ASSESSMENT OF THE INFLUENCE OF WEATHER ON MALARIA EPIDEMIC IN SOME PARTS OF MINNA METROPOLIS, NIGERIA

BY

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M.TECH/SSSE/2006/1505

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NIGER STATE.

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DECLARATION

I hereby declare that my thesis has been conducted by me (Peter Akoro Jatau) under the supervision of Dr. P.S Akinyeye, Department of Geography, Federal University of Technology, Minna.

Peter Akoro Jatau 4/5/10

Student's name Date & Signature

CERTIFICATION

This thesis titled: The influence of weather on malaria epidemics in some areas in Minna metropolis, Nigeria by: Jatau, Peter Akoro (M.Tech/SSSE/2006/1505) meets the regulations governing the award of the degree of Master of Technology (M.Tech) of The Federal University of Technology, Minna and is approved for its contribution to scientific knowledge and literary presentation.

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ABSTRACT

Malaria disease is one of the most debilitating diseases in Minna metropolis. The disease is most prevalent among children and aged ones in Nigeria, thus making their contributions to Gross Domestic Product (GDP) very low. In Minna metropolis, three areas with a total of ten units/wards were chosen as endemic of malaria disease. Climatic data were used to compute an index for seasonal variability of malaria disease. Six models of malaria were developed and varied using computer software packages. The models developed as an official model for predicting the prevalence of malaria disease and climatic variability in the study areas for Makera, Kpakungu and Chanchaga respectively. The actual figures of the findings were: In makera area: $p = 0.000$ and 262. In Kpakungu area: $p = 0.001$ and 0.250 while in Chanchaga area: $p = 0.000$ and 0.131. For the analysis of mean malaria against mean rainfall in the three areas: the p values were <0.05 ($p < 0.05$). H_0 were rejected and H_1 were accepted. This indicated that as mean rainfall increases more mean malaria prevalence cases were recorded. Implying that rainfall has a greater effect as a cause of malaria. While for the analysis of the mean malaria against temperature, the p-values were > 0.05. H_0 were accepted and H_1 were rejected. This indicated that as mean temperature increases, the prevalence of mean malaria cases tends to decrease downwards.The index of endemicity (IE) used in this study indicated that the units under study ranged from hyper-endemic to mildly endemic. There is a seasonal pattern in the transmission of malaria disease which indicates the involvement of climatic elements in the prevalence of malaria disease. The transmission of malaria disease takes place mostly during the early rainy season and late rainy season. The result of the simple linear regression analysis using some climatic parameters for a maximum of twenty five and minimum of fourteen years periods revealed that the two climatic parameters selected (rainfall and temperature) only rainfall have significant relationship with the incidence of malaria disease, implying that temperature rarely affect malaria prevalence thus, does not have significant effect. The models put forward should be further 'exploited' in planning eradication measures of malaria disease. Awareness and education of the populace is vital and highly recommended as the prevalence of malaria is due to more ignorance about its mode of transmission.

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ABREVIATIONS

BHC	Benzenehexchloride
DDT	Dichlorodiphenyltrichloroethane
EC	European commission
EIR	Entomological Inoculation rate
ENSO	El-nino Southern Oscillation
EWS	Early warning systems
FMOH	Federal ministry of health
GCM	Global circulation model
IBBSH	Ibrahim Babangida Badamasi Specialist Hospital
ITCZ	Inter tropical convergence zone
MPO	Modified plan of operation
NAMCITY	Niger American medical city
NMEP	National malaria eradication programme
PF	Plasmodium falciparum
PFPC	Plasmodium falciparum containment programme
RBM	Roll back malaria
RO	Reproduction rate
UNICEF	United Nations children's fund
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

In human history, the major problems of health that men have faced and have been facing concerned the control of transmissible disease, the provision of medical care and the relief of disability and destitution. The relative emphasis placed on each of these problems has varied from time to time, but they are all closely related and from them, have come public health, as we know it today. The disturbance, by weather of physical (e.g. weather pattern, sea level, water supplies) and of ecosystems (e.g. agro ecosystems, disease-vector habitats) would therefore pose risk to human health. The anticipated health Impact is that of whole communities or populations (i.e. it is a public health, not a personal health issue).These health Impacts would occur in various ways, via path ways of varying directness and complexity including disturbance of natural and managed ecosystems (Martens, 1998).

Population with different levels of natural, technical and social resources would differ in their vulnerability to climate induced health impact, such vulnerability due to crowding, food In-security, local environmental degradation and perturbed ecosystems already exists in especially many communities in developing countries. De Zulueta (1994) reported that, weather may, via various processes, exacerbate those ecosystem disturbances. Because an ecosystem comprises a suite of interacting components, in which member organisms relate to the whole suite rather than to Individual part the uncoupling of relationship by climate change could initiate a cascade of disturbances that might jeopardize human population health. Indeed, recent global and Regional climate events may have contributed to some of the Increase observed in that Incidence of new and recurrent Infections diseases. Martens (1998) Weather is a significant and emerging threat to public health and changes the way we must look at protecting vulnerable populations. There is overwhelming evidence that humans are affecting the global weather and climate resulted to a wide range of Implications for human health. Weather, Climate variability and change caused death and disease through natural disasters, such as heat wave, floods and droughts. In addition, many important diseases are highly sensitive to changing temperatures and precipitation. These Include common vector-borne diseases such as malaria and dengue; as well as other killers such as malnutrition and diarrhoea. Weather influence already contributes to the global burden of disease and this contribution is expected to grow in the future.

