ENSO) events. People with rift valley virus infections typically have a flu-like illness with fever, weakness, back pain, dizziness and weight loss. Sometimes, infection can cause hemorrhage (severe bleeding), encephalitis (inflammation of the brain), or severe eye complications.

Mathew (2005) confirmed some kinds of weather effects on health, such as aching joint occurring when the temperature is low. Extremely high temperature leads to heat stroke, while extremely low temperature causes hypothermia. A thunderstorm could trigger off an asthma attack.

Centre for disease control and prevention (CDC, 2008), when describing the health effects of weather remarked that increased temperature has a range of effects from mild rashes to deadly heart stroke. It can aggravate chronic cardiovascular and respiratory disease. Droughts can also result in shortages of clean water and may concentrate contaminate that negatively affect quality of surface waters in some areas. Drought may also strain agricultural productivity and could result in increased food prices and food shortages, this may lead to malnutrition.

Gubler et al (2001) argued that diseases such as plaque, typhus, malaria, yellow fever and dengue fever transmitted between humans by blood – feeding arthropods, were once common in the United States. Many of these diseases are no longer present, mainly because of changes in land use, agricultural methods, residential patterns, human behaviour, and vector control. However, diseases that may be transmitted to human from wild birds or mammals (zoonoses) continue to circulate in nature in many parts of the country. Most vector –borne diseases exhibit a distinct seasonal patterns, which clearly suggests that they are weather sensitive.

Sawa and Buhari (2011) noted that the outbreak of meningitis and measles in Zaria could be aggravated by the overcrowding of houses, poor ventilation, poor building and street layouts in the area.

2.7 Nutrition

Nutritional value of preparation or cooking can be affected by temperature, humidity, sunlight and pressure. Dietary habits are similarly influenced by weather elements. Humidity can spoil some dry foods if not well protected; sunlight destroys vitamin C especially in liquid form and in vegetables, fruit juice and milk. People eat certain food based on weather condition to either keep warm or cold. These affect the nutritional value of the food ingested and could lead to malnutrition or imbalance which could make people susceptible to diseases (CDC, 2008, Griffiths, 1976).

2.8 Sanitation

Cleanliness promotes healthy living in any community. When sanitation is not properly observed it could pose a serious threat to the health of the people. Most vector-borne diseases find breeding home in stagnant water. This is very common in rainy season and in places with none or poorly constructed drainages. Personal hygiene also helps to prevent direct contact with some bacteria and virus that could be detrimental to health (Griffiths, 1976).

The implication of all these is that, planning for the protection of human health from the potential impacts of climatic factors requires an understanding of other environmental factors that could promote the vulnerability of the people.

2.9 Weather elements and human health

Akinbobola and Omotosho (2004) carried out a research on the relationship between meteorological variables and the occurrence of malaria, measles, chicken pox, meningitis and pneumonia in Ikeja, Akure and Kaduna (Nigeria) and their results showed that there is a relationship between outbreak of the 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 the hot periods. Adefolalu and Omotosho (1984) also investigated how temperature relates with respiratory diseases in northern Nigeria and discovered that the diseases thrive more when the temperature is very low.

Ericsson (2010) reported that cold air can trigger asthma because it can increase the blood pressure which will affect the heart. The author also stated that an asthmatic attack takes place when something affects the lungs. Extremes of heat and humidity can trigger asthma attacks because heat increases the metabolic rate and body temperature. This makes the body use more energy and oxygen. The need for more oxygen means faster or deeper breathing which is a problem for asthmatics. Extreme humidity makes it difficult to lower body temperature. The body will then have to work harder and longer, again increasing the need for oxygen.

Sawa and Buhari (2011), in their study on the temperature variability and outbreak of meningitis and measles observed that peak cases of meningitis and measles outbreak in Zaria is in March and that increase in temperature has a significant influence on the outbreak of these two airborne diseases. This is further aggravated by poor ventilation in the buildings as a result of inadequate window provisions for proper cross ventilation.

Better health Channel (2010) described the pattern of relationship that exists between the home environment where people live and their health condition. According to these researchers, certain diseases like asthma, meningitis and pneumonia are influenced by nature of the home environment where the patients live.

Griffiths (1976) described four major aspects to consider when building a house for living. These are: thermal considerations, ventilation and wind pressure, day lighting factors and precipitation or dampness aspects. These factors all contribute to the wellbeing of the people.

Duncan (1996) remarked in his study on environmental health principles that the potential presence of diseases of all types whether in urban or rural communities is a feature of life in human settlement. He further explained that several "health principles of housing were defined by WHO. The principles were stated in the context of socio-economic development and with particular emphasis on the health risks of the urban and rural poor building pattern.

According to Gambsch et al (2000), connections between weather elements and diseases are not new. Weather elements to a great extent affect the season and intensity of outbreaks. The reappraisal of these relationship is aided by the increased understanding of the earth's climate system, in particular, how land and sea surface temperatures and pressure gradients drives winds and weather. All increase in cloud cover blocks outgoing heat, contributing to disproportionate warming at night and during the winters, conditions that are unhealthy for human beings but advantageous for insects that transmit infectious diseases. Sudden weather changes such as droughts suppress predators, whereas, heavy rains boost food supplies a synergy that can support insect and rodent population explosion. They maintained that climatic factors are potentially the largest global threat to human health ever encountered. The earth is warming and is affecting human activities. If the current emissions and land use trends continue unchecked, the next generation will face more injury, disease and health related to natural disasters and wide spread malnutrition.

McMichael *et al.,* (2001), stated that the paths by which climate can affect human health are diverse and involve both direct and indirect impacts. The most direct impact includes human exposures to climate extremes that can result in injury, illness and death. Climatic factors can also affect human health by influencing human exposure to infectious diseases through effects on the biology, habitats and behaviors of diseases pathogens, hosts and vectors. Furthermore, climatic elements can affect human health through impacts on the resources that individuals and communities need to maintain good health. Many vector-borne infectious diseases are climate sensitive and epidemics of these diseases can occur when their natural ecology is disturbed by environmental changes, including changes in weather elements.

Minakawa, *et al* (2005), argued that the transmission of malaria to human is higher when temperature increases. They further argued that increase in human population density have led to deforestation and swamp reclamation leading to the creation of puddles and providing ideal breading sites for mosquitoes. More so, the removal of vegetation in swamp areas also results in relatively higher temperatures that further augment malaria transmission. Positive trends in maximum temperatures are significantly linked to the El Nino which, in turn, has been associated with serious malaria epidemics in the lake basin of East Africa, indicating that the exposure of the communities to malaria incidence is dramatically increased during El Nino periods. High temperature and wide spread flooding favour the proliferation of the mosquito vectors. Temperature controls the rate of laval and parasite development, with higher temperatures shortening the development period of the lavae as well as parasites in the mosquitoes. Rainfall increases the parasites in the mosquito breeding habitats, thus, contributing to the size of mosquito populations which directly influences the intensity of Malaria transmission.

Kenneth, Thomas, Rebecca and Edward (2008), asserted that weather elements could significantly affect vector borne disease in humans. Temperature, precipitation, humidity, pressure and wind are known to affect the reproduction development, behavior and population dynamics of the arthropod vectors of these diseases. Climatic factors can also affect the development of pathogens in vectors, as well as the population dynamics and ranges of the non human vertebrate reservoirs of many vector borne diseases. Whether changes increase or decrease the incidence of vector borne diseases in humans will depend not only on the actual weather conditions but also on local non climatic epidemiologic and ecologic factors. Predicting the relative impact of sustained climatic factors on vector borne diseases is difficult and will require long-term studies that look not only at the effects of climatic factors but also at the contributions of other agents of global change such as increased trade and travel, demographic shifts, civil unrest, changes in land use, potable water availability, and other issues.

A study by Reiter (2001) suggested that global atmospheric temperatures are presently in warming phase that began 250 – 300 years ago. Speculations on the potential impact of continued warming on human health often focus on mosquito borne diseases. Elementary models suggest that higher global temperatures will enhance their transmission rates and extend their geographic ranges. However, the histories of diseases such as malaria, yellow fever, cholera, meningitis, prumous and dangur reveal that weather elements has rarely been the principal determinant of their prevalence or range; human activities and their impact on local ecology have generally been much more significant. It is therefore inappropriate to use climate-based models to predict further prevalence.

Patz *et al.*, (2002), also argued that disease outbreaks are known to be often influenced by local weather, but how changes in disease trends might be affected by long-term global warming is more difficult to establish. In a study of malaria in the African highlands, it is revealed that there is no significant change in long term climate at four locations where malaria incidence has been increasing since 1976. We contend however, that their conclusions are likely to be flawed by their inappropriate use of global climate data set. Moreover, the absence of a historical climate signal allows no inference to be drawn about the impact of future climate change on malaria in the region. The existence of critical climate thresholds, the association between change on malaria incidence and change in climate can be biologically meaningful even without significant climate change.

According to Lipp, Hug and Colwell (2002), the role of the environment and climate in disease dynamics has become a subject of increasing interest to microbiologists, clinicians, epidemiologists, and ecologists. Much of the interest has been stimulated by the growing problems of antibiotic resistance among pathogens, emergence and / or reemergence of infectious diseases worldwide, the potentials of bioterrorism, and the debate concerning climate change. Cholera, caused by Vibrio cholera, lends itself to analysis of the role of climate infectious disease, coupled with population dynamics of pathogenic micro organisms, for several reasons. First, the disease has a historical context linking it to specific seasons and biogeographical zones. In addition, the population dynamics of V. cholerae in the environment are strongly controlled by environmental factors, such as water temperature, salinity, and the presence of cope oils, which are in turn controlled by climatic factors. In this review, the association between plankton and V. cholorae that has been documented over the last 20 years is discussed in support of the hypothesis that cholera shares properties of a vector-borne disease. In addition, a model for environmental transmission of cholera to humans in the context of change in climatic factors is presented. The cholera model provides a template for future research on climate sensitive diseases, allowing definition of critical parameters and offering a means of developing more sophisticated methods for prediction of disease outbreaks.

Oluleye and Akinbobola (2010), asserted that climatic parameters play a role in the prevalence and severity of some common diseases as speculated in the face of changing climate of the world. They investigated this supposition by expounding the relationship between malaria, pneumonia, and rainfall and air temperature over Lagos, Nigeria. The study used temperature and rainfall data of 60 years and 14 years record of reported cases of malaria and pneumonia infection. Significant climatic change was detected in both rainfall and air temperature when standard methods of change detection was applied. While rainfall showed a decreasing trend resulting into drier conditions, temperature tends to increase resulting into warmer environment. Temperature spells were found to increase in frequency during the last two decades, and there are tendencies for further increment given the current rate of increasing temperature. Air temperature and malaria correlation coefficient was high and positive in the months of February and

December ranging between 40 and 96% but high and negative only in November. It was therefore concluded that climatic parameters of rainfall and air temperature have profound influence on both malaria and pneumonia occurrence and are responsible directly for intractable increase of the diseases.

Onche (2009) explained that pneumonia is a condition of illness of the lung. It is an infection which causes the air sacs in the lungs (called the alveoli), and the smaller bronchial tubes to become inflamed and filled with fluid. Special white blood cells then travel to the lungs to fight off the infection. This makes it hard for the lungs to do their job, which is to get oxygen from the air into the blood stream and then around the whole body. The symptoms include cough producing greenish or yellow sputum, or phlegm and a high fever that may be accompanied by shaking chills. Pneumonia is a common illness which occurs in all age groups, and is a leading cause of death among the elderly, children less than five years and people who are chronically and terminally ill. Pneumonia claims more children less than 5 years of age in Nigeria however, reports on how weather affects the occurrence and rate of hospitalization of this disease are still very scarce, but the disease manifests shaking chills as one of its symptoms. It therefore suggests that weather extremes may have profound effects on patients as to exacerbate its severity, increase hospitalization and cause accelerated death. Weather may have influence in the pneumonia infection not only because of the shaking chill symptom but in creating a favourable atmosphere for the bacteria and virus that cause the infection to thrive (Onche 2009). Thus, weather may cause an increase in the rate of infection of the disease.

According to Rees (1996) the relationship between human health and climate is not a new concept, nor is it a new subject. In fact, at least, as far back as Hippocrates, many believed that human health was intricately linked to seasons, local weather patterns and other environmental factors. While preceding the advent of Pasteur's Germ theory in the mid 1800s, these notions described certain patterns of disease and often therapies were based directly on changes in the environment. Proponents of Miasma, that is, a poisonous atmosphere arising from swamps and putrid matters, as a source of diseases noted that fevers and intestinal ailments were associated with wet, poorly drained and humid areas, such as swamps. This incident motivated draining of swamps and the installation of the first central sewer systems in urban areas in North America. Of course, the therapeutic benefits of these practices had little to do with ridding the environment of Miasma, but these practices did reduce the size and number of habitats breeding mosquitoes (disease vectors) and removed raw waste (hence, waterborne pathogens) from immediate contact with humans. In spite of the developments in the mid to late 1800s demonstrating the role of microorganisms in disease, the theory of weather-borne diseases held firm in early medicine until the late 1800s.

Barnett, Pierce and Schnur (2001) found in their study that during the past few years, scientists and several agencies, including World Health Organization (WHO), American Academy of Microbiology, Intergovernmental Panel on Climate Change (IPCC), and U.S. Global Change Research Program, among others, have published papers and issued reports highlighting the effect of weather elements on the occurrence and severity of diseases. Concerns over the impact of anthropogenic alterations to both terrestrial and aquatic habitats, coupled with a changing global climate, have helped to spawn an expanding cross-disciplinary effort to understanding how such changes might affect human health.

Scot-Evans (2007) noted that some people have symptoms that worsen with cold weather while others suffer more in hot weather. He observed that people with imbalances that reflect environmental energies such as heat, cold or dampness often have symptoms that worsen when the weather is similar to their internal imbalance. The average body temperature of man is made up of both his surface temperature and his rectal temperature which is the temperature at which the human body functions most efficiently. When the average body temperature is too low (internal cold) or too high (internal heat), then, there is an internal imbalance. Those with internal heat have symptoms that worsen in hot weather and feel better in cold weather, while those with internal cold will have symptoms that worsen in cold weather and feel better in hot weather.

Benzer (2009) has also argued that the effect of change in weather on our health is undeniable. She justified this fact by describing how weather affects the mood and activities of man like being depressed and weak on a cloudy day and being very active on a sunny day. She also argued that *rheumatoid arthritis* patients will have more pains during rainy days because of the effect of atmospheric pressure on their health. Furthermore, it has been observed that relative humidity leads to excessive dehydration of nasal passages and the upper respiratory tract during winter and increases the chances of microbial and viral infections.

2.10. Mode of Disease Transmission

2.10.1. Vector- borne

According to WHO (1999), vector-borne diseases are those that require a host (most often arthropods or rodents) to transmit a pathogen. Variability in climate and weather can affect both the vector population and the amplification of the pathogen within the host. Malaria and dengue fever continue to be the most-important vector-borne diseases worldwide. Unlike yellow fever and rift valley fever, which affect humans only incidentally, malaria and dengue are transmitted directly by infected mosquitoes that commonly bite humans. Other mosquito-borne infections, including rift valley fever, yellow fever, and encephalitis, are transmitted between the mosquito vector and a nonhuman animal host under normal circumstances and affect humans only incidentally. Plague and Lyme diseases, among others, are transmitted to animals by fleas and ticks, respectively, and Hantavirus is transmitted by rodents. While humans are not a normal host for some of these agents, they can all pose a threat when the pathogen uses a vector that bites or cohabitates with humans.

Vector-borne diseases remain the most-studied group of diseases in the context of climate variability. The geographical range of the vector population is indicative of ecological and climatic conditions that limit the distribution of both the host and the pathogen. Often, ecological disturbances, including weather-related events, can cause a shift in host vectors or change in habitat that results in a greater likelihood of the pathogen coming in contact with humans, thus increasing the risk of human infection. In border areas where conditions are not optimal for the pathogen and/or vector, small ecological disturbances or changes in weather may also alter conditions for disease transmission by creating a more favorable environment. It is often in such border regions that the most dramatic results of climate change and/or variability are recognized. In the recent literatures, many researchers have documented relationships between changes in weather due to the ENSO and certain vector-borne disease outbreaks. In this review, we have adopted a more inclusive definition of vector-borne disease that encompasses pathogens that do not require an obligate host (vector) for transmission but which are likely to be transmitted to humans by such a route.