Marsh (2005) reported that over 300 million people world wide are affected by malaria and between 1and1.5million people die from it every year. Previously extreme wide spread, the malaria is now to Africa, Asia and Latin America.Fontaine et al (2000) reported that malaria is of public health importance in the tropical region, it is remaining widely spread throughout the tropics but also occurring in many temperate regions. It exacts a heavy toll of illness and death-especially among children and pregnant women. It also poses a risk to travellers and Immigrants, with imported cases increasing in non-endemic areas. Treatment and control have become more difficult with the spread of drug – resistant strains of parasites and Insecticide resistant strains of mosquito vectors. Heath education, better case management, control tools and concerted actions and needed to limit the burden of the disease.

Najera et al (1998) Malaria has become a global problem. It is endemic in 105 countries and is responsible for over 300 to 500 million clinical cases and more than a million deaths each year. The dream of global eradication of malaria is beginning to fade with the growing number of cases, rapid spread of drug resistance in people and

Increasing Insecticide resistance in mosquitoes. Mcmicheal et al (1996), is of the view that, the impacts of weather on human health will not be evenly distributed around the world. Developing country populations, particularly in small Island states, arid and high mountain zones and in dense, populated coastal areas, are considered to be particularly vulnerable. Fortunately much of the health risk is avoidable through existing health programmes and Interventions. Concerted actions to strengthen key features of health systems and promote healthy development choices, can enhance public health nouns as well as reduce vulnerability to future weather influence. WHO supports member states in protecting public health from the Impacts of weather and provides the health – sector voice.

1.2 Statement of the Problem

Weather, Climate variability and change cause death and disease through natural disasters such as heat waves, floods, and droughts. In addition, many important diseases such as malaria are highly sensitive to changing temperature and precipitation (Martens et al, *1995*).Weather influence has already contributed to the Minna metropolis' burden of disease and this contribution is expected to grow in the future,

The dream of Minna metropolis eradication of malaria is beginning to fade with the growing number of cases, rapid spread of drug resistance in people and increasing insecticide resistance in mosquitoes. Weather accelerate/spread malaria infection, exacerbate malaria infection. The influence of weather in minna metropolis affect food supply, which in turns lower nutritional status of individuals.

Against this back ground, this study quantify and analyze the influence of weather on malaria epidemics in Minna metropolis in order to identify those factors that influence the variations of the epidemic /transmission of the disease.

1.3 Aim and Objectives

The main purpose of this project is to quantify the influence of weather on malaria epidemics in Minna metropolis. Within this broad aim, lie the following specific objectives are to be pursued

1. To identify the pattern and intensity of the spread of malaria disease in terms of space, seasons, gender and age group.

2. To examine the relationship between rainfall, temperature and malaria transmission.

3. To recommend strategies for the eradication of malaria infection in the study area.

1.4 Research Hypothesis

The hypothesis for this research is:-

H_O: There is no significant difference between mean malaria and mean rainfall

H_1: There is significant difference between mean rainfall and mean temperature

1.5 Justification of the study

The Increasing number of malaria Infected persons and a heavy toll of illness and death in various regions of the world especially amongst children, pregnant women, travellers, Immigrants and failures of some health schemes e.g. Roll back Malaria (RBM) launched in 1998 and vigorous campaign to eradicate malaria point to the necessity for the study of influence of weather on malaria epidemics.

The world Health Assembly resolution of malaria 1986 in support of the elimination of malaria and World Health Organisation (WHO) has helped to focus attention on the disease and the problems involved in its study. Although, malaria disease has been recognised for many years and its occurrence reduced in some areas where it was previously highly prevalent, various studies such as Freeman (1995) have revealed that the disease is increasing in prevalence, distribution, intensity and importance in parts of Nigeria and elsewhere in the world, especially among the rural and poor accessible communities and the knowledge of its transmission is not widely known. The continued outbreak, spread and escalating cases of malaria disease in parts of Minna metropolis, the Global 2000,UNICEF and other agencies had committed so much resource is embarrassing and be given urgent attention.

In Minna metropolis and other parts of the savannah region of Nigeria, climatic parameters such as rainfall, temperature, humidity, drought, flood etc are the primary source control of weather influence on malaria epidemics. In view of this, the analysis of Minna metropolis climatic parameters (rainfall and temperature) will constitute a useful tool for assessing the epidemics/eradication of malaria disease amongst the populace. The project will also present an account of the distribution, endemicity of the disease and the influence of weather on the prevalence of the disease so as to arrive at a more reliable prediction of the out breaks and more accurate early warning systems (EWS) to avoid the disease outbreaks.

1.6 The Study Area

1.6.1 Locational aspect

Niger state is one of the second-generation states of the Federal Republic of Nigeria. The state was created soon after General Murtala Ramat Mohammed assumed power in

1976 with the aim of bringing development closer to the grass roots. Niger state is within the middle bell of Nigeria, which is characterized by relatively sparse and fragmented population groups whose key ethnic groups are Nupe, Gwari and Hausa. Minna been the capital of Niger State and the study area, is located between longitude 6^{oC} 32 – 6^{Oc} 34 East and latitude 9^{0C} 36 –9^{0C} 38 North with an area of about 884 hectares on a geographical base of undifferentiated basement complex of mainly gneiss and magmatite on which the finding is only confined to, and it shares a common border with Shiroro and Munya Local government to the north and East respectively,Bosso Local government to the West ,while Paikoro Local government is located at the southern border, with a population of about 201429 thousand, which according to the 2006 census (source: population commission).

It is suggested that Minna got its name from a Gwari word "***Myina***" meaning "***to spread fire***". This is from the Gwari spiritual bonfire festival that used to be celebrated on the Paida hill. This further suggests that the early settlers of Minna are Gwaris.

The modern history of the present Minna started in 1905 when the railway line was extended to Minna. This brought about the influx of many professionals, technicians, labourers, traders and so on to the town. This was followed by the setting up of administrative machinery. In 1908, a leader, assisted by a secretary was appointed to preside over the social issues of the then permanent settlements of the present Kwangila, Limawa and Ketaren-Gwari.