2.10.2. Air- borne

To Bernard, Samet, Ebi and Romieu (2001), little is known about airborne infectious diseases and how they are affected by climate. While there is a growing body of work that focused on health impacts associated with air pollution and climate change, these studies largely focus on noninfectious agents (ozone and particulate matter, etc.) or allergens. Influenza and rhinoviruses, which cause flu and colds, respectively, are recognized as infectious airborne pathogens. Indeed, there does seem to be a regular season for flu and colds, and climatic factors are suspected to contribute in part to these cycles. In the Northern Hemisphere, flu cases peak in the late fall and winter, but there is no significant correlation with mean temperature. Humidity, however, may affect survival of aerosolized virus particles. In the southwestern United States, *Coccidioides immitis*, a soil fungus responsible for valley fever, causes higher infection rates during dry periods that follow a rainy season, when wind can distribute the pathogen.

2.10.3. Dust- borne

Griffin, Garrison and shinu (2001), discovered that dust-borne agents distributed in the air are also affected by large atmospheric phenomena. Relative to normal conditions, large numbers of viable microorganisms have been isolated in Caribbean air samples during "African dust events". Periodically, massive plumes of dust are transported across the tropical Atlantic from the sub-Saharan region of Africa. Such events have been exacerbated by drought in the Sahel region, overgrazing, and the drying of Lake Chad. To date, microorganisms found in the dust particles include *Aspergillus* spp., *Pseudomonas* spp., and *Sphingomonas* spp., among others; however, it remains unknown if any human infections can be related to the African dust events. Similar phenomena are associated with the Gobi Desert and wind-swept dust from this region of the world.

2.10.4. Water-borne

To Oshea and Field (1992), the quality and quantity of drinking water, irrigation water, and environmental and/or recreational waters can be associated with changes in environmental conditions including weather- or climate-related variables. Floods may cause the overflow of wastewater treatment plants, failure of septic systems, or combined sewer overflows, which could contaminate nearby surface waters or wells. Furthermore, there is increasing concern about pathogens in storm water runoff. Maintaining sanitary water conditions is also an issue during drought conditions, when contaminants may become concentrated in available water. Additionally, the likelihood of multiple uses in a water body may increase (e.g., for cleaning, bathing, and drinking) during droughts and consequently enhance the risk of contamination and exposure. Increasingly, the importance of the effect that weather and climate have on water quality, and not simply quantity, is being realized. Severe weather events appear to be correlated with enteric diseases, such as outbreaks of cryptosporidiosis related to excessive demand placed on sewage treatment plants from heavy rains and flooding. A retrospective study of drinking water-related outbreaks of acute gastrointestinal illness in the united state revealed that 20 and 40% of groundwater and surface water outbreaks, respectively, between 1971 and 1994 were statistically associated with extreme precipitation. Other work has also demonstrated an ENSO connection to rates of enteric illness in South America, levels of enteric microorganisms in coastal areas of south Florida (United States), and cholera in Bangladesh.

Wittman and Colwell (2000) argued that, in addition to enteric pathogens, climate also influences the abundance and ecology of nonenteric and other pathogens which are naturally present in the environment. The best examples of this include the pathogenic *Vibrio* spp., which are autochthonous in estuarine ecosystems. *Vibrio parahaemolyticus* and*Vibrio vulnificus* are responsible for a majority of the nonviral infections related to shellfish consumption in the United States and also result in infections of open wounds during recreational exposure, such as swimming and fishing. Along with *V. cholerae*, these bacteria thrive in warm waters of moderate salinity and are closely associated with aquatic invertebrates. Therefore, with a changing climate, the geographic range of these pathogens may also change, potentially resulting in increased exposure and risk of infection for humans. Furthermore, changes in plankton populations, and other hosts for which vibrios are commensals or symbionts, would similarly alter the ecology of these pathogens that are autochthonous to the aquatic environment.

CHAPTER THREE

THE STUDY AREA AND METHODOLOGY

3.1. Introduction

This chapter is concerned with the study area and the methodology adapted. In the study area the focus is on the location, historical development, physiographic characteristics and the economic activities. In the other hand, the aspect of methodology discussed includes the types and sources of data and the methods used in the analysis and presentation of data.

3.2. The Study Area

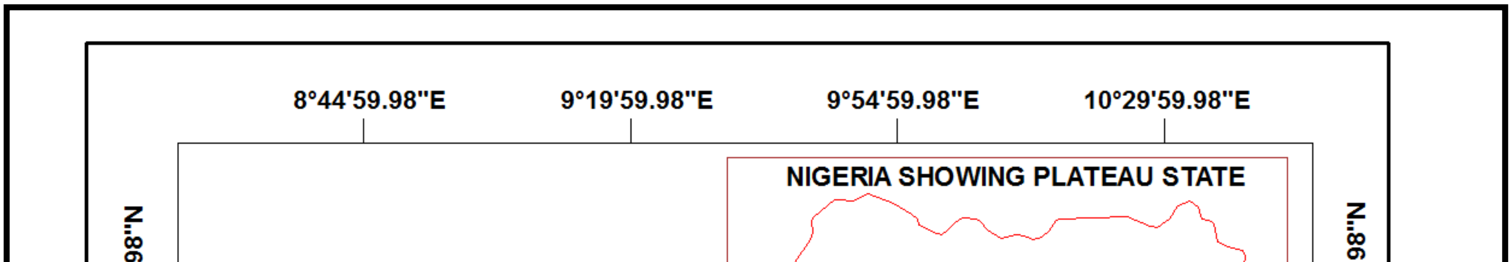
3.2.1 Location

Jos North Local Government Area (L.G.A) is located between latitude 9° 51′ and 10^0 15′N and longitudes 8° 44′E and 8° 58′E. It is found almost at the geographical centre of Nigeria (see Figure 3.1). Jos North Local Government is bounded by Bauchi state to the north, Jos East to the East, Jos South to the south and Bassa Local Government to the West (see Figure 1). Jos North local Government Area covers an area of about 291 square kilometers.

3.2.2 Physical setting

3.2.2.1 Geology

According to Iloejo (1981), Jos North is thought to be an area of Younger Granite which covers the entire locality and other neighboring localities. These younger granites are thought to be about 160 million years old. This creates unusual scenery of Jos. There are numerous hillocks with gentle slopes emerging from the ground like mushrooms scattered with huge boulders.



3.2.2.2 Relief and Drainage

Omotosho (2007) argued that the average elevation of the Jos Plateau is about 1150 meters above mean sea level and the highest peak, some 20km eastward from Jos, the Shere hills, rise to about 1777 meters above sea level. The Jos-plateau is said to be the hydrological centre of the surrounding lowland where most rivers such as Dilimi, Kaduna, Riyom and Kwall take their source. The study area is well drained with more runoff than percolation.

According to Adams (2000), the drainage pattern on the Jos Plateau is in a radial pattern where the many rivers and streams diverge from the top of the plateau and flow away to different directions. Some streams and rivers that are scattered over the study area pour into the Dilimi River, which flows down to Bauchi State and beyond. Kurra falls and Assop falls are the most notable of Plateau State's water falls. The two waterfalls are located at the edge of the Jos Plateau, some few kilometers away from Jos city. The Assop river which feeds the picturesque rapids and falls, drains part of the Jos Plateau to river Kaduna. Kurra falls resulted from the activities of tin mining in the area. It drains its water into river Ganawuri and finally to river Kaduna. Kurra falls is used by Nigerian Electricity Supply Company (NESCO) to generate electric power for a large member of communities in Jos. The Kerang highlands are located about 88 kilometers from Jos. These beautiful volcanic hills are the source of natural springs, which supply the popular spring water company (SWAN) (Adams, 2000).

3.2.2.3 Climate Characteristics

Ojo, Gbuyiro and okoloye (2004) asserted that the influence of the oscillation of the Inter Tropical Discontinuity (ITD) is completely modified by the height of the Plateau. Jos therefore has a more tolerant weather than most parts of Nigeria on the same latitude.

The highest rains are recorded in August. The driest months are December to January. Jos North LGA like any other part of the Jos-Plateau receives very high amount of rainfall of about 1351mm due to its altitude on the Plateau. The length of the rainy season extends from April to October.

Temperature in Jos is relatively lower than the surrounding lowland areas ranging from 20°C during hamarttan to about 28°C in March/April. The highest mean maximum occur in April with about 27°C the low being 22°C in December. The mean minimum is as low as 4.5°C in December and 14.7°C in March.

The maximum hour of sunshine occurs in April/May, and reduces in October. The effects of cloud cover on the Jos Plateau have contributed to the amount of solar radiations received in Jos North. The radiations vary between 749cm/day in December and 890cm/day in April. The sunshine hours for December are about 11.7 and 12.9 hours in June, but when we take account of the normal cloud cover in the wet season, the average sunshine hours is about 6.5 hours per day while during the harmattan haze, it is reduced to 5.9 hours per day.

The mean maximum relative humidity for the rainy season of April to October is between 75% and 85%, while the minimum for the period is 42%. Absolute minimum is below 10% with 3.6% in February during harmattan.

The highest wind speed on the Jos Plateau is about 390km/day but normal from 220-240km/day occur in the dry months while in November and December the wind runs 120-190km/day.

3.2.2.4 Soil and Vegetation

According to Iloejo (1981), two soil types can readily be identified at the superficial level. These are the sandy loam and grey loam soils. Most Soils are stony, fertile and hard to work on for the agriculturalist. This seems to result from the washing away of the top soil by denudation processes. The undulating terrain is covered mostly by montane type of vegetation characterized by short trees and tall grasses; there are varieties of economic trees, like mango, baobab, mahogany and locust beans trees. Forested areas include the leeward sides of the plateau, valleys and sacred traditional places preserved by communities.

3.2.2.5 Ecological Problems

The major ecological problems of Jos North L.G.A. include flood and gully erosions. The occurrence of gully erosions is due largely to mining activities that have bedeviled the locality. For decades, both formal and informal mining of tin have been carried out on the plateau. In spite of the economic benefits, a myriad of environmental problems has been the attendant accompaniments. Tin mining causes gully erosion, water pollution and hence, a hazard to the aquatic habitat. It also affects the soil and consequently, agriculture. Tin mining also causes air pollution. In addition, it affects the land by hampering the use of it for human settlement (Adams, 2000).

Flooding in the locality is due to the narrowness of the river channel and the dumping of refuse on the river channels. Furthermore, the construction of buildings either near or in the river channels is also a contributing factor to the problem of flooding in the study area.

Vector-borne diseases such as malaria, pneumonia, meningitis and cholera are also a major threat to human health in the study area. Water in the mining ponds also serves as breeding grounds for vectors such as mosquitoes and other diseases carrying organisms thereby enhancing the outbreak of malaria typhoid and cholera. Changes in weather condition such as increase or decrease in rainfall, temperature, relative humidity, wind velocity and cloudiness can promote the activity of anthropods and rodents in the transmission of vector-borne diseases in the study area.

3.2.3 Human settings

3.2.3.1 Historical Development of Jos North Local Government Area

According to Adams (2000), the area designated as Jos North L.G.A came into being in September, 1991 when the former Jos L.G.A was divided into two to create Jos North and Jos South L.G.AsThe original occupants of Jos North L.G.A. are the Beroms, the Jarawas, and the Anagutas. These natives lived on the hills when tin and columbites were discovered on the Jos Plateau when mining started in 1902, the town started growing and the natives migrated to the plains.

The mining industry attracted migrants from all over Nigeria and other parts of the world and this led to the rapid urbanization of Jos which served as the headquarters of the mining companies. The city as the capital of Plateau State is provided with social amenities such as water, electricity, access roads, housing, administrative offices, recreational and educational facilities.

The provision of the social amenities mentioned above attracted a large population to Jos North. This led to the emergence of shanty areas like Nasarawa Gwong and development of slumps with consequent over-straining of existing but never expanded social amenities.

3.2.3.2 Population, People and culture

Jos North LGA is densely populated with about 1475 persons per square kilometer. According to the 2006 population census, the population of the locality was 429,300. The locality is mainly inhabited by the Berom, Jarawa and Anaguta. Other settlers include the Hausa, Fulani, Igbo and the Yoruba. Cultivation of Irish potatoes, maize and vegetables are the major agricultural practices common among the people in the locality. The people in the area especially the Beroms engage in the traditional way of tin mining by excavation as a means of livelihood. Dry season agriculture is also a major agricultural practice in the area. The Beroms are known for high consumption of locally made alcohol known as burkutu.

3.2.3.3 Economic Activities

Adams (2000) observed that the major economic activities on the plateau include: grazing, manufacturing, wholesale trade, retail trade of all forms of manufactured goods including food stuff, services such as transportation, banking and insurance among others. Other economic activities include transportation by means of tricycles, cars and heavy trucks. The farming of Irish potatoes, tomatoes, onions, cucumber, water melon, cabbage and maize through rainfed and irrigated agriculture are common in the study area. Others include tailoring, bakery, hoteliers and tourism.

3.2.3.4 Infrastructures

Jos North LGA is endowed with infrastructures such as the primary health care facilities, tertiary hospitals like Jos University Teaching Hospital (JUTH) and Plateau Specialist Hospital, primary and secondary school,s marketing shopping centers, post office, are provided with electricity water treatment plant, post and telecommunication complex, drainage and solid waste management. Tertiary institutions also abound in Jos North LGA, they include University of Jos, Federal College of Forestry, School of Nursing, Centre for Continuing education and College of Accountancy. The study area is served with good road networks, which link it with the surrounding communities like Bauchi, Jos South, Jos East and Saminaka. There are several motor parks, police headquarters, banking facilities and public toilets. Other facilities include the Plateau State publishing house, Plateau Radio Television Corporation (PRTV), Solomon Lar Amusement Park, Jos wild Life Park and National Museum. The state and federal secretariat are all located within Jos North LGA.

3.3 Methodology

3.3.1. Types of Data

The data needed for this study include: maximum and minimum temperature, relative humidity and rainfall records for 10 years (2002-2011). Secondly, records of both inpatients and outpatients treated for malaria, meningitis and pneumonia in Jos North Local Government Area for the same period (2002 – 2011).

3.3.2 Sources of Data

The data needed for this study were obtained from secondary sources. Monthly maximum and minimum temperatures, relative humidity and rainfall records for the 10 years (2002 – 2011) were sourced from the meteorological unit of the University of Jos. The records of patients (both inpatients and out patients) treated for malaria, meningitis and pneumonia in Jos North local government area for the same period (2002 – 2011) were obtained from the two major hospitals: Jos University Teaching Hospital (JUTH) and Plateau Specialist Hospital, Jos. The period 2002 – 2011 were used because it is the period with continuous records of patients treated for the three listed diseases in the study area. The two hospitals are chosen because they are located within the study area and they are the hospitals where most people go to for treatment.

3.3.3. Data Analysis

The daily records of both climatic elements and patients treated for the mentioned diseases were summed up to obtain the mean monthly records which were used in the analysis.

To achieve the objectives stated in this study, different methods were used to systematically analyze all the relevant data that were generated for this study. This was done as follows:

3.3.3.1 Objective One**:**

Times series analysis was used to exhibit trends in the weather elements and health parameters. Trend lines and trend line equations were drawn to show the direction of change in the variables.

3.3.3.2. Objective Two: Multiple graphs of each disease and the climatic parameters were plotted to determine the seasons of occurrence and spread of the diseases mentioned in the study area.

3.3.3.3. Objective Threee

To determine the relationship between the weather elements (temperature, relative humidity and rainfall) and the incidence of malaria, meningitis and pneumonia in Jos North Local Government Area, the ordinary least square (OLS) estimates of the multiple regression models was used. Basil (1977) argued that correlation analysis is usually used to measure the degree of relationship that exists between two or more variables of interest. Before this was done, the values of the climatic elements and reported cases of the diseases were transformed to a common base using log10. The multiple correlation coefficient formula is given by;

$$Y = \beta \quad + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots + \beta_n X_n + e$$

Where

$Y =$ dependent variables(malaria, pneumonia and meningitis)

$X_1, X_2 and\ X_3$ = independent variables (weather parameters)

X_1 = rainfall

X_2 = temperature

X_3 = relative humidity

β = constant showing intercept for regression

$\beta_1\ to\ \beta_n$ = independent variable coefficient

e = error term

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter deals with the presentation and discussion of result of this study.

4.2 Trends in the Weather Parameters

4.2.1 Trends in Temperature

The temperature pattern of the study area from 2002-2011 is presented in Figure 4.1.

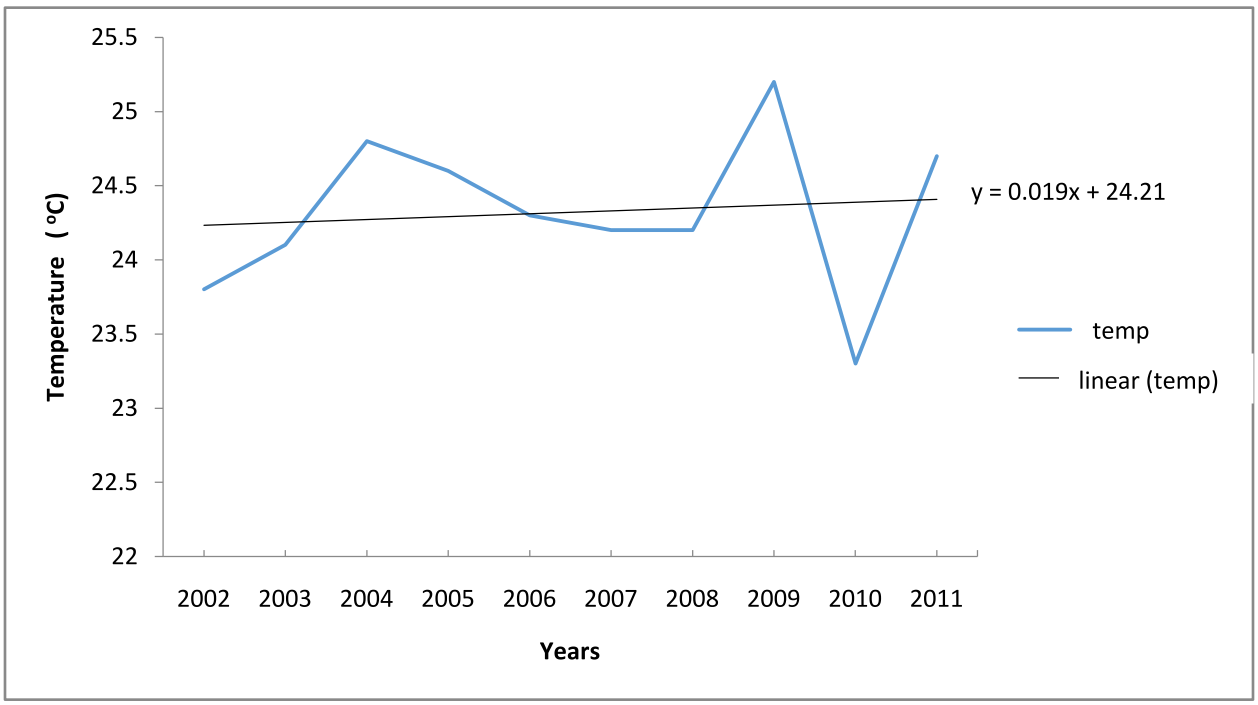


Figure 4.1: Temperature Trend of Jos North LGA (2002 – 2011)

SOURCE: Field Survey, 2014

Figure 4.1 shows the temperature trend from 2002 to 2011. The trend revealed that the highest amount of temperature was recorded in 2009 (25°C) whereas the lowest was recorded

2010 (23.5°C). The trend line is positive; meaning that, on average, temperature was increasing from year to year throughout the period of study. This is further explained by the positive trend equation of y = 0.019x + 24.21. The positive trend in temperature will mean increase in the cases of meningitis in the study area. This findings corroborates the assertion by Babour (1982) that two third of the reported cases of meningitis in Nigeria occur within just three months (February, March and April) where temperatures are higher.

4.2.2 Trends in Annual Rainfall

Trends in annual rainfall of the study area is presented in Figure 4.2

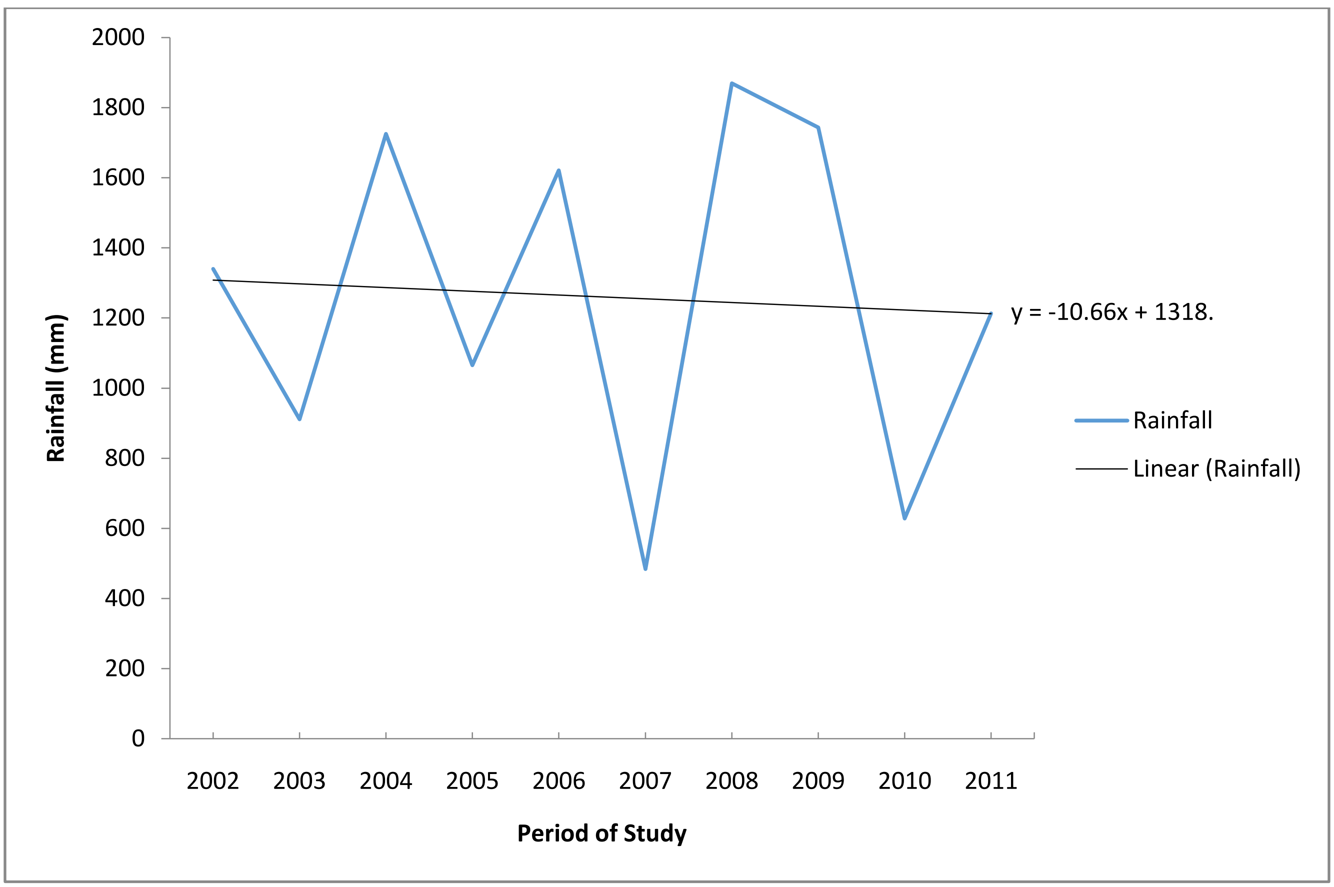


Figure 4.2: Trend in Annual Rainfall of Jos North LGA (2002 – 2011)

SOURCE: Field Survey, 2014

Figure 4.2 gives a picture of the pattern of rainfall from 2002 to 2011 in the area. Unlike temperature, there was a lot of variation in the amount of rainfall throughout the period under study. The presence of unequal distances between the several peaks is an indication of great variability in annual rainfall. The trend line is negative; meaning that, on average, rainfall was decreasing from year to year throughout the period of study. Furthermore, across the year there is high rainfall in the year 2008. The negative trend line equation of $y = -10.66x + 1318$ supports this. The downward trend of rainfall is more obvious in this case than that of temperature. The negative trend in rainfall presupposes a reduction in the cases of malaria and pneumonia as this study has revealed that there is a positive relationship rainfall and the reported cases of malaria and pneumonia. This result contradicts the findings of Osadare (2011) that rainfall does not determine the outbreak of malaria in zaria.

4.2.3 Trends in Relative Humidity

Figure 4.3 shows the trend pattern of relative humidity over the study area between 2002 and 2012

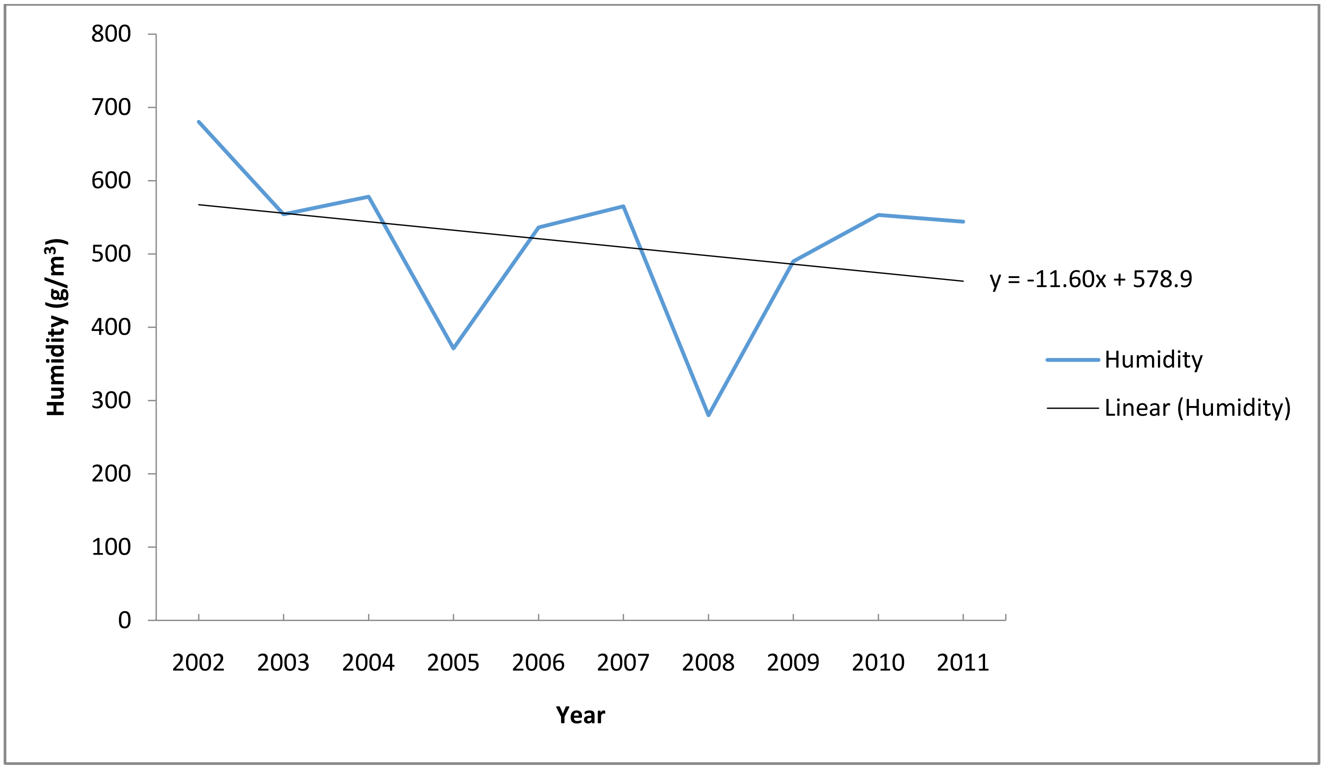


Figure 4.3: Trend in Relative humidity of Jos North LGA (2002 – 2011)

SOURCE: Field Survey, 2014

Figure 4.3 shows a similar trend to that of rainfall, relative humidity varied a lot with some periods of high level of humidity. However, it is observed that from the year 2002 Relative humidity was very high but continued to decrease as the years go by. Trend in relative humidity is negative from 2002-2011. Moreover, from the negative trend line equation: $y =-11.60x+578.9$, we can confidently say that from year to year relative humidity was reducing by a level of 578.9g/m^3. This implies that there will be more cases of pneumonia as this study has shown that there a negative relationship between relative humidity and the outbreak of pneumonia. A study by Ayoade (1983) has shown that relative humidity influence to a great extend the physiological functioning of the human body.

4.3 Trends in Reported Cases of the Selected Diseases

4.3.1 Trends in Occurrence of Malaria

Fig 4.4 presents the reported cases of malaria in the study area between 2002-2011

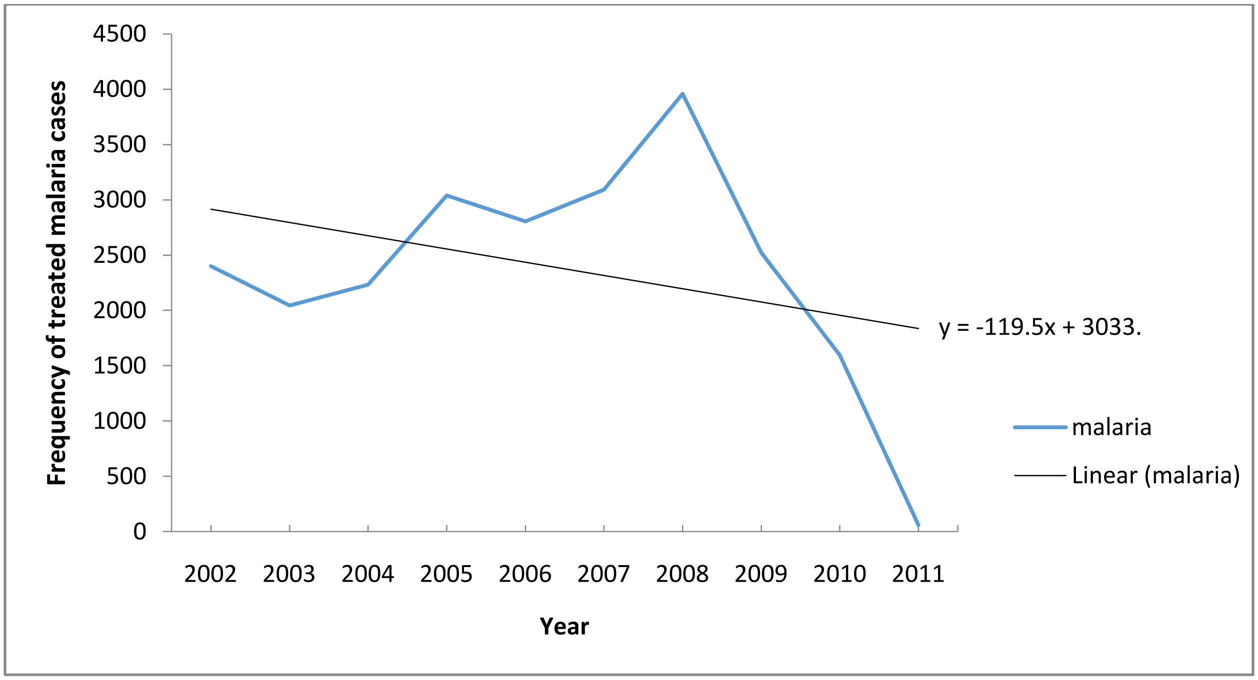


Figure 4.4: Trend in Reported cases of Malaria (2002 - 2011)

SOURCE: Field Survey, 2014

Figure 4.4 shows that the number of people that were treated for malaria decreased on the average from year to year. The year 2008 recorded the highest incidence of 4000 cases. The decrease is justified by the negative trend line equation; Y= -119.5x+3033. The trend has shown that the recorded incidence cases of malaria for the year 2002 is 2400 and then declined to 60 incidence cases in the year 2011. Thus the number of people suffering from malaria decreased from year to year.