Further developments occurred in 1910 when the Sarkin Kuta was asked to move to Minna by the Resident Officer as a plan to establish a new headquarters in Minna. This invitation was not honoured because the sarki did not want to work with the Hausas who had then established prominent presence in Minna. A similar invitation was extended to the Sarkin Wushishi. He obliged and the headquarters of Kuta Division was moved to Minna. The Division was made up of nine administrative districts of Wushishi, Kuta, Paiko, and Galadima Kogo, Fuka, Maikukele, Bosso, Guni and Gini. These events led to the demotion of Sarkin Kuta and the promotion of Sarkin Wushishi. The Sarkin Wushishi, Ibrahim, upon arrival in Minna appointed Mallam Mu'azu Sokoto as the local native judge "***Alkali***" because he was learned in Islamic religion. Capt. Taylor, the Resident, also appointed people to occupy various administrative positions of Sarkin Dillali (head of middlemen) Magajiya (head of women), Sarkin Pawa (head of butchers) and so on. Mu'azu was serving as judge, native treasurer and Chief Imam. In 1917 the official Imam was appointed in person of Mallam Aliyu.

In 1921, the Kuta Division was reorganized and Sarkin Wushishi was sent back to Wushishi and the headquarters of the Division relocated to Kuta. Sarkin Bosso, Abubakar Zarumai, assumed the administrative leadership of Minna.

The Minna Township Council was established in 1934. But in 1950 another administrative reorganization abolished the Town Council. In its place was Ward Administration. In the same year Alhaji Ahmadu Bahago was appointed both Sarkin Minna and Sarkin Kuta in council. Six wards were created namely:- Nassarawa, Kwangila, Makera, Limawa, Sabon-Gari and Keteren-Gwari. Later population increase brought Paida as the seventh ward in 1959.

In 1976 when the old Niger Province was excised from the then North Western State, the city became the capital of the then new Niger State. Apart from being the state capital, Minna is presently also the headquarters of Chanchaga Local Government. See Figure 1.1 showing map of the study area. And the Sampled Medical centres are

General Hospital, NAMCITY-IBBSH Chanchaga and Unity Hospital Kpakungu. See Figure 1.2 Showing the map of the sampled medical centres.