4.3.2 Trends in occurrence of pneumonia

Fig 4.5 presents the reported cases of malaria in the study area

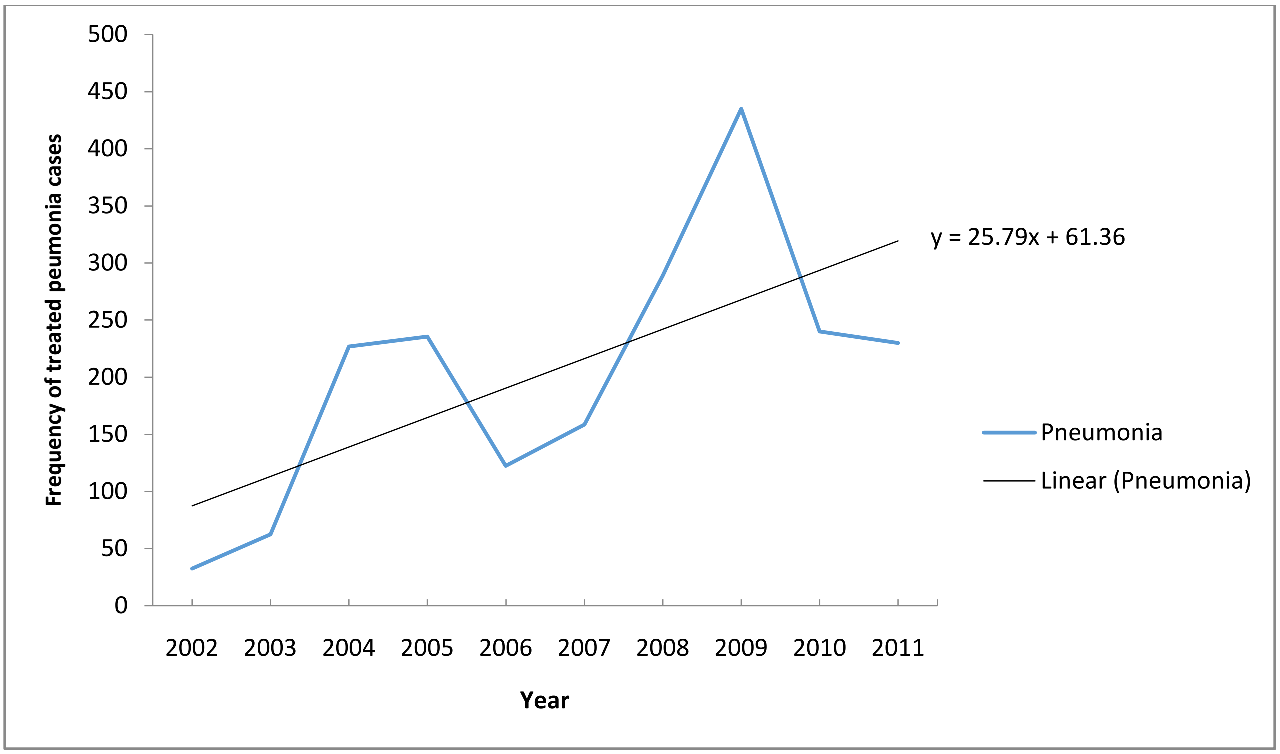


Figure 4.5: Trend in Reported cases of Pneumonia (2002 – 2011)

SOURCE: Field Survey, 2014

Figure 4.5 shows the pattern of reported outbreak of pneumonia between 2002 and 2011. The pattern fluctuated throughout the period of study but with more deviations in recent years, the highest reported cases are in 2009 and the least in 2002. The trend line exhibits a positive slope meaning that the number of reported cases of pneumonia was increasing from one year to another as explain by the trend equation y = 25.79x+61.36. Specifically, without the influence of time, there was an expectation of about 25 reported cases of pneumonia. The trend has also revealed that recorded incident cases of pneumonia for the 2002 are 30 and increased to about 260 recorded cases in the year 2011. Thus the incidence of pneumonia has increasing from year to year. However, with the influence of time the number of cases increased on average by about 61.36 from year to year as indicated by the trend equation.

4.3.3 Trends in frequency of reported cases of Meningitis

Fig 4.6 presents the occurrence of meningitis in the study area

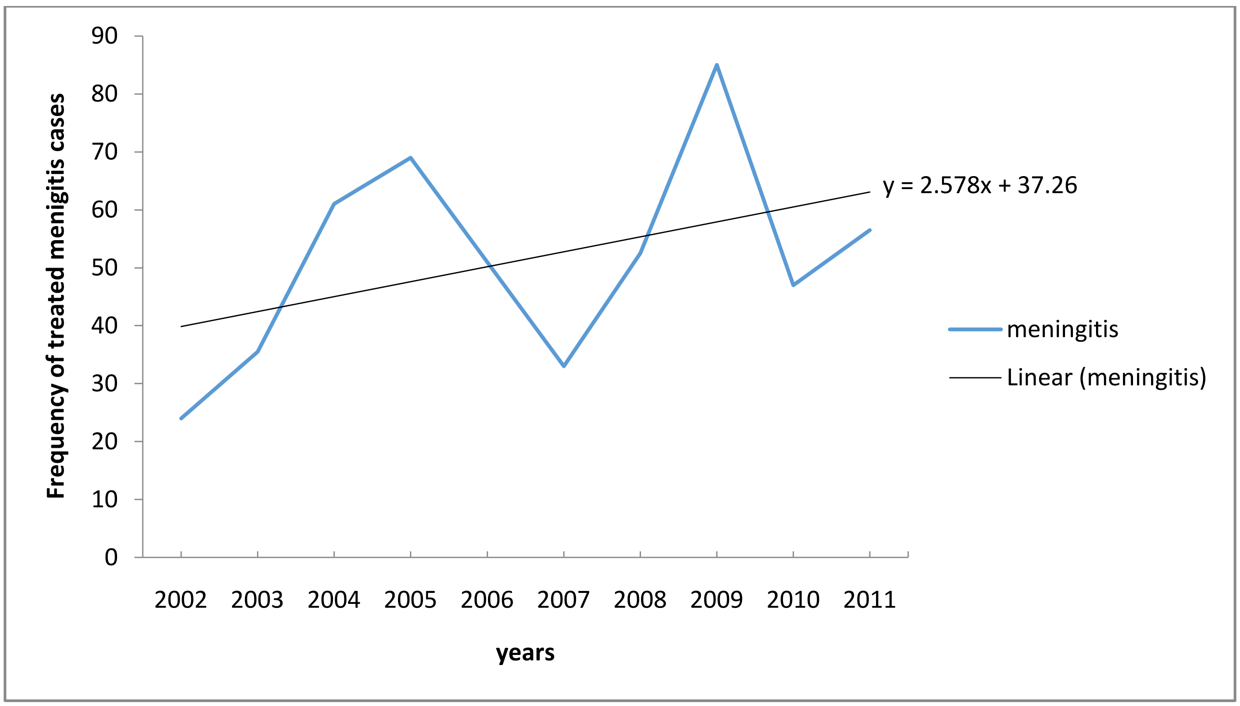


Figure 4.6: Trend in outbreak of Meningitis (2002 - 2011)

SOURCE: Field Survey, 2014

Figure 4.6 shows that the highest reported cases of 83 meningitis incidences were observed in 2008 and a low incidence of 23 cases in 2002. The recorded number of people that were treated for meningitis increased on average from year to year. This is observed from the slope of the trend line equation: $y = 2.578x + 37.26$. The low reported incidence cases of meningitis in 2007 was due to low temperatures and high rainfall recorded in the year and in the other hand, the high incidence of recorded cases of meningitis in the year 2009 was due to the high temperatures experience in the year.

4.4 Seasonal Occurrence of the Selected Diseases

The monthly (seasonal) reported cases of the three diseases under study are presented in this section

4.4.1 Monthly Reported Cases of the three diseases (2002)

The occurrence of the three diseases in 2002 are presented in figure 4.7

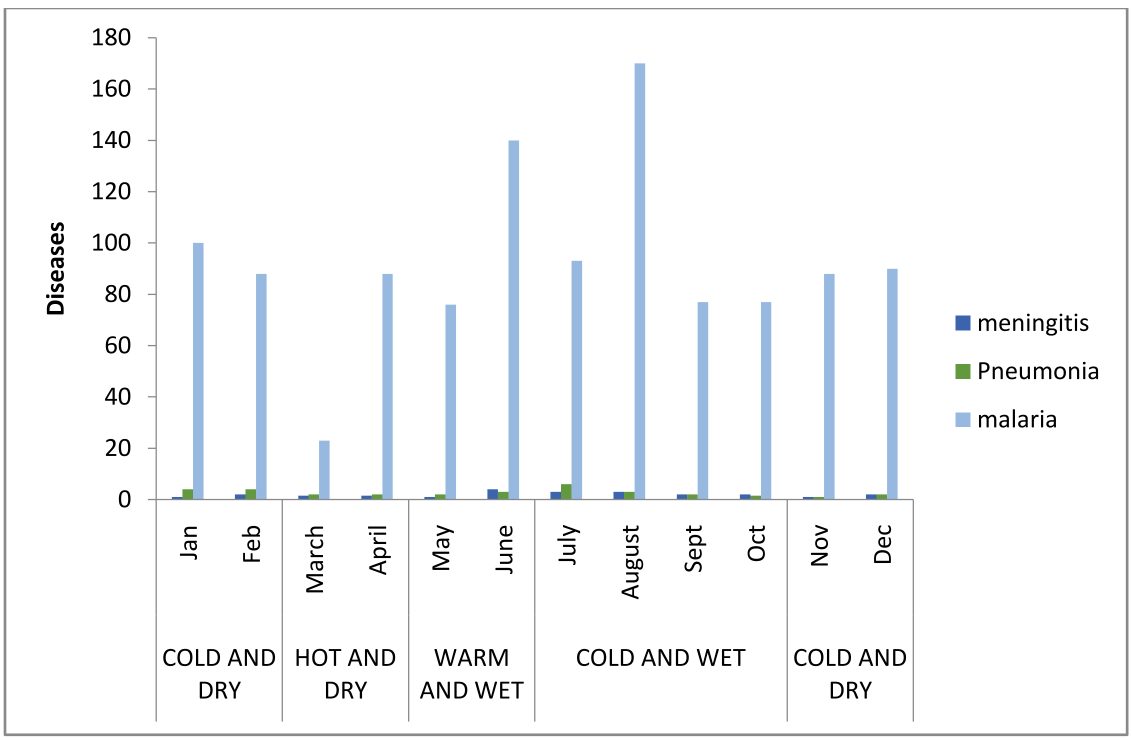


Figure 4.7: Reported cases of the three Diseases (January to December 2002)

SOURCE: Field Survey, 2014

Figure 4.7 revealed that the incidence of malaria is the highest reported cases throughout the year. It is also seen that the occurrence of pneumonia is higher than meningitis. The cold and wet season has the highest occurrence of malaria in 2002 with a total of 170 cases while the hot and dry season has the lowest incidence of malaria with 20 cases. Pneumonia is more prevalent during cold and wet season with about 20 cases in July, whereas it recorded low cases during hot and dry seasons. The incidence of meningitis in the other hand occurred more frequently during the warm and wet season with 7 cases and is lowest during cold and dry season.

4.4.2. Reported cases of the three diseases (2003)

The reported cases of the three diseases by season is presented in figure 4.8 for the year 2003

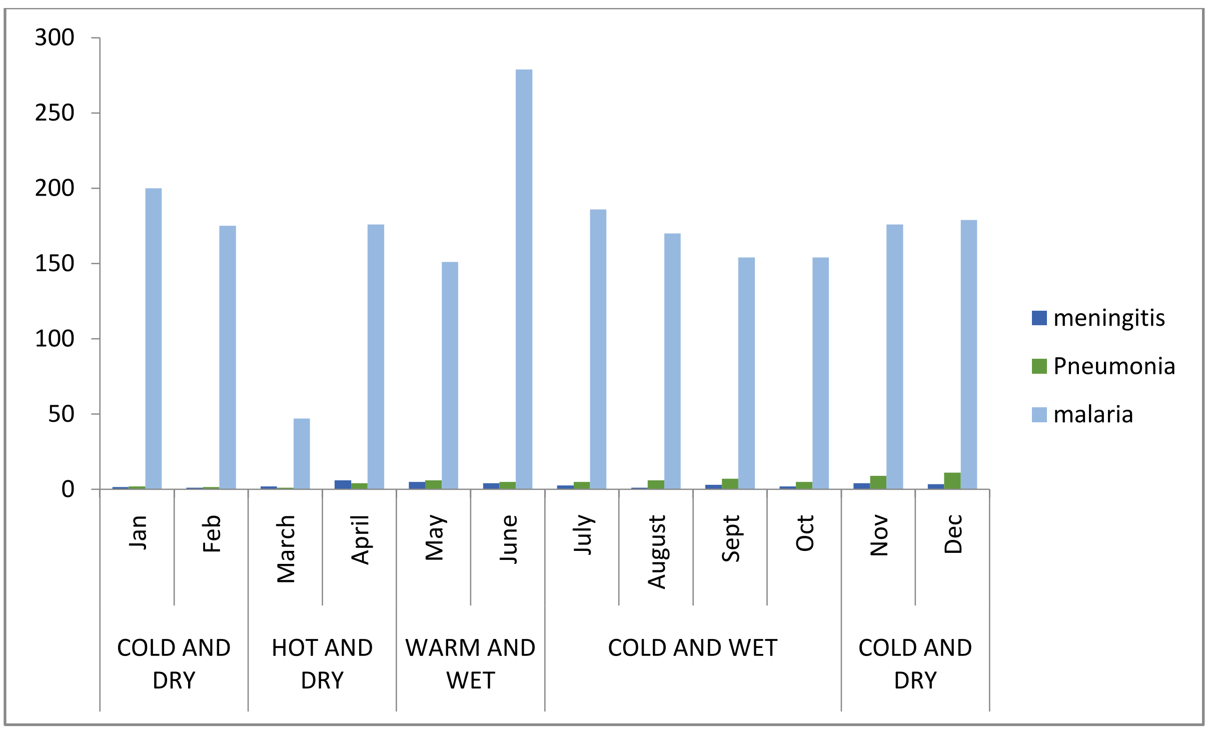


Figure 4.8: Reported cases of the three Diseases (January to December 2003)

SOURCE: Field Survey, 2014

Figure 4.8 shows that, in 2003 the reported cases of the diseases fluctuated but still having malaria incidence as the most prevalent reported disease. Throughout the year except for the month of June (280 reported cases). This presupposes that the reported cases of malaria were more prevalent during the warm and wet season due to high rainfall. Pneumonia is more prevalent during the cold and dry season with about 16 reported cases in December and its incidence was lowest in the hot and dry season with only one reported case in March. Meningitis in the other hand has the highest reported cases during the hot and dry season with about 5 reported cases in April and has the lowest frequency during the cold and wet season with only 2 reported cases in the month of August.

4.4.3. Reported cases of the three diseases (2004)

The reported cases of the three diseases in 2004 by season is presented in figure 4.9

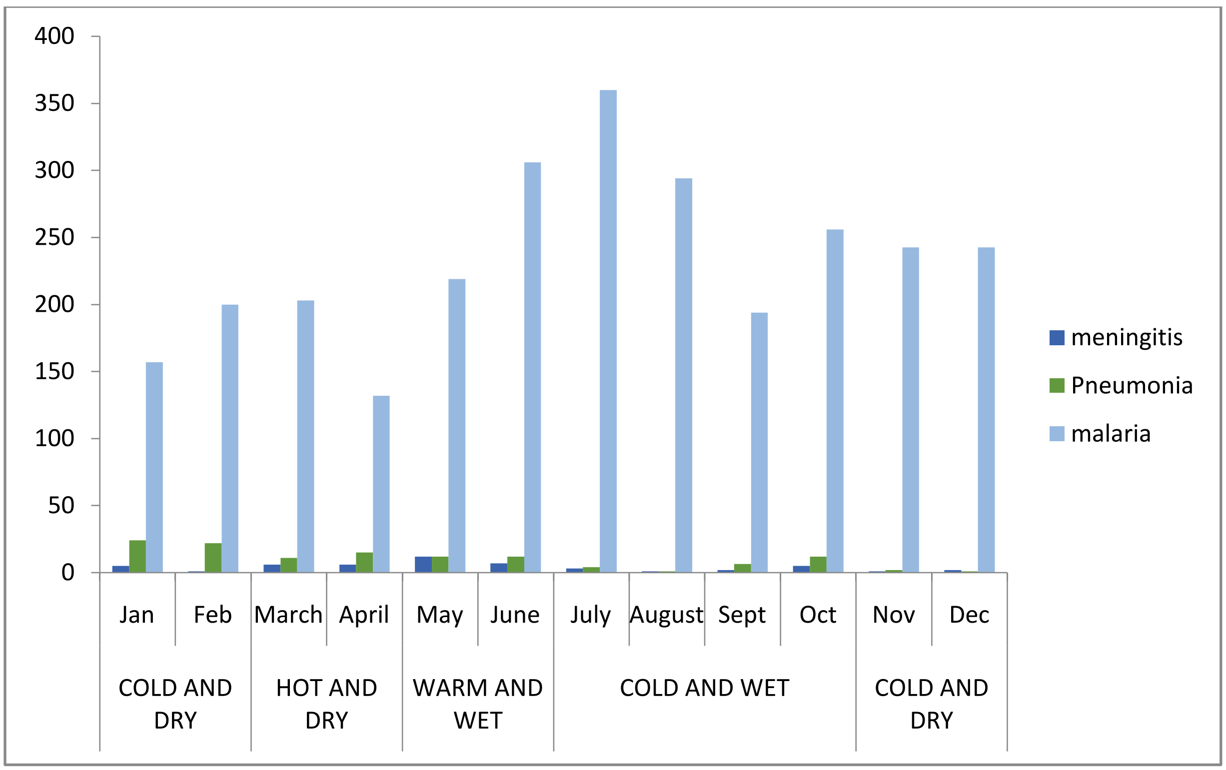


Figure 4.9: Reported cases of Three diseases (January to December 2004)
Source: Field Survey, 2014

Figure 4.9 shows that in 2004, malaria incidence occurred more frequently than the other two diseases having the highest frequency of reported cases during the warm and wet season with about 280 cases in June and is lowest during the cool and dry season with 80 reported cases in January. The occurrence of pneumonia is more prevalent during the wet seasons with 32 cases in April but reduces during the cool and dry season with 8 reported cases in the month of January. The reported cases of meningitis occurred more frequently during the hot and dry season with 10 cases in the month of May and its incidence is lowest during the wet and dry season with just one reported cases each in July and August.

4.4.4. Reported cases of the three diseases (2005)

The reported cases of the three diseases in 2005 by season is presented in figure 4.8.10

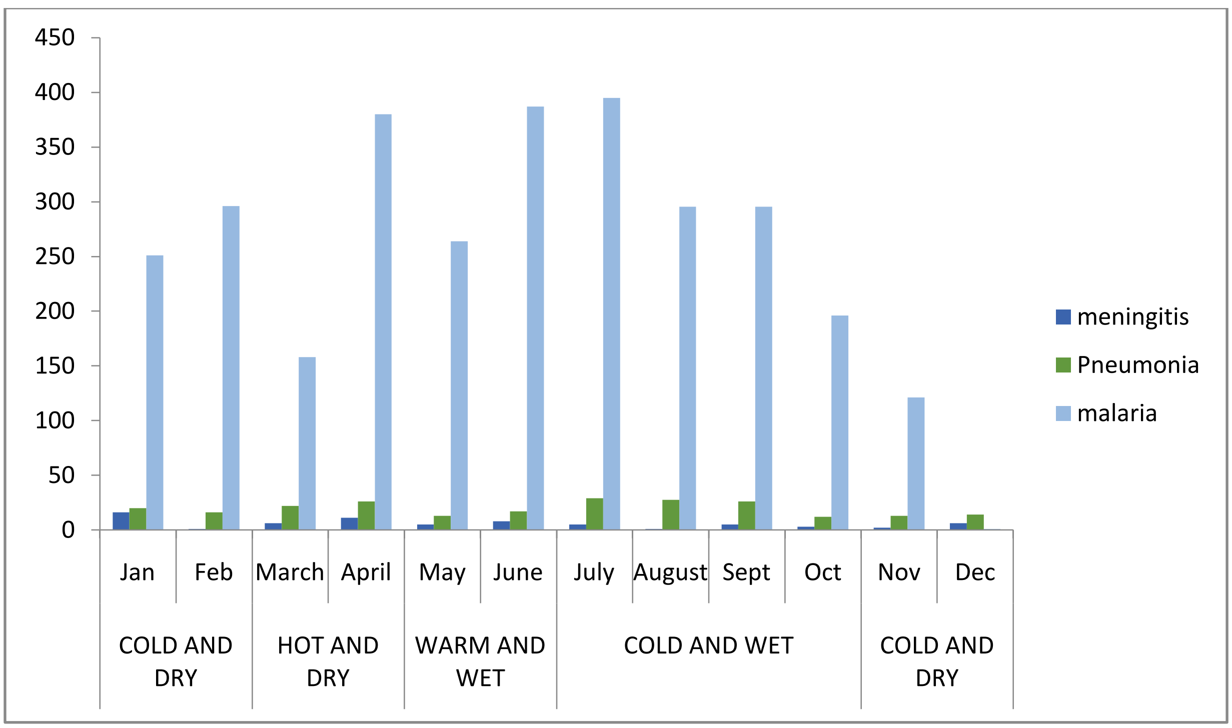


Figure 4.10: Reported Cases of the Three Diseases (January to December 2005)
Source: Field Survey, 2014

Figure 4.10 shows that in 2005, malaria occurrence is more prevalent during the cold and wet season with 390 reported cases in July and has the lowest reported cases during the cold and dry season with only 1 case in the month of December. Pneumonia incidence is more prevalent during the cold and wet season with 30 reported cases in the month of August but its incidence is lowest during cold and dry season with 13 reported cases in November. In the other hand, the reported cases of meningitis is more prevalent during the cool and dry season with 20 reported cases in January and is lowest during cold and wet season with only 1 reported case in August.

4.4.5. Reported Cases of the Three Diseases (2006)

The reported cases of the three diseases by season are presented in figure 4.11 for the year 2006.

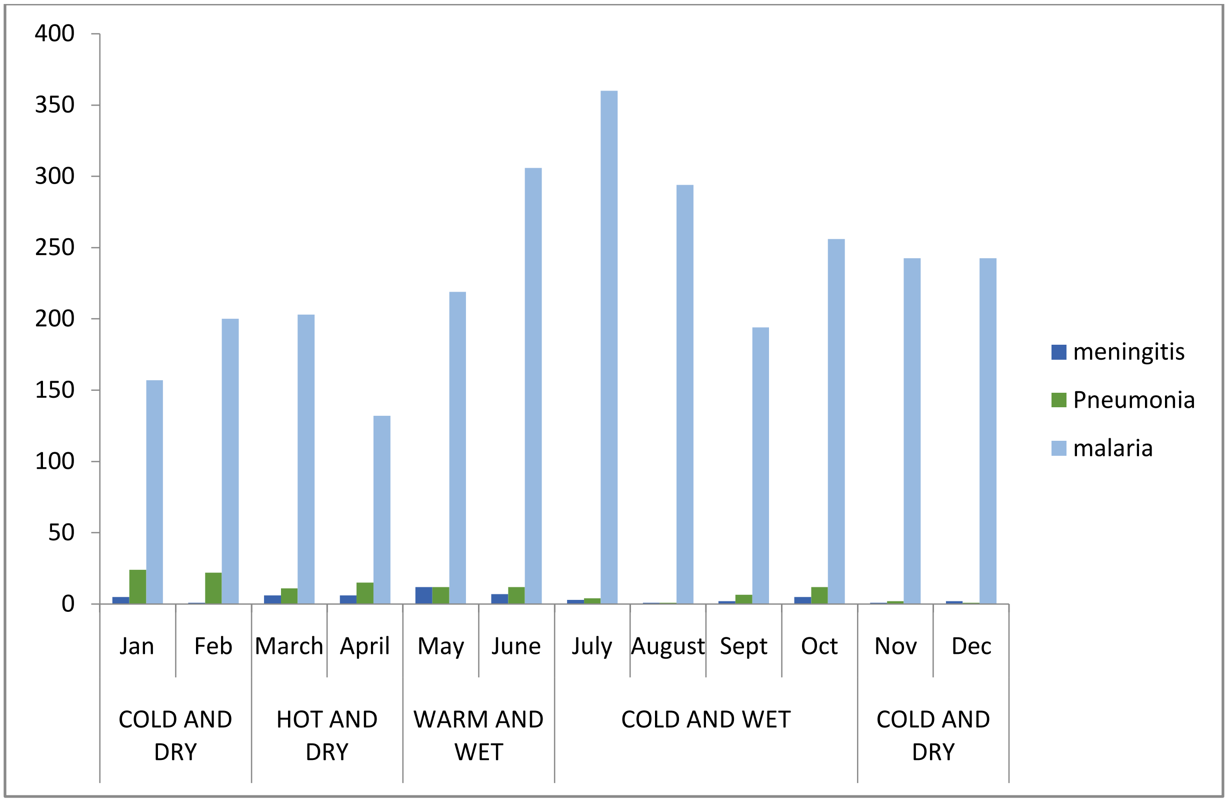


Figure 4.11: Reported Cases of the Three Diseases (January to December 2006)

SOURCE: Field Survey, 2014

Figure 4.11 shows that in 2006, malaria occurrence is more frequent during the cold and wet season with 350 reported cases in July and reduces during the hot dry season with only 120 reported cases in April. Pneumonia occurrence is more prevalent during the cold and dry season with the frequency of occurrence to be 30 in January and its incidence reduces during the cold and wet season with just 1 reported case in August. Meningitis occurrence is more frequent within the warm and wet season with the highest frequency of occurrence to be 17 in May that is when temperatures are higher and reduces during cold and wet season with 1 reported case in August.

4.4.6. Reported cases of the three diseases (2007)

The reported cases of the three diseases by season in 2007 are presented in figure 4.12

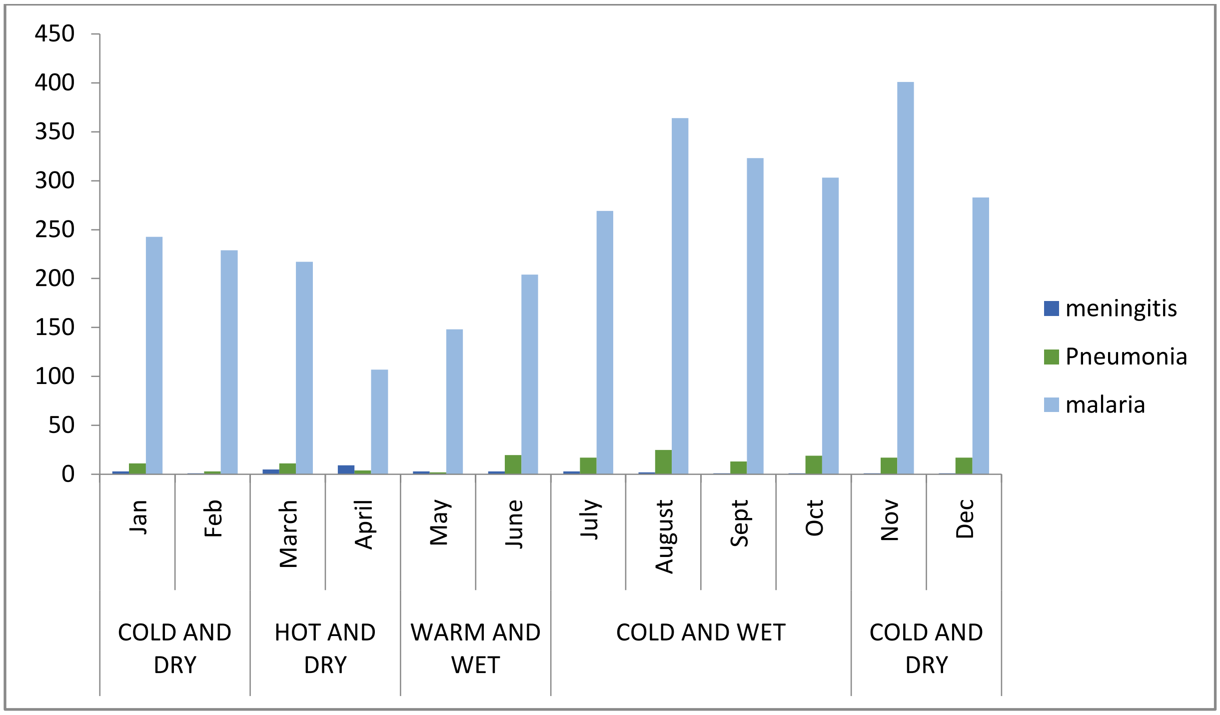


Figure 4.12: Reported Cases of the three Diseases (January to December 2007)

SOURCE: Field Survey, 2014

Figure 4.12 shows that in 2007, malaria is more prevalent during the cold and wet season but the highest reported case was observed in November with about 400 reported cases. The incidence of malaria is lowest during the warm and wet season with 105 reported cases in the month of April. Pneumonia occurred mostly during the cold and wet season with 27 reported cases in August and has the lowest incidence during the warm and wet season with only 1 reported case in May. Meningitis occurrence is more prevalent during hot and dry season with 9 reported cases in April and reduces during the cold and dry season with only 1 reported case in December.

4.4.7. Reported Cases of the Three Diseases (2008)

The reported cases of the three diseases by season are presented in figure 4.13 for the year 2008.

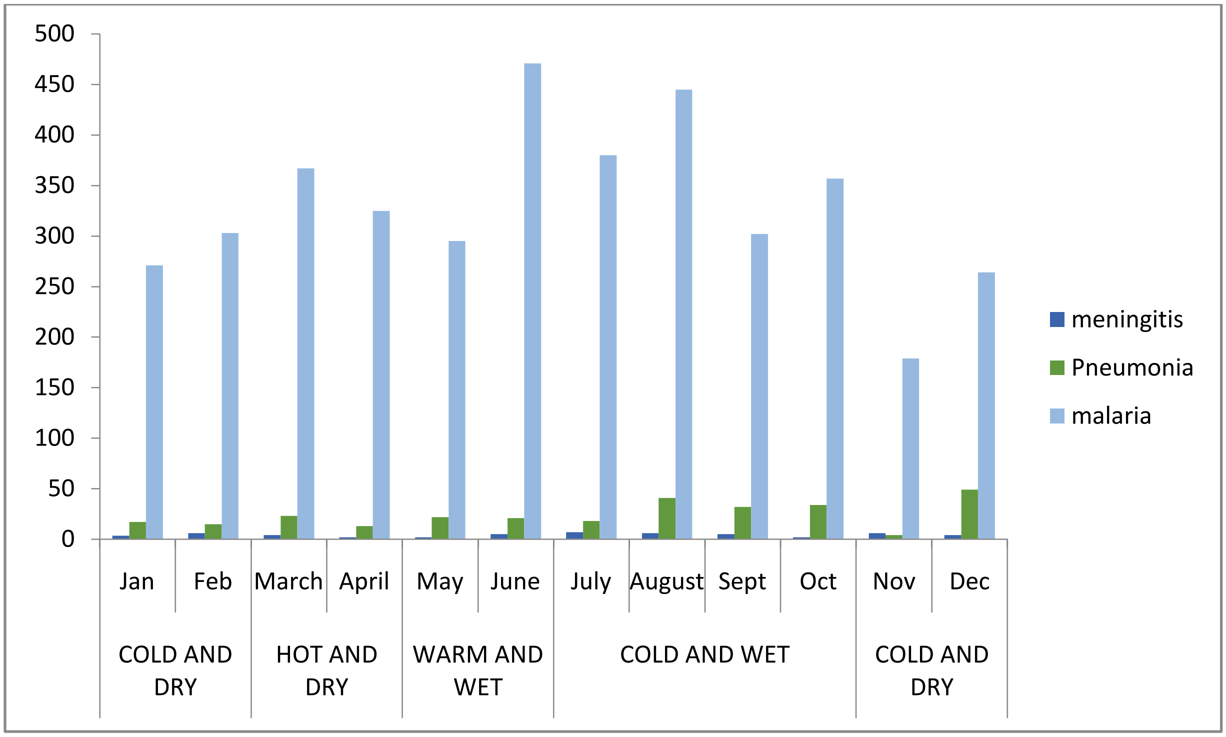


Figure 4.13: Reported Cases of the Three Diseases (January to December 2008)
Source: Field Survey, 2014

Figure 4.13 shows that in 2008, malaria incidence is the most frequent among the three diseases having the highest frequency of reported cases (475) during the warm and wet season and its incidence is lowest during the cold and dry season with 105 reported cases in November. The incidence of pneumonia is more frequent during the cold and wet season but the month with highest incidence is December with about 50 reported cases and reduces mostly during the hot and dry season with 12 reported cases in April. Meningitis incidence on the other hand is more prevalent during the cold and wet season with 10 cases in July and its occurrence is lowest during the warm and wet season with 3 reported cases in May.