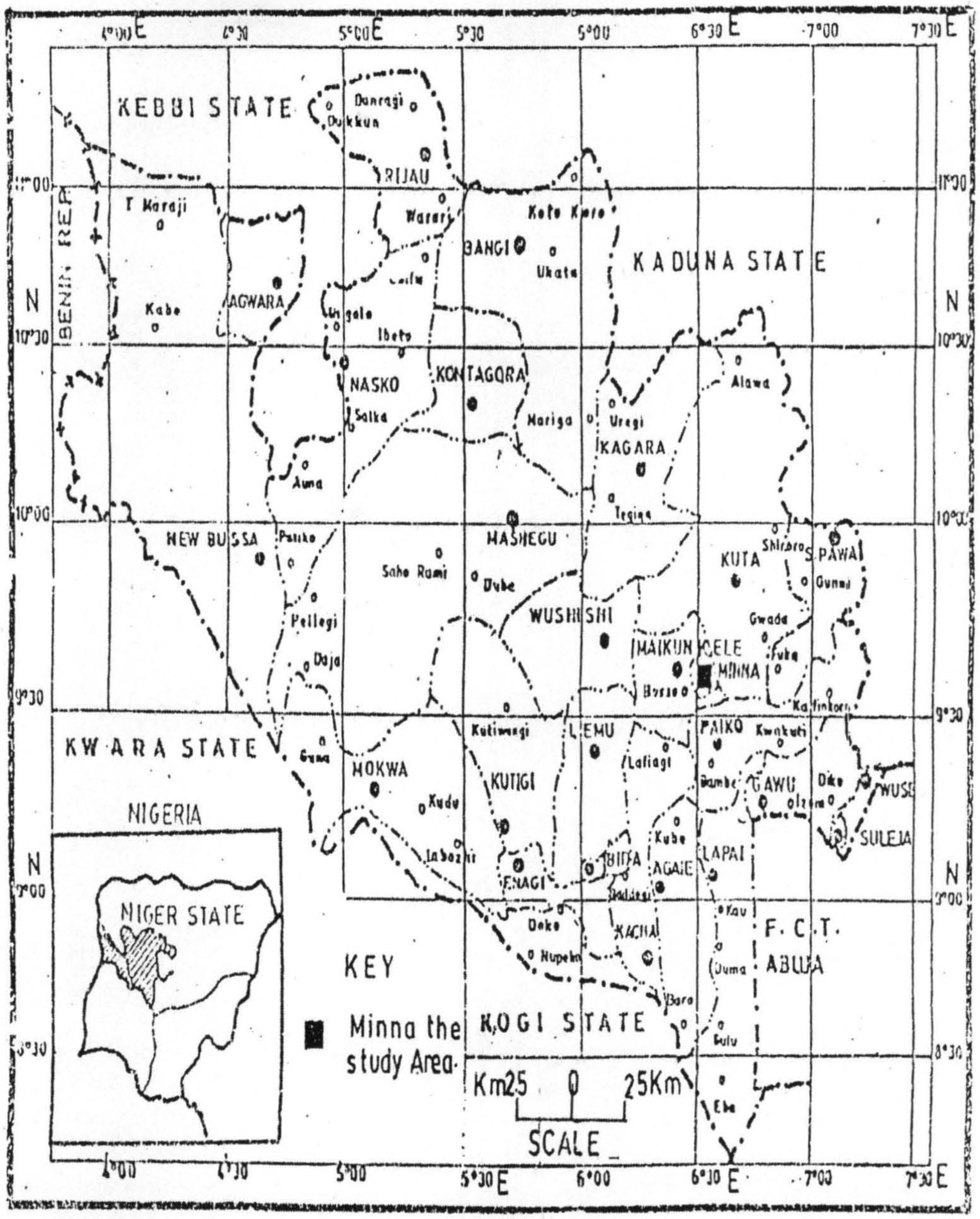

Fig 1·1 NIGER STATE SHOWING MINNA THE STUDY AREA·

Source Geography Department F.U.T. Minna·

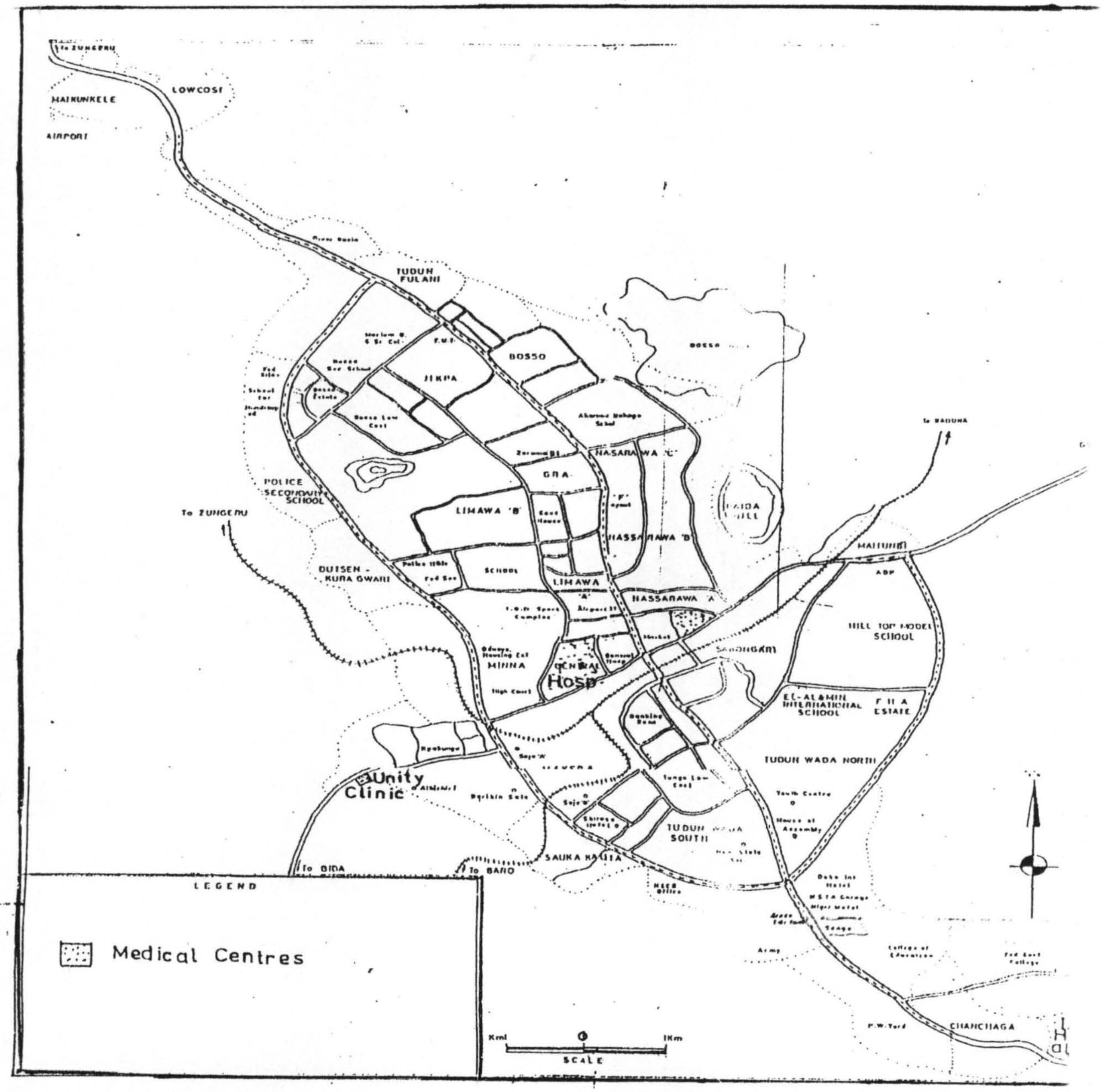

Fig 1.2 Minna showing the location of sampled medical centres

Source: Geography Department F.U.T Minna

Minna experiences distinct dry and wet seasons with the wet season decreasing in amount of rainfall from south to North. The mean annual rainfall for Minna varies. The rainy season in most cases start in April and last between 190-200days. The mean monthly temperature is higher in March at 30.5^{oC} and lowest at 25.1^{oC}.The relative humidity is generally high throughout the year.

Socially and economically Minna has witness tremendous development similar in pattern to other cities in Nigeria. Also its strategic position conveys on it an advantage. Above all the town has witnessed growth in size (physical expansion of ifs fabrics) and in population. As a result of all these, people of different ethnic, religious and occupational background who engage in one form of urban activities or the other.

1.6.2 Climate

The characteristics of some aspects of rainfall in Nigeria in general and in Minna (study area) in particular in relation to the endemicity of malaria diseases me the focus of this study. According Adefolalu et al (1995), rainfall amount is not a health problem to man but the distribution of the amount on a month-to-month basis is critical in relation to rainfall spread in time. The study area is located in the northern part of the country, which is characterised by a dry season of seven months or more usually between October/November and April/May. According to Martola et al (2001) transmission of malaria disease most commonly occurs when ponds are filling up at the beginning of the wet season.

The study area has a tropical wet and dry climate, the two seasons are governed by the movement of the Inter tropical convergence Zone (ITCZ) which decrease from south to North and characterised by two prevailing air masses (hot and cold). Rainfall begins in about April and ends October with heaviest fall in July and August and September, while dry season covers October to March. The observed parameters such as rainfall, temperature, Relative humidity etc have an Influence or control malaria transmission.

1.6.3 Rainfall

Rainfall Influences the availability of mosquito habitat and the size of mosquito to populations, various studies shows that the best climate conditions for malaria are a long rainy season that is warm and wet, followed by a dry season that is not too hot followed by a hot and wet short rainy season.

The rainfall in the study area is season, the dry season last for a minimum of five months (November – March) while the wet season spans from April to October. The mean annual rainfall varies from place to place with the range from 100mm to 1500mm. The wettest months are August and September (source; Niger state ministry of Agriculture).During the period of dry season, most especially in November to January cold dry dusty winds (harmattan) prevail blowing from the Sahara desert. The amount and type of rainfall Influence the rate of malaria transmission

According to Nagpal et al (1995) Anopheline mosquitoes breed in water habitats and different Anopheline mosquitoes prefer different type of water bodies in which to breed. Rainfall affects malaria transmission because it increases relative humidity and modifies temperature, and it also affects where and how much mosquitoes breeding can take place (Pampana, 2002).

1.6.4 Temperature

In Minna the highest level of atmospheric temperature is between the months of March, April and may before the onset of the rainy season. During this period the atmospheric temperature rise up to 38^{oC}.The lowest temperature is recorded from the end of December to end of February. The rise of temperature during this period can be link to highest amount of sunshine experienced. Freeman etal (1996), temperature is particularly critical, for example temperature below 20^{oC} plasmodium Falciparum (which causes severe malaria) cannot complete its growth cycle in this Anopheles mosquito and thus cannot be transmitted and in warmer regions closer to the equator, transmission will be more Intense, malaria is transmitted year-round and plasmodium falciparum predominates. In cooler regions transmission of malaria is less Intense and more seasons. Plasmodium vivax is more prevalent because it is more tolerant of lower ambient temperature.

According to Banrang (2003) the density and dynamics of vector populations are regulated by temperature, water relation and host presence. Changes in temperature water relation and host presence changer in temperature can affect the development and survival parasites and the mosquito that carry them temperature cause a threat to health of Individuals by facilitating the rare of malaria transmission during its extreme cold or heat. Temperature affects many parts of the malaria life cycle and the duration of the incubation time depends on temperature and on the species of the parasite the mosquito is carrying (Pampana, 2002).

1.6.5 Relative Humidity

There is spatial and seasonal variation in the relative humidity throughout the study area. Between January and march is very low about 35% owing to the prevalence of tropical marine air masses which originates from the Atlantic ocean and hence there is moisture laden across (Including the study area).The relative humidity starts Increasing from April and reach the peak (above 65%) in August September. In general, there is a North – south Increase in relative humidity values in the study area.

1.6.6 Sunshine

The duration of the sunshine per day combine with solar radiation Intensity is two important parameters that determine the drying power of the ambient air. Minna metropolis enjoys high sunshine hours of 8 – 9 hours per day. Hence day time length is on the average about 8.5 hours for most of the dry season. The long period of sunshine may mean Increase in evaporation which in turn reduces large surface water bodies to pond which may harbour vector.

The high evaporative power of water in November also suggests a very high drying Power. Extreme dryness is usually associated with 40% of Relative Humidity or below. This dryness in most cases encourages the spread of various epidemics that dust containing various diseases may be deposited on water bodies and other substances that are important to man (Freeman, 1995)

1.6.7 Topographic Aspects

The physiography of the study area is dominated by gentle undulating plain with slopes, covering about 75% of the land area; steep slopes greater than 25% are also present as well as rocks with shallow patches of soil bedrock. Flat lying or gentle dipping rocks tends to be eroded into tabular relief. The physiography is under laid by differentiated basement complex of Igneous and metamorphic rocks from which the soil are developed.

1.6.8 Soil

Most parts of the study area are under ferruginous tropical soils, which are derived from basement complex and old sedimentary rocks. These soils are highly marked laterised by the loss of silica. These ferruginous soils are the most important type of soils in Nigeria, this is because the support most of the important cash crops and food crops produced in the country (Areola, 1978) Apart from ferruginous soil and type found here is hydromorphic and alluvial soils. These are seasonal or permanently water logged soils found mainly along flood plains of Chanchaga River. This type of soil, favour the production of come crops such as maize, rice guinea corn etc. There is a close relationship between the physiographic regions and the soil types. The type of soil also defines how long pools of stagnant water bodies which form good breeding ground for vector of malaria disease.

1.6.9 Drainage

Minna metropolis is a land locked state with no major water body like ocean or sea bordering it and thus precipitation is not as high as the southern parts of the country. A size able amount of rain water is lost through percolation to underground water. The bulk of the rain water however, flows as run-off into rivers, streams and gutters. Some of the rain water is also lost to the atmosphere through evaporation. Minna town is influenced by two principal seasons. The rainy and dry season. The rainy season start from May and ends in October. At the peak of rainy season, streams and gutters flood their banks with temperatures being lowered. During this period, the soil moisture content is usually high which Influences plant growth. Most of the agricultural activities are carried out within the rainy season.

The dry season which starts in November and ends in April is characterised by high temperature except during the period of harmattan. During this period the relative humidity is low, while seasonal streams and gutters dry up to form pools of stagnant water bodies which forms good breeding ground for mosquitoes (Vector of malaria disease).Weather has Impact on fresh water resources-both the availability of fresh water (for domestic, agricultural or Industrial consumption and water quality). The timing and Intensity of rain is a major determinant of run-off flooding, ground water recharge and also soil erosion (Lasaki et al 1999).Flooding can lead to the contamination of water with human and animal waste as well as agricultural chemicals. Reduced water level can concentrate pollutant pathogens and other disease vectors in surface water. The distribution of vector borne diseases is restricted by the climatic tolerance limits of their vectors. Before thus devastating floods of September 1986 in Minna there was poor drainage system most of the existing drainage network prior to the floods of 1986 where either Inadequate or non functional. The construction of large multi-million Naira modern drainage systems across Minna has reduced to the barest minimum; the Incidents of flooding in Minna.