4.4.8. Reported Cases of the Three Diseases (2009)

The reported cases of the three diseases by season in 2009 are presented in figure 4.8.14

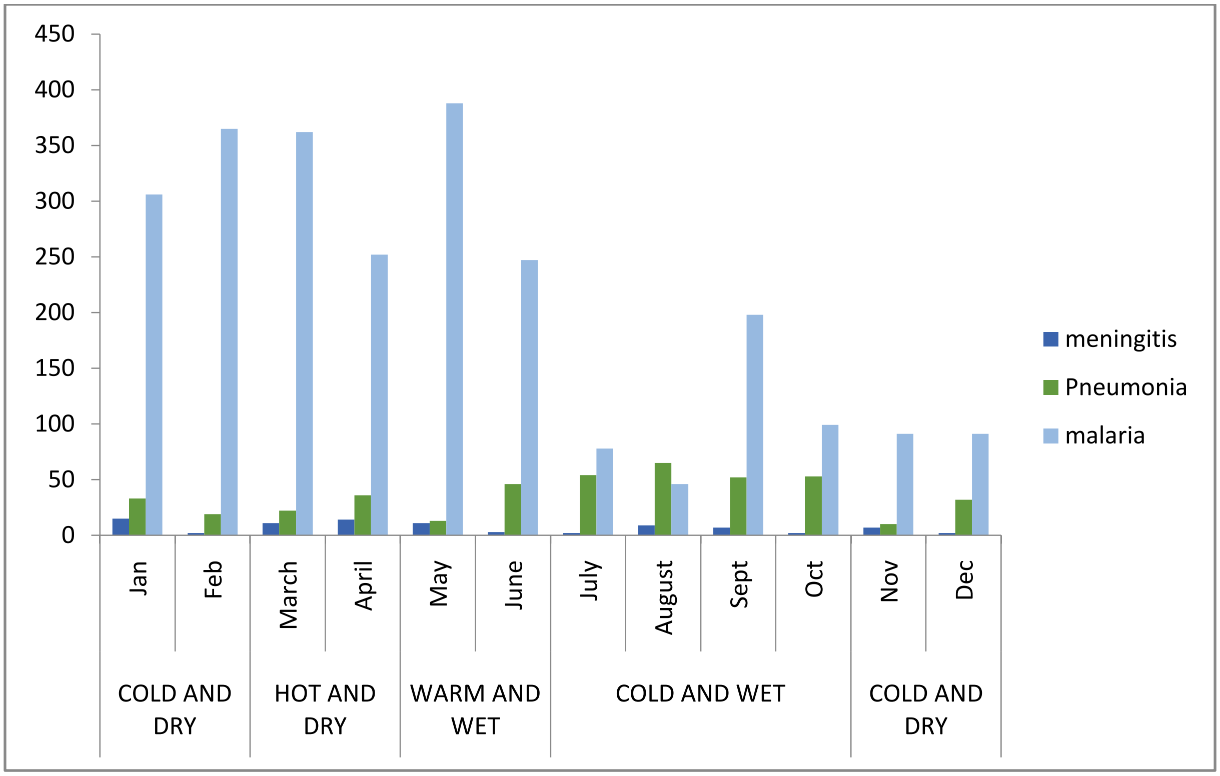


Figure 4.14: Reported cases of disease (January to December 2009)

SOURCE: Field Survey, 2014

Figure 4.14 shows that in 2009, malaria incidence is more prevalent during the warm and wet season with 390 reported cases in May and its incidence is lowest during the cold and wet season with 45 reported cases in August. The occurrence of pneumonia is more frequent during the cold and wet season with 70 cases in August and it has the lowest frequency of occurrence during the hot and dry season with about 21 cases in May. Meningitis occurred mostly during the hot and dry season with 22 reported cases in April and reduces during the cold and wet season with the frequency of occurrence to be only1 in July.

4.4.9. Reported Cases of the Three Diseases (2010)

The reported cases of the three diseases by season in 2010 are presented in figure 4.15

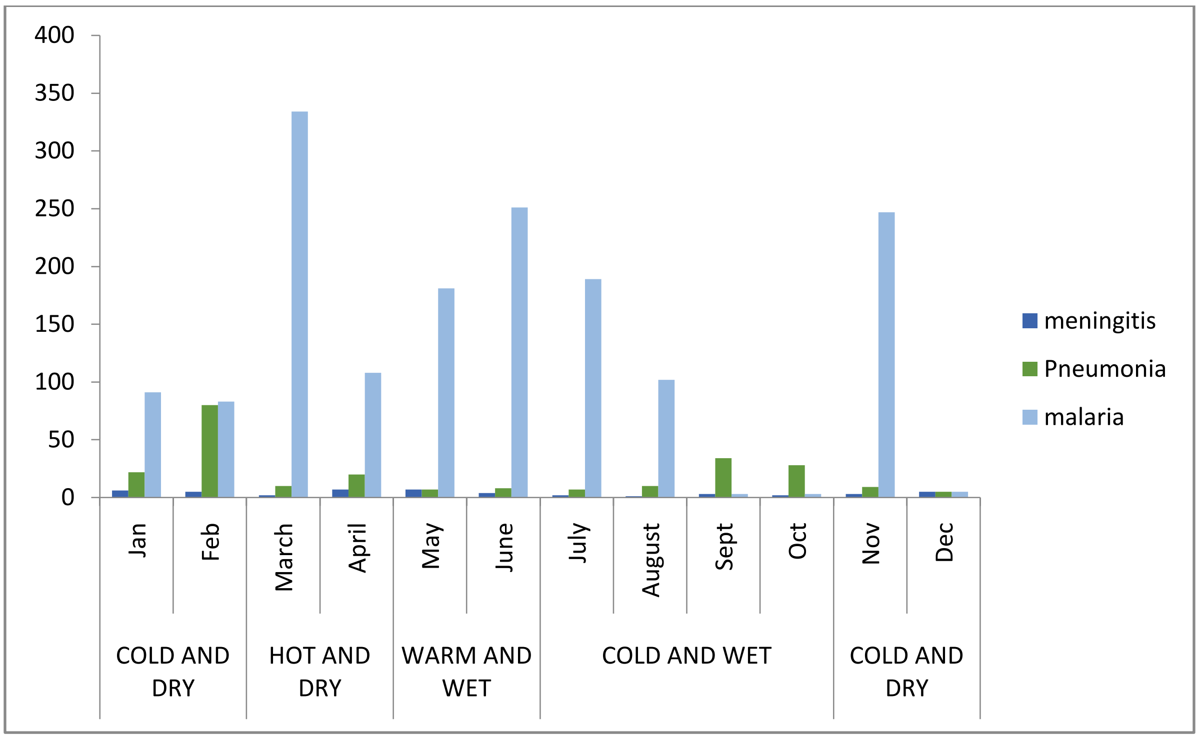


Figure 4.15: Reported Cases of the Three Diseases (January to December 2010)

SOURCE: Field Survey, 2014

Figure 4.15 shows that in 2010, the peak season for the incidence of malaria is during the hot and dry season with 330 reported cases in March and its frequency of occurrence is lowest during the cold and dry season with only 2 reported cases in December. The occurrence of pneumonia is more prevalent during the cold and dry season with frequency of 72 reported cases in February and has a lowest frequency of occurrence during warm wet season with about 2 reported cases in December. Meningitis occurred more frequently during the hot and dry season with 7 reported cases in April as the peak month and its incidence is lowest during the cold and wet season with only 1 reported case in August.

4.4.10. Reported cases of the three diseases (2011)

The reported cases of the three diseases by season in 2011 are presented in figure 4.16

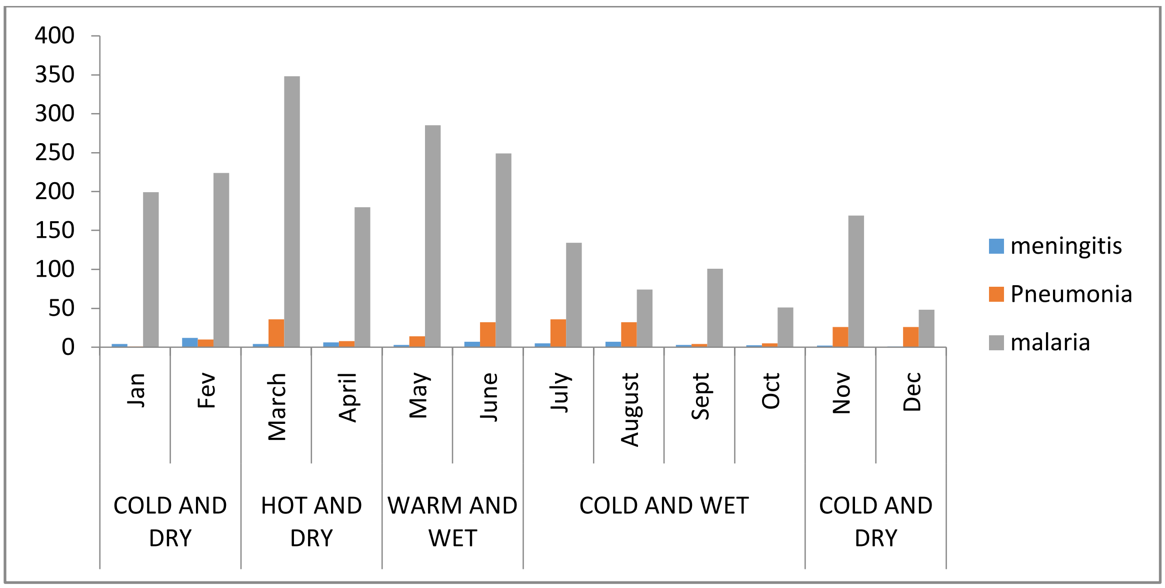


Figure 4.16: Reported Cases of the Three Diseases (January to December 2011)

SOURCE: Field Survey, 2014

Figure 4.16 shows that in 2011, the frequency of the occurrence of the reported cases of malaria is evenly distributed throughout the months of the year with about 5 reported cases in every month. Pneumonia incidence is more prevalent during cold and wet season with frequency of 37 reported cases in July and has the lowest incidence during the cold and dry season with 1 reported case in January. Meningitis incidence is more prevalent during the cold and dry season with peak month in February having a frequency of 12 reported cases and its occurrence is lowest during the cold and wet season with only 3 reported cases in October.

4.4.11. Reported cases of the three diseases (2002-2011)

The reported cases of the three diseases by season 2002- 2011 are presented in figure 4.17

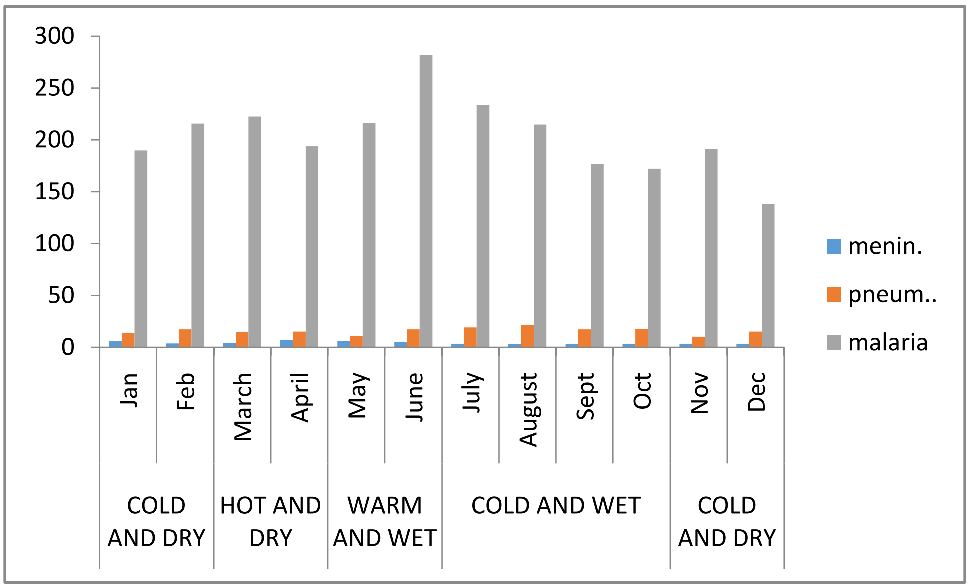


Figure 4.17: Reported Cases of the Three Diseases from 2002- 2011

SOURCE: Field Survey, 2014

Figure 4.17 shows that the average reported cases of malaria from 2002-2011 is more prevalent during the warm and wet season and cold and wet season (rainy season) with the highest recorded cases of 282 in June and its occurrence is lowest during the cold and dry season with 138 reported cases in December. Pneumonia in the other hand is more prevalent during the warm and wet season and has a frequency of 21 reported cases in August and its incidence is lowest during the cold and dry season with 10 reported cases in November. Meningitis incidence is more frequent during the warm and wet season with 7 reported cases in April and its occurrence is lowest during the colds and dry season with only 3 reported cases in December.

4.5 Relationship between the Selected Climatic Parameters and the Incidence of Malaria, Meningitis and Pneumonia in Jos North LGA

To establish the relationship between the selected weather parameters and the selected diseases in the in the study area, the ordinary least square estimate of the multiple regression was used.

4.5.1 Relationship between Malaria and Climatic Parameters

The ordinary least square estimates of the multiple regression model for the relationship between malaria and the climatic parameters namely temperature, rainfall and humidity is presented in Table 4.1.

Table 4.1: Relationship between Malaria and Climatic Parameters in Jos North LGA

Variables	Coefficient	Standard Error	T-Ratio	P-value
Constant	478.64	124.58	3.84	0.001
Temperature	-11.35	4.91	-2.31**	0.02
Rainfall	0.42	0.16	2.65**	0.01
Humidity	-0.77	0.41	-1.86*	0.07
Model Fitness				
R-Square	0.11			
F-Statistic	4.49			0.01

Source: **Field Survey, 2014**

Note: ** and * = Significant at 5 and 10% Level of Probability respectively

The Fisher statistic (F-statistic) was estimated to be 4.49 with a P-value of 0.01 which represents the true probability of rejecting the null hypothesis of no relationship. The P-value being less than the hypothesized one of 0.05, the output showed that the combined effect of temperature, rainfall and humidity was significant at 5% level of probability. This therefore means that the null hypothesis which states that there is no significant relationship between the diseases and the weather parameters is rejected and the alternative hypothesis which states that there is significant relationship between the diseases and the weather parameters is accepted. In other words, there is a significant relationship between malaria incidence and the climatic parameters. However, the variation in the reported cases of malaria which is explained by these factors was low since the coefficient of determination was found to be 0.11. That is, only 11% of the variation in the incidence of malaria was due to the climatic parameters. This implies that other factors accounted for the 89% causes of malaria in Jos North LGA of Plateau state. These factors could include poor drainages, presence of ponds arising from tin mining, indiscriminate refuse dumps and the cultivation of crops around residential areas which to a large extend serve as a breeding ground for mosquitoes thereby enhancing the incidence of malaria in the study area.

The individual effects of the climatic parameters were found to be significant. Temperature and humidity were found to be negatively related at 5 and 10% level of probability to malaria incidence while rainfall was found to be positively related at 5% level of significance to malaria cases. Omotosho and Akinbobola (2004) carried a research on the relationship between meteorological variable and the incidence of malaria in Kaduna, Akure and Ikeja and found also that that malaria has a positive relationship with rainfall. In the other hand, Ogbaji (2006) discovered that there is positive relationship between temperature and malaria outbreak in Zaria. According to the result, one unit increase in temperature which in this case is 1^{o}c will cause about 11 persons to be malaria free while any 10 units increase in humidity which in this case is 10% will cause about 8 persons to be malaria free. In the other hand, any 10 units increase in rainfall which in this case is 10mm will increase the number of people suffering from malaria by about 4.

4.5.2 Relationship between Pneumonia and Climatic Parameters

The ordinary least square estimates of the multiple regression models for the relationship

Between Pneumonia and the climatic parameters are presented in Table 4.2.