1.6.10 Vegetation

The vegetation cover of the study area is an essential part of the ecological aspects of malaria Infestation. For example the current vegetation can be termed the `drying era' where more defoliation and deforestation give way to shrub/Sahel vegetation, (Adefolalu D.O, 1982). This lead to reduction in watershed areas and the surface water bodies are there by exposed to direct sun rays which leads to the Increase evaporation of water from the unprotected streams and ponds.

The vegetation of the study area was initially a typical guinea savannah with mixture of trees, shrubs, herbs and grasses. However as a result of settlement, this vegetation has disappeared and only pockets of shrubs, herbs and grassed can be found in some part of the town and they Increases North-South of the study area. Places with these pockets of trees, shrubs, herbs and grasses create a good breeding ground for mosquitoes. .

1.6.11 Land Use

The largest percentage of the land is essentially used to build residential houses to accommodate the rising and ever increasing population. The land is also used for agricultural purposes. Within Minna metropolis, crops like maize, melon, rice, etc are produced. Vegetable gardens are also maintained in some households.

Considerable percentage of the land is also used for building both government and private office blocks. A reasonable percentage of the land is also used for building of township roads.

1.7 Scope and Limitation of the Study

This study covers the entire Minna metropolis with respect to influence of weather on malaria epidemics. Field surveys were carried out in the study area both in the dry and wet seasons with respect to climatic parameters only Rainfall and temperature were considered. This is because these parameters affects the availability of water in an area, as malaria disease is a crippling water associated disease. The study focused on influence of weather on malaria epidemics, the data on in and out patients was collected and these data were analysed.

Some of the limitations regarding data collection on both the climatic and prevalence of malaria have to do with time frame. The data on malaria covered only fourteen and twenty five year's period. Whereas climatic data were available for a longer period. The climatic data were extracted from various sources such as climate change centre, Federal University of Technology, Minna. Minna Airport meteorological station, while data on malaria were collected from General Hospital Minna, IBB specialist Hospital Minna. General constraints Include personal experience of the researcher. such as language barrier, poor response from the respondents and retrieval of administered questionnaire.

1.8 Organization of the Thesis

This thesis divided into five chapters. The first chapter deals with the introduction-background of the study. It also contains objectives and justification for the study. Chapter Two reviews the past relevant literature on the disease, while Chapter Three describes the materials and methods used in carrying out the research. Chapter Four dwells on results. Chapter Five, the last chapter deals with Discussion, summary and conclusion and recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 An Overview of Global Human Malaria and weather Influence.

2.1.1 Human Malaria

Human malaria is caused by one or a combination of four species of Plasmodia: Plasmodium falciparum, P. vivax, P. malariae, and P. ovale. The disease caused by each species is different in terms of the way the species responds to drugs, behaves in the mosquito phase and behaves once inside the human (Kreier, 1980). P. falciparum causes malignant tertian malaria, which causes death more often than the other species. However, P. vivax remains in the body longer than P. falciparum, causing more gradual health deterioration. The course of vivax malaria, however, is more predictable than falciparum malaria. P. malariae causes the third most common type of malaria in the world, although it grows slower than the other three species. P. ovale causes the least common and least pathogenic malaria of the four human malaria species (Kreier, 1980).

Other Plasmodia species cause malaria in other vertebrates. In general, the species, and therefore the diseases caused by them, are different enough between humans and other vertebrates such that there is almost no transmission between humans and animals. P. malariae can be found in chimpanzees, however, and although laboratory tests have proven that humans can be infected with simian malaria species, this has only been known to have occurred four times in nature (Kreier, 1980). Although there are different species of the malaria parasite, the basic life cycle of each follows the same basic pathway described below. The life cycle of the malaria parasite begins in a female Anopheline mosquito where two gametocytes (sexually differentiated Plasmodium parasites) that were ingested by the Anopheline mosquito from the human host fuse to form the ookinete or egg. The ookinete develops in the midgut of the mosquito and eventually breaks open, releasing sporozoites, which circulate through the mosquito, eventually arriving at the salivary glands where they can then be injected into a host when the mosquito next feeds. This stage, which occurs within the mosquito, is called the extrinsic cycle. Once injected into the human host, the sporozoites move to the liver and enter liver cells where they asexually reproduce to form merozoites, which then spread through the blood and invade red blood cells. Inside the red blood cells, the merozoites synthesize all the necessary components for the multiplicative production of more merozoites. When full of merozoites, the red blood cell breaks open, causing fevers and the other symptoms of malaria. Some of the merozoites differentiate into gametocytes that can start the cycle over again when another female Anopheline feeds on the infected host (Oaks et al., 1991).

The human suffers from symptoms of malaria when the red blood cells that are infected with the parasites rupture and release merozoites into the human's bloodstream. The main symptom experienced by the malaria-infected human host is a fever or paroxysm which involves one-half to two hours of a cold shivering stage, a few hours of a hot stage and then two or more hours of sweating as the body temperature falls. The length of the incubation period, the time between being bitten by an infected mosquito and experiencing a fever, depends on the species of the parasite. For P. falciparum, the average incubation period is 11 days, whereas for P. vivax 14 days is average (Pampana, 2002). The symptoms of malaria, in addition to fever, are chills, headache, laise, weakness, hepatomegaly (enlarged liver), splenomegaly (enlarged spleen), and dehydration. Malaria can also cause anaemia, anorexia, nausea, vomiting, abdominal pain and diarrhoea. Deaths from malaria are normally caused by cerebral, renal, or pulmonary failure or a combination of the three (Kabilian, 1997).After the first fever attack, relapses occur with a pattern dependent on the species of the parasite. Falciparum malaria has frequent relapses during the first few months, whereas vivax malaria has two patterns of relapse, the first period involves short-time relapses for two months beginning two weeks after the primary attack followed by a latency period, and then, six to nine months later, long-term relapses. This creates what appear to be two outbreaks of vivax malaria in the year, but the second is just the long-term relapse from the infections caused six to nine months earlier (Pampana, 2002) The vivax parasite can therefore survive the winter in the human host, becoming active again when the mosquito vectors are likely to be alive and circulating (Mcmicheal, 2000, personal communication).

Morbidity and mortality from malaria also depends on the species. P. falciparum causes the shortest infections, lasting ten months or less on average, but if not treated these infections can lead to death in up to 25% of cases. Occasionally deaths due to P. vivax do occur, especially during epidemics and when infections are left untreated, and P. vivax causes death less frequently. These infections last about two to four years on average (Pampana, 2002). Some individuals have genetic resistance to malaria. In individuals who are heterozygous for sickle-cell haemoglobin, the internal environment of the red blood cells does not allow for the development of the merozoites (Brewster, 1999).Therefore red blood cells don't rupture, thus limiting transmission because more merozoites are not created in the red blood cells. This person, although infected with malaria, does not suffer from its symptoms nor can the disease be spread from this person. The duffy antigen, which is expressed the surface of the red blood cell, is necessary for P. vivax to enter the red blood cell and therefore people without this antigen are protected from vivax malaria. The fact that many people in endemic areas are infected with the parasite but do not have the disease gives evidence to the existence of acquired immunity (Kabilian 1997). Much research is being conducted currently into the mechanisms of this acquired immunity to malaria in order to create a malaria vaccine. It is this acquired immunity to malaria that limits the correlation between rates of morbidity and mortality, and malaria transmission rates (Brewster, 1999).

Acquired immunity does not last forever, because the parasites have a large diversity of antigens that vary between species, strains, stages, and during the course of an infection. This means that a person may gain acquired immunity to one type of malaria, but can be infected by other strains that the immune system will not recognize (Kabilian, 1997). By continued exposure to the malaria present in a population, a person can gain and maintain acquired immunity to changing strains, whereas people who leave a location and then return to it are no longer immune (Bradley et al., 1987). Only by "exposure to multiple parasite variants circulating in the community" (Kabilan, 1997) can a person form an immunity across strains of the malaria parasite. The ability of parasites to mutate, which limits the power of acquired immunity in humans, also gives the parasites the ability to resist anti-malarial drugs. Once a parasite mutates into a form that can resist the effects of the drug, that form is naturally selected for as it rapidly multiplies and spreads from host to host (Oaks et al., 1991). P. falciparum has become resistant to chloroquine in many parts of the world and there are now strains of multi-drug resistant P. falciparum that were first discovered in Asia and may be spreading around the world (Pate etal, 1998). Malaria vectors have also proven to be resistant to many insecticides, including DDT (Sharma etal, 1994).

2.1.2 Temperature

Temperature affects many parts of the malaria life cycle. The duration of the extrinsic phase depends on temperature and on the species of the parasite the mosquito is carrying (Freeman etal, 1996).The extrinsic cycle normally lasts nine or ten days, but sometimes can be as short as five days (Bradley et al., 1987). As the temperature decreases, the number of days necessary to complete the extrinsic cycle increases for a given Plasmodium species.P.vivax and P.falciparum have the shortest extrinsic incubation times and therefore are more common than P. ovale and P. malariae (Oaks et al., 1991). The extrinsic phase takes the least amount of time when the temperature is 27°C (Pampana, 2002). The time required for development of the ookinete, the egg of the parasite, in the midgut of the Anopheline mosquito, decreases as temperature increases from 21°C to 27°C (Patz et al., 1998). Below 20°C, the life cycle of P. Falciparum is limited. Malaria transmission in areas colder than 20°C can still occur because Anophelines often live in houses, which tend to be warmer than external temperatures. Larval development of the mosquito also depends on temperature (Russell et al., 2005). Higher temperatures increase the number of blood meals taken and the number of times eggs are laid by the mosquitoes (Freeman et al., 1996).

The intersections of the ranges of minimum and maximum temperature for parasite and vector development determine the impact of changes in temperature on malaria transmission. The minimum temperature for mosquito development is between 8-10°C; the mini6um temperatures for parasite development are between 14-19°C with P. vivax surviving at lower temperatures than P. falciparum. The optimum temperature for mosquitoes is 25-27°C, and the maximum temperature for both vectors and parasites is 40°C (Mcmicheal et al., 1996). There are some areas where the climate is optimal for

malaria and Anopheles mosquitoes are present, but there is no malaria. This is called "Anophelism without malaria" which can be due to the fact that the Anopheles mosquitoes present do not feed primarily on humans (Bruce-Chwatt, 1985) or because malaria control techniques have eliminated the parasite (Martens ,1998). If any changes, whether environmental or otherwise, were to occur to bring another species to the area that does act as a vector for human malaria, then the potential for outbreaks of malaria is very high since there is no immunity in the human population there.

2.1.3 Precipitation

Anopheline mosquitoes breed in water habitats, thus requiring just the right amount of precipitation in order for mosquito breeding to occur. Little is known about the biology of this aquatic phase (Oaks et al., 1991). However it is known that different Anopheline mosquitoes prefer different types of water bodies in which to breed (Nagpal and Sharma, 1995). Too much rainfall, or rainfall accompanied by storm conditions can flush away breeding larvae. Not only the amount and intensity of precipitation, but also the time in the year, whether in the wet or dry season, affects malaria survival (Russell et al., 2005). Rainfall also affects malaria transmission because it increases relative humidity and modifies temperature, and it also affects where and how much mosquitoes breeding can take place (Pampana, 2002).