Variables	**Coefficient**	**Standard Error**	**T-Ratio**	**P-value**
Constant	6.77	5.39	1.26	0.21
Temperature	0.18	0.21	0.85	0.4
Rainfall	0.03	0.01	3.66***	0.003
Humidity	-0.05	0.02	-2.81**	0.01
Model Fitness				
R-Square	0.15			
F-Statistic	6.51			0.0004

Source: Field Survey, 2014

Note: *** and ** Significant at 1 and 5% Level of Probability respectively

Based on the null hypothesis of no relationship between pneumonia incidence and the climatic parameters, the F-statistic was estimated to be 6.51 with a P-value of 0.0004. The P-value being less than the hypothesized value (0.01), the output showed that the combined effect of temperature, rainfall and humidity was significant at 1% levels of probability all things being equal. In other words, there is a significant relationship between Pneumonia and the climatic parameters. However, the variation in the reported cases of Pneumonia which is explained by these climatic parameters was low since the coefficient of determination was found to be 0.15. That is, only 15% of variation in pneumonia was due to the climatic parameters. This again shows that other factors apart from the climate parameters might be responsible for the occurrence of pneumonia in the study area. These factors may include poor housing condition, wearing of light clothes during cold days, emission of toxic waste from industries and poor nutrition as pointed out by Adebayo (2001).

Two climatic parameters out of the three under study were found to be significantly related to Pneumonia incidence. Rainfall was positively related to Pneumonia incidence at 1% level of probability while humidity was found to be negatively related to the reported cases of Pneumonia at 5% level of probability. Temperature was positively and insignificantly related to Pneumonia incidence since its P-value was found to be greater than 0.05. In other words, temperature was not an important predictor of Pneumonia cases in the study area over the period of study. A research carried out by Oluleye and Akinbobola (2010) on the role of temperature and rainfall on the incidence of pneumonia and malaria in Lagos has also shown that rainfall relate positively to malaria whereas temperature has a negative relationship with pneumonia.

Considering the individual effect of the significant climatic parameters on the reported cases of pneumonia, it can be noted that any 100 units increase in humidity which in this case is 100% will cause about 5 persons to suffer from Pneumonia. In the other hand, any 100 units increase in rainfall which in this case is 100mm will increase the number of people suffering from pneumonia by about 3. In the same manner, 10^{o}c increase in temperature will cause about 18 more people to suffer from Pneumonia in the study area.

4.5.3 Relationship between Meningitis and Climatic Parameters

The ordinary least square estimates from the multiple regression models for the relationship between meningitis and the climatic parameters are presented in Table 4.3.

Table 4.3: Relationship between Meningitis and Climatic Parameters in Jos North LGA

Variables	Coefficient	Standard Error	T-Ratio	P-value
Constant	0.21	0.09	2.35**	0.02
Temperature	0.01	0.003	2.98***	0.004
Rainfall	-0.02	0.01	-2.42**	0.02
Humidity	-1.50	2.23	-0.67	0.50
Model Fitness				
R-Square	0.15			
F-Statistic	6.41			0.0005

Source: Field Survey, 2014.

Note: *** and ** = Significant at 1 and 5% Level of Probability respectively

F-statistic was estimated to be 6.41 with a P-value of 0.0005. The P-value being less than the hypothesized value of 0.01, the result showed that the combined effects of temperature rainfall and humidity were significant at 1% levels of probability all things being equal. In other words, there is a significant relationship between the occurrence of meningitis and the climatic parameters. Therefore the null hypothesis which states that there is no relationship between the incidence of meningitis and weather parameters is rejected. However, the variation in meningitis incidence which is explained by these factors is low since the coefficient of determination was found to be 0.15. That is, only 15% of variation in meningitis is due to the climatic parameters. Other factors which may account for the 85% causes of meningitis in the study area include poor housing condition especially in areas like Unguwan Rogo, Unguwan Rimi, Tudun wada, Gada Biyu, Dilimi and Gangare all in Jos North LGA, poverty and refusal to be vaccinated against meningitis due to ignorance.

Two climatic parameters out of the three under study were found to be significantly related to meningitis outbreak. Rainfall was negatively but significantly related to incidence of meningitis at 5% level of probability while temperature was found to be positively and significantly related to the reported cases of meningitis at 1% level of probability. Humidity was negatively but insignificantly related to meningitis since its P-value (0.5) was found to be greater than 0.05. In other words, humidity was not an important predictor of Pneumonia in the study area over the period of study.

Regarding the individual effects of the significant climatic parameters on meningitis, it can be noted that 100 units increase in temperature which in this case is 100^{o}c, will cause about 1 person to be Pneumonia free. In other hand, any 100 units increase in rainfall which in this case is 100mm will reduce the number of people suffering from pneumonia by about 2 in the study area. Studies by Adebayo (2001), Akinbobola and Omotosho (2004) and Sawa and buhari (2011) also revealed that meningitis has a negative relationship with rainfall but it is positively related to temperature. That is increase in temperature will trigger more incidence cases of meningitis.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This chapter is concerned with the summary of this research work. Furthermore, conclusion and recommendations are made based on the research findings.

5.2. Summary

This research work focused on the role played by weather elements on the occurrence of malaria pneumonia and meningitis in Jos North local government area of Plateau state. The period of ten years (2002-2011) was used for the study.

To achieve the aim and objectives stated in this study, the weather parameters (maximum and minimum temperatures, rainfall and relative humidity) and in and out-patients treated for malaria, pneumonia and meningitis were collected for the period of ten years (2002-2011). The daily records of both climatic elements and patients treated for the diseases in this study were summed up to obtain the mean monthly and annual records which were used in the research.

The trends in the weather elements showed that temperature increase from year to year. For example, the mean annual temperatures for the year; 2002, 2003 and 2011 are 23.8°C, 24.2°C and 24.8°C respectively. The trends in rainfall have indicated a decline in the total amount of rainfall throughout the period of the study. Forinstance, the total annual rainfall for the year in 2002, 2005 and 2007 and 2011 are respectively 1350mm, 1150mm, 450mm and 1200mm. Humidity just like rainfall trended negatively. That is humidity has been declining from year to year. From the data collected the records for relative humidity for 2002, 2004, and 2011 are 680g/m, ^{3} 570g/m^3 and 550g/m^3 respectively. The trend in the occurrence of the diseases has shown that, Malaria incidence exhibit a negative trend that is malaria increase from year to year. For example the recorded cases of malaria incidences for the year 2002, 2003 and 2011 are 2400, 1980 and 60 respectively. In the other hand, pneumonia and meningitis all exhibit positive trends that is, they have been increasing from year to year. Forinstance, the number of reported cases of pneumonia incidence for the year 2002, 2003, 2004 and 2011 are respectively 30, 50, 230 and 250. In the same manner, the reported incidence cases of meningitis for the year 2002, 2003 and 2011 are 24, 35 and 45 respectively. This means that the number of reported cases of pneumonia and meningitis have been increasing from one year to another.

The ordinary least square model was used to determine the relationship between the weather elements and disease and how much of the variation in the occurrence of the three diseases is accounted for by the climate parameters. The result showed that whereas malaria has a positive relationship with rainfall, its relationship with temperature and relative humidity is negative. That is, increase in rainfall parameter lead to increase in the incidence of malaria.

Pneumonia shows a positive relationship with rainfall and a negative relationship with relative humidity. That is increase in rainfall will lead to increase in incidence of pneumonia in the other hand increase in relative humidity lead to decrease in the incidence of pneumonia. Pneumonia has a positive relationship with temperature although its relationship is a weak one.

Meningitis shows no strong relationship with relative humidity but with rainfall and temperature. Whereas rainfall has a negative relationship with meningitis, temperature has a positive influence in the incidence of meningitis. That is, increase in temperature will trigger more incidence of meningitis and in the other hand, increase in rainfall lead to decrease in the incidence of meningitis.

Malaria is a disease that occurs almost throughout the year but its incidence is higher during rainy season, this is because the water collected in ponds during rainy season serves as a breeding ground for mosquitoes and consequently leading to high incidence of malaria. Pneumonia has a higher incidence in the rainy season as compared to dry seasons. In the rainy season, Jos North LGA experience low temperatures and high rainfall damned air which favours the high incidence of pneumonia. Meningitis occurs mostly in the hot seasons when temperatures are high. Hot and dry season usually favours the multiplication and activities of the bacteria and virus that cause meningitis.

5.3 Conclusion .

From the research carried out, it was discovered that the weather elements have significant relationship with the diseases selected in this study. Thus, it can be said that the weather elements in Jos North LGA play a role in the incidence of diseases especially, malaria pneumonia and meningitis. Hence, climatic factors are important and should be considered along with other factors in mitigating the spread of common diseases such as malaria, pneumonia and meningitis.

5.4 Recommendations

The trend in weather elements and the diseases have been determined. Furthermore, the relationship between the diseases and the weather elements has been established. The result of the research findings indicated that only 11 – 15% of the incidence of the diseases are accounted for by the weather parameters and this implies that other factors such as indiscriminate refuse dump, poor drainage construction, refusal to take vaccines due to ignorance, poor housing condition, poverty, poor nutrition and toxic waste account for the for the outbreak of the selected diseases in the study area. There is therefore a need for recommendations to be made to suggest preventive strategies for both current and future planning purposes.

1. Individuals in the study area should identify what seasons of the year they are more susceptible to a particular diseases to enable them take precautionary measures. Forinstance, those who are more susceptible to malaria during the rainy season should encourage the use of treated nets and preventive drugs to minimize or avert the incidence of malaria. Similarly, those that are more susceptible to pneumonia during cold and wet season should put on thick clothes so as to prevent or reduce the incidence cases of pneumonia. In the same manner, those that are more prone to meningitis during the warm and wet season should endeavor to allow cross ventilation in their rooms and should not avoid taking vaccines against meningitis at this particular season in order to avert the high occurrence of it in the study area.
2. This study has revealed that malaria showed a positive relationship to rainfall in the study area. This is because the rain water that collect into ponds and crops grown around residential areas serve as breeding grounds for mosquitoes threby enhancing the spread of malaria. The government and individuals should therefore construct drainages in and around houses so as to drain the rain water in order to discourage the breeding grounds for mosquitoes and other vector – borne diseases. Moreso, cultivation of crops around residential areas should be discouraged.
3. This study has also revealed that temperature relate positively to meningitis in the study area. That is, increase in temperature trigger more incidence cases of meningitis. To minimize the incidence cases of meningitis will therefore mean taking measures that will reduce high temperature in the study area. These measures will include planting of trees and grasses around houses and in open spaces. Furthermore, nature of buildings that

encourage high temperatures such as building with small undersized window or no window at all should be discouraged as this will increase room temperatures thereby promoting the activities of vectors that transmit meningitis. In addition, high walled fences should be discouraged since the walls not only prevent the flow of air but also store heat thereby increasing the temperature.

4. It has been established in this study that weather elements affect the incidences of malaria, pneumonia and meningitis in the study area. I therefore recommend that timely weather forecasting for; temperature, rainfall and humidity should be conducted regularly in the study area. This will give the people insight as to which disease incidence will be higher and how to cope or adopt precautionary measures and to as well help health planners in the locality to know which drugs or vaccines that should be made available on time so as to mitigate the effects of weather on diseases incidence.
5. This research studied the role of weather on the incidence of diseases in Jos North L.G.A, Plateau State but has not discussed human perception on the effects of weather on human health. I therefore recommend that a study should be carried out on human perception on the effect of weather on the occurrence of diseases in the study area. Also, a study on the role of weather on diseases occurrence that will use mathematical model to predict future occurrence of the diseases in the study area should also be carried out.

REFERENCES

Adams, S. (2000). Environmental impact of tin mining on the Plateau. *A journal of contemporary legal issues.* Vol 4; pp 1-2000.

Adebayo, A.A. (2001). Temperature variability and outbreak of measles and meningitis in Yola, Nigeria. *Global Journal of Applied Sciences.* 7 (1), pp 133-135.

Adefolalu, A and Omotosho, J.B. (2004). The relationship between meteorological variable and climatic sensitive diseases in some selected stations. Lecture series. Department of meteorology, Federal University of Technology, Akure, Lagos

Akinbobola, A and Omotosho, J.B. (2004). The relationship between meteorological variables and some common diseases in some selected stations. Department of meteorology, Federal University of Technology Akure, Nigeria.

Ati, O.F (2002). Understanding Basic Climatological Terms. Pistevo Publishers, Orlando, USA.

Ayoade, J.O. (1983). Introduction to Climatology for the Tropics. John Wiley and Sons, New York, pp 297.

Ayoade, J. O (1988). Tropical Hydrology And Water Resources 1st Edition Macmillan Publishers, London and Basingstoke

Barbour, K.M. (1982). Human Diseases and Health Facilities In: Barbour, K.M., et al, (Eds), Nigeria in Maps. Hodder and Stoughton, London, pp: 54-55.

Barnett, T.P; D.W. Pierce and R. Schnur (2001). Detection of anthropogenic climate change in the world's ocean. *Science*, Vol:292 pp 270-274.

Basil, B (1977). Statistics in Geography: A Practical Approach. J.W Arrowsmith Ltd, pp74- 105.

Benzer, M. (2009). Weather and our health.http://www.bbc.co.uk/weather. Retrieved June, 2011.

Bernard, S.M; J.M. Samet; K.L. Ebi and I. Romieu (2001). The potential impacts of climate variability and change on air pollution and related health effects in the United States. *Enviromental health perspective*, Vol: 109 pp 199-210\

Better Health Channel (2010). Does the weather affect asthma? Is it better to live a warm climate? http:www.pub med central. nih.gov/articlerender.f.c.gi? Retrieved 23-07-2001

Centre of Diseases Control (2008). Climate change and public Health http://www.cds.gov/climatechange/effects/default .html. downloaded June,2011.

Chen, A. A. and Taylor, M. A. (2002). Investigating the link between early season caribean rainfall and the EL Nino + 1 year. *International Journal of Climatology*, 22, PP 87 – 106.

Climate and Health Resources Room (CHRR, 2008). Climate and Malaria/Meningitis in Africa. http/www.irillideo.columbia.Edu/maproom/health/Regional/Africa/malaria. Retrieved June, 2011.

Colwell, R.R (1996). Global Climate and Infections Diseases the Cholera Paradigm. *Science*, vol. 274, No. 5295, Dec 20 pp 2025- 31

Duncan, J.W.K. (1996). In: Sofoluwe,G.O; Schram, R; Ogunmekan, D.A.(eds)(1996). Environmental Health Principles, Planning for Healthy Housing in Principles and Practice of Public Health in Africa. Vol 1, 2nd Edition.

Ebi, K.L, Benard,S.M; Epstein, P.R; Rose,J,B; Paul, R,E; Erin, K,L; Benjamin, H.S (2004). Weather changes associated with hospitalizations for cardiovascular diseases and stroke in California, 1983-1998. *Int J. Biometeoroly* 49: 48-58.

Ericsson, C. (2010). How Does Our Cold Weather Affect Your Health. http://www.usatoday.com/weather/health/wealth.htm. Downloaded June,2011.

Grambsch, A; Gubler, D.J, Recter, P; Romieu, I, Rose, J.B., Samet, J. M and Titani, J. (2000). The potential health impacts of climate variability and change for the united states; executive summary of the report of the health perspectives vol.1 N0.4.

Griffin, D.W; V. Garrison; E.A. Shinu (2001). African dust in the Caribbean atmosphere; Microbiology and public health. *Aerobiologia*,Vol: 203-213.

Griffiths, J.F. (1976). Applied climatology: An introduction 2nd edition.

Gubler, D.J., Paul, R., Kristie L.E., Wendy. Y., Roger, N; and Jonathan, A.P. (2001). Climate variability and change in the united states: potential impacts and change and Rodent-borne Disease. *Environmental Health Perspectives*, vol. 109, pp. 223-233.

Haines, A, Kovats, R.S, Cambell-Lendrum, D and Corvalan, C (2006). Climate Change and Human Health: Impacts, Vulnerability and Public Health. Public Health 2006. Vol 120 pp 585-596.

Hansen, J and Beltina, M (2006). AIGAP – Analysis for the implementation of the Global climate. Observing System Programme in Africa, 2006.

Hensel, H. (1979). In: Fanger, P.O. and Valbjourn, O.(eds)(1979). Thermoreception and Human Comfort “in INOOR CLIMATE, Effect on Human comfort, performance and Health in Residential, Commercial and Light Industry Building.