Some contend that the amount of rainfall may be secondary in its effects on malaria to the number of rainy days or the degree of wetness that exists after a rain event. Malaria has also been found to be dependent on the groundwater level (Russell et al., 2005).

2.1.4 Relative Humidity

Relative humidity also affects malaria transmission. Plasmodium parasites are not affected by relative humidity, but the activity and survival of Anopheline mosquitoes are. If the average monthly relative humidity is below 60%, it is believed that the life of the mosquito is so shortened that there is no malaria transmission (Pampana, 2002).

2.1.5 Wind

Wind may play both negative and positive roles in the malaria cycle because very strong winds can decrease biting or ovipositing by mosquitoes, while at the same time extending the length of the flight of the mosquito. During a monsoon, wind has the potential to change the geographic distribution of mosquitoes (Russell et al., 2005).

2.2 Weather and vector succession

In addition to changing the amount and rate of transmission of the vectors and parasites that are already in a certain location, changing the weather of an area can allow the introduction of different vectors and parasites that may be more efficient. Since P. malariae and P. ovale have longer extrinsic cycles, some mosquitoes do not live long enough to transmit them. However, if environmental conditions change in ways that would increase the survival time of those mosquitoes, then they would be able to transmit other species of malaria that were not present in that area before (Pampana, 2002).

2.2.1 Epidemics

Epidemics of malaria are caused by a disturbance of the equilibrium between host, parasite and vector. Najera et al. (1998) defined three different types of epidemics. Type I epidemics are caused by meteorological conditions, which create temporary epidemics that will eventually revert back to the previous condition. Type II epidemics are caused by landscape changes or colonization of sparsely populated areas that create a new equilibrium level of endemicity. And type III epidemics are caused by interruptions in measures that were controlling malaria.

Meteorologically created epidemics normally only last one season of transmission. Many areas experience epidemics caused by meteorological changes that occur in interannual cycles. These cycles, which have been well illustrated by ENSO (El Niño Southern Oscillation), have been found in many parts of the world to follow the paraquinquennial cycle, which means epidemics happen every 5 to 7 years, however, in some areas the period of the cycle is longer. Because of the periodicity of cycles caused by meteorological factors, if those variables are monitored, there should be a way to predict epidemics based on the risk factors related to epidemics including: a sudden increase in the number of non-immunes that are exposed to malaria, a rapid increase in vectorial capacity (increased density of vectors or invasion of a more efficient vector), land-use change, and failure of control efforts (Najera et al., 1998). P. vivax and P. falciparum cause different types of epidemics. P. vivax epidemics occur mainly in areas with only seasonal transmission and show a bimodal peak, the second peak caused by relapses, whereas P. falciparum epidemics grow slowly and then explode causing only one peak of transmission (Najera et al., 1998).

2.2.2 Weather influence and Malaria

The three main weather elements that affect malaria are temperature, precipitation, and relative humidity (Pampana, 2002).Weather predicts, to a large degree, the natural distribution of malaria (Bouma et al, 1996).The effects of temperature on both the vectors and parasites of malaria are easily seen in the latitudinal and altitudinal boundaries to malaria transmission. However, these boundaries seem to be changing as many highland areas have experienced malaria epidemics in the past few years. It has been hypothesized that increasing temperatures could be part of the reason why malaria can now survive at higher altitudes. Many other confounding factors, however, could be causing the increase in malaria in these areas (Patz and Lindsay, 1999).

In addition to predictions of the effects of weather on malaria, studies which identify the factor or factors that are most responsible for any changes in malaria are important in order to understand the complexities of malaria in the actual world. There are many variables that affect malaria transmission in addition to climatic changes, such as environmental modification (e.g. deforestation, increases in irrigation, swamp drainage), population growth, limited access to health care systems, and lack of or unsuccessful malaria control measures (Patz et al,1999). Some studies have been done on the subject, yielding differing results as to which factor or factors are most responsible for the increase in malaria. Most of the studies, however, do not take into account all of the factors that are related to malaria transmission. This makes it difficult to assess the true determinants of malaria in each area.

2.3 Related Studies on Malaria and weather influence

Climatic factors such as rainfall, temperature and humidity etc have a direct effect on man's health, his comfort and his physical performance. Adefolalu (2000) highlighted the effect of both subtle and extreme weather events on human health where he said "we are most aware of the weather when it is hot or cold, or very wet or very dry". It is the extremes of weather that have the devastating impacts on human health and well-being. Storms, tropical cyclones and flood kill many thousands of people every year. On-catastrophic weather can also have varied and significant impact on human health. For example weather affects the level of air pollution in a city, rainfall and temperature can increase the local population of malaria mosquitoes.

According to Brewster (1999) in his study carried out on the influence of weather on the vector population observed that the density and dynamics of some vector populations are regulated by the three principal factors –rainfall, temperature and host presence. He stressed that they are best considered as an exerting their influences in that order of presence. In his study he observed that the rate of all developmental processes in some vectors as observed by Brewster (1999) are directly regulated by rainfall and temperature, being accelerated when temperatures are raised and retarded when they are lowered.

In a similar study carried by Brewster (1999) he noted that the weather has an effect on the prevalence of malaria by influencing the development and distribution of the vectors transmitting it. Clearly, weather and climate not only limits the distribution of many vectors but may also, due mainly to variations in temperature and photoperiod, cause differences in the biology of different populations of the same species(Brewster, 1999).Levine was concern mainly with the effects that short-time meteorological fluctuations(weather),have on vector biology and he feasibility of predicting both the vector behavior and also the trends in population size by the study of weather conditions.

2.3.1 Malaria in India

Malaria is endemic in all of India except at elevations above 1800 meters and in some coastal areas (Sharma, 1996c). In most parts of the country, periodic epidemics of malaria occur every five to seven years (Sharma