Ilemona, J.O. (1983). A Prospective Study of Pneumonia in Under 5 as seen in A.B.U T.H, Zaria. An undergraduate dissertation, Department of Medicine, Ahmadu Bello University, Zaria.

Iloeje, N.P. (1981). A new geography of Nigeria. New revised edition, Longman Nigeria Plc. pp 21-31.

Inter-Governmental Panel for Climate Change (2001). Climate change: The scientific Basis third Assessment Report, Cambridge University press, Cambridge, UK, 1 – 944.

Inter-Governmental Panel for Climate Change (2007). Energy and Health Policy. United Nations Report, Nov. 1990, WMO, Geneva, Switzland.

Jonathan, A. P, Diarmid C. L., Tracey H, Jonathan A. F (2005). Impact of Regional Climate Change on Human Health. *Nature, Rev* . Vol 10 pp 438- 1038.

Kaplan, M (2009). Biometeorology: it may be the weather, not just in your head. http:www.weather.com, aches and pains.

Kenneth, L; Thomas, R; Rebecca, J and Edward, B (2008). Climate and vector- borne diseases. *American Journaj of Preventive Medicine.* Vol 35 (5), pp 436-450.

Lindsay, S.W and M.H. Birly (1996). Climate Change and Malaria transmission, *Annals of Tropical Medicine and Parasitology,* vol. 90 No.6, pp. 573-88

Lipp. E.K. Huq. A and colwell R.R (2002). Effects of Global Climate on Infections Diseases: The Cholera Model “Clinical Microbiology Reviews, vol. 15, No. 4, October, pp. 757-770. http://www.mbio,ncsu.edu/SL/MB590790/Cholare/cholera.pdf. downloaded June,2011.

Luber,T and prudent, D (2009). Climate Change and Human Health. *Transactions of the American clinical and Climatological Associatio*n, vol. 120, 2009.

Martens, W.J.M, Spoof, R and Jackson, E.K (1997). Climate Change and Human Health and Sustainable Development, *a Bulletin of the World Health Organization*, 1997, 75(6): 475-488

Mathew B. (2005). Weather and Your Health USATODAY, a Division of Gannet Co. inc.

McMichael, A.J, Patz, Jand Kovats, R.S (1989). Impacts of Global Environmental change on Future Health and Health Care in Tropical Countries. *British Medical Bulletin*, 1998, 54 (No.2): 475-488.

McMicheal, A, Githeko, R; Aktitar, R; Carcavalo, D; Gubler, A; Haines, R.S; Kovats, P; Martens, J; Patz, A and Sasaki (2001). Human health in J.J. McCarthy (2001), Climate Change: Impacts and adaptations and vulnerability. Pp 157-538.

Miller,R (1977). Malaria in Infections Disease; a Modern Treatise of Infectious processes 2nd Edition by Hoeprich, P.D Published by Harper and Row Publishers, Inc.

Minakawa, N; Munga, S; Atieli, F; Mushinzamana, E; Zhou, G; Githeko, A.K and Yau, G. (2005). Spatial distribution of anopholine laval habitats in Western Kenyan highlands. *American Journal of Tropical Hygiene*, Vol 73, pp 157- 165.

Ogbaji, E.C. (2006). Role of temperature in the distribution of malaria. A case study of Zaria and environs. Unpublished B.Sc. Dissertation, Department of Geography, Ahmadu Bello University, Zaria.

Ojo, O. (1977). The Climate of West Africa. Heinman, London, pp 63-69.

Ojo, O; Gbuyiro, S.O; Okoloye,C.U.(2004). Implications of climatic variability and climate change in West Africa. *Geo.J*. 61, pp 111-119

Oluleye, A. and Akinbobola, A. (2010). Malaria and pneumonia occurrence in Lagos, Nigeria: role of temperature and rainfall. *African Journal of Environmental Sciences and Technology* vol.4 (8) pp 506-516, August, 2010.

Omotosho J.B.(2007). Pre raining season moisture building and storm precipitation delivery in the West African Sahel. *International journal of climatology*, vol 10 pp 1002.

Onche, O. (2009). Nigeria: Pneumonia infects six million, kills 200,000 children annually. Daily Independent, 21 January, 2009. P 25.

Osadare, R.O (2011). Effects of weather on the Occurrence of some common diseases in Zaria. An unpublished MSc Thesis, Department of Geography Ahmadu Bello University, Zaria.

Oshea, M.L and R. Field (1992). Detection and disinfection of pathogens in storm- generated flows. *Can J. Microbiol*, Vol: 38 pp 267- 276.

Park, K. (1997). Epidemiology of Communicable Diseases; in Park's Textbook of Preventive and Social Medicine. 15th Edition.

Patz, J. A., P.R. Epstein, T.A., Burke and J.M. Balbus (1996). Global Climate Change and Emerging Infections Diseases, "*Journal of the medical Association*," vol . 275, No.3, PP 217 -223.

Patz, J.A, McGeehin, M.A., Bernard, S.M, Ebi, K.L; Eps tein, P.R Rose, J.B, Paul R.E, Erin, K.L., Benjamin, H.S, Susan, M.B and Jonathan A.P. (2001). Climate Variability and change in the united states. Potential Impacts on water and food born Disease caused by microbiologic Agents, *Environmental Health Perspectives*, vol. 109, May, pp. 211-221.

Patz, J.A;Hulme, M; Rosenzweig, C; Mitchel, T.D; Goldberg, R.A; Lele, S; McMicheal, A.J and Sueur,D (2002). Regional warming and malaria resurgence. *Nature*, Vol. 420 pp 627-628.

Persinger, O.O. (1980). Lag responses in mood reports to change in the weather matrix . *Inter. J . Biomet;* 19, 108 -114.

Rees, R. (1996). Under the weather: Climate and diseases. *History today*. Vol: 46 pp 35-42

Reiter, .P. (2001). climate change and mosquito – Borne diseases" *Environmental Health perspectives*, vol. 109, PP 141– 161.

Rose, J.B; Paul R.E; Erin, K.L; Benjamin, H; Susan, M.B. and Jonathan, A.P.(2001). Climate change variability and change in the United States: Potential impacts on water and food-borne diseases caused by microbiological agents; *Environmental health perspectives*, vol. 109, pp 211-221.

Sawa, B. A. and Buhari, B. (2011). Temperature Variability and outbreak of meningitis and measles in Zaria, Nigeria. *Research Journal of Applied Science, Engineering and Technology*, 3(5), pp 399- 402.

Schneider, S. H. (1990): The Global warming debate Heats up: an analysis and perspective. *Bull. A. M. Meteor. Soc*, 17(9): 1292-1304

Scott-Evans, L.A. (2007). How climate affects your health. http/www.gilbertguide.com. Downloaded 20/5/2007.

Walker, J. (1998). Malaria in a Changing World: an Australian Perspective, *International Journal for Parisitology*, Vol. 28, No 6, June, PP 947-953.

Wenner, H.A. (1997). Viral meningitis in infectious diseases. A modern treatise of infectious processes. Harper and Row publishers Inc.

World Health Organization (WHO) 1999. ELNino and health. W.H.O ./ S.D.E/ 99.4. World Health Organization, Geneva, Switzerland.

WHO (2004). Global Environmental Change, using Climate to Predict Outbreaks: a review.

WHO (2008). Climate Change and Allergic Diseases. Report of a WHO Task group, Geneva WHO Unpublished Document. WHO/PEP/90.10.

Willet, K. M., Gillett, N. P., Jones, P. D. and Thorne, (P. W. 2007): Attribution of observed surface humidity changes to human influence. *Nature*, vol. 10, pp 449.

Wittman, K.E. and R.R. Colwell (2000). Viroplankton: Viruses in aquatic ecosystems. *Molmicrobial*, Vol: 64, pp 69-114.

APPENDIX I: METEOROLOGICAL RECORDS OF J0S NORTH LGA FROM 2002-2O11

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2002

Month	Year	Temperature	Rainfall	Humidity
Jan	2002	23	17	21
Feb	2002	22	17	18
March	2002	25	17	21
April	2002	27	119	52
May	2002	27	81	57
June	2002	26	272	68
July	2002	22	133	75
August	2002	23	309	86
Sept	2002	23	231	87
Oct	2002	23	66	87
Nov	2002	23	40	55
Dec	2002	22	40	53

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2003

Month	Year	Temperature	Rainfall	Humidity
Jan	2003	23	40	24
Feb	2003	25	40	19
March	2003	27	40	9
April	2003	27	15	5
May	2003	26	46	16
June	2003	23	65	72
July	2003	26	99	8
August	2003	23	77	86
Sept	2003	23	87	70
Oct	2003	24	134	76
Nov	2003	20	134	65
Dec	2003	22	134	36

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2004

Month	Year	Temperature	Rainfall	Humidity
Jan	2004	22	134	21
Feb	2004	24	134	18
March	2004	26	23	20
April	2004	29	88	52
May	2004	25	182	75
June	2004	25	216	78
July	2004	24	366	82
August	2004	24	236	82
Sept	2004	26	191	67
Oct	2004	24	44	39
Nov	2004	24	56	22
Dec	2004	24	56	22

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2005

Month	Year	Temperature	Rainfall	Humidity
Jan	2005	21	56	21
Feb	2005	27	56	25
March	2005	28	56	27
April	2005	28	67	31
May	2005	25	77	55
June	2005	25	25	76
July	2005	23	192	22
August	2005	23	229	21
Sept	2005	23	151	24
Oct	2005	24	56	24
Nov	2005	24	50	23
Dec	2005	24	50	22

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2006

Month	Year	Temperature	Rainfall	Humidity
Jan	2006	25	50	22
Feb	2006	27	50	15
March	2006	26	50	15
April	2006	28	44	25
May	2006	25	208	60
June	2006	24	198	65
July	2006	24	247	72
August	2006	22	406	77
Sept	2006	23	292	71
Oct	2006	24	38	57
Nov	2006	23	19	29
Dec	2006	21	19	28

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2007

Month	Year	Temperature	Rainfall	Humidity
Jan	2007	25	19	31
Feb	2007	23	19	18
March	2007	27	1	25
April	2007	27	3	45
May	2007	26	29	60
June	2007	24	84	68
July	2007	22	89	73
August	2007	22	86	75
Sept	2007	23	44	64
Oct	2007	25	37	39
Nov	2007	24	37	31
Dec	2007	22	37	36

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2008

Month	Year	Temperature	Rainfall	Humidity
Jan	2008	21	37	21
Feb	2008	23	37	19
March	2008	27	37	24
April	2008	28	31	26
May	2008	25	93	21
June	2008	24	249	25
July	2008	22	488	20
August	2008	24	368	25
Sept	2008	23	122	23
Oct	2008	25	136	27
Nov	2008	26	136	27
Dec	2008	22	136	22

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2009

Month	Year	Temperature	Rainfall	Humidity
Jan	2009	24	136	22
Feb	2009	21	136	31
March	2009	27	136	14
April	2009	28	136	50
May	2009	25	149	58
June	2009	23	20	64
July	2009	21	132	80
August	2009	26	260	48
Sept	2009	26	248	48
Oct	2009	26	130	16
Nov	2009	30	130	37
Dec	2009	25	130	22

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2010

Month	Year	Temperature	Rainfall	Humidity
Jan	2010	19	130	17
Feb	2010	23	130	13
March	2010	24	130	19
April	2010	26	5	29
May	2010	24	12	53
June	2010	24	10	53
July	2010	25	25	73
August	2010	22	19	78
Sept	2010	24	19	74
Oct	2010	24	12	61
Nov	2010	24	68	54
Dec	2010	21	68	28

MEAN MONTHLY METEOROLOGICAL RECORDS OF J0S NORTH LGA 2011

Month	Year	Temperature	Rainfall	Humidity
Jan	2011	21	68	23
Feb	2011	23	68	25
March	2011	25	68	11
April	2011	28	125	30
May	2011	27	113	62
June	2011	26	173	72
July	2011	24	339	72
August	2011	23	228	79
Sept	2011	25	24	65
Oct	2011	26	3	58
Nov	2011	26	3	24
Dec	2011	22	3	23

APPENDIX II: MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA FROM 2002-2011

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2002

Month	**Year**	**meningitis**	**Pneumonia**	**Malaria**
Jan	2002	1	4	100
Feb	2002	2	4	88
March	2002	1.5	2	23
April	2002	1.5	2	88
May	2002	1	2	
June	2002	4	3	140
July	2002	3	6	93
August	2002	3	3	170
Sept	2002	2	2	77
Oct	2002	2	1.5	77
Nov	2002	1	1	88
Dec	2002	2	2	90

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2003

Month	Year	meningitis	Pneumonia	malaria
Jan	2003	1.5	2	200
Feb	2003	1	1.5	175
March	2003	2	1	47
April	2003	6	4	176
May	2003	5	6	151
June	2003	4	5	279
July	2003	2.5	5	186
August	2003	1	6	170
Sept	2003	3	7	154
Oct	2003	2	5	154
Nov	2003	4	9	176
Dec	2003	3.5	11	179

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2004

Month	Year	meningitis	Pneumonia	malaria
Jan	2004	3	8	82
Feb	2004	5	16	194
March	2004	3	17	167
April	2004	6	32	191
May	2004	9	22	152
June	2004	5	23	287
July	2004	1	31	252
August	2004	1	21	186.5
Sept	2004	2	11	121
Oct	2004	11	21	225
Nov	2004	8	19	200.5
Dec	2004	7	6	176

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2005

Month	Year	meningitis	Pneumonia	malaria
Jan	2005	16	20	251
Feb	2005	1	16	296
March	2005	6	22	158
April	2005	11	26	380
May	2005	5	13	264
June	2005	8	17	387
July	2005	5	29	395
August	2005	1	27.5	295.5
Sept	2005	5	26	295.5
Oct	2005	3	12	196
Nov	2005	2	13	121
Dec	2005	6	14	1

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2006

Month	Year	meningitis	Pneumonia	Malaria
Jan	2006	5	24	157
Feb	2006	1	22	200
March	2006	6	11	203
April	2006	6	15	132
May	2006	12	12	219
June	2006	7	12	306
July	2006	3	4	360
August	2006	1	1	294
Sept	2006	2	6.5	194
Oct	2006	5	12	256
Nov	2006	1	2	242.5
Dec	2006	2	1	242.5

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2007

Month	Year	meningitis	Pneumonia	Malaria
Jan	2007	3	11	242.5
Feb	2007	1	3	229
March	2007	5	11	217
April	2007	9	4	107
May	2007	3	2	148
June	2007	3	19.5	204
July	2007	3	17	269
August	2007	2	25	364
Sept	2007	1	13	323
Oct	2007	1	19	303
Nov	2007	1	17	401
Dec	2007	1	17	283

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2008

Month	Year	meningitis	Pneumonia	Malaria
Jan	2008	3.5	17	271
Feb	2008	6	15	303
March	2008	4	23	367
April	2008	2	13	325
May	2008	2	22	295
June	2008	5	21	471
July	2008	7	18	380
August	2008	6	41	445
Sept	2008	5	32	302
Oct	2008	2	34	357
Nov	2008	6	4	179
Dec	2008	4	49	264

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2009

Month	Year	meningitis	Pneumonia	Malaria
Jan	2009	15	33	306
Feb	2009	2	19	365
March	2009	11	22	362
April	2009	14	36	252
May	2009	11	13	388
June	2009	3	46	247
July	2009	2	54	78
August	2009	9	65	46
Sept	2009	7	52	198
Oct	2009	2	53	99
Nov	2009	7	10	91
Dec	2009	2	32	91

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2010

Month	Year	meningitis	Pneumonia	Malaria
Jan	2010	6	22	91
Feb	2010	5	80	83
March	2010	2	10	334
April	2010	7	20	108
May	2010	7	7	181
June	2010	4	8	251
July	2010	2	7	189
August	2010	1	10	102
Sept	2010	3	34	3
Oct	2010	2	28	3
Nov	2010	3	9	247
Dec	2010	5	5	5

MEDICAL RECORDS OF SOME SELLECTED DISEASES IN JOS NORTH LGA 2011

Month	Year	meningitis	Pneumonia	Malaria
Jan	2011	4	1	199
Feb	2011	12	10	224
March	2011	4	36	348
April	2011	6	8	180
May	2011	3	14	285
June	2011	7	32	249
July	2011	5	36	134
August	2011	7	32	74
Sept	2011	3	4	101
Oct	2011	2.5	5	51
Nov	2011	2	26	169
Dec	2011	1	26	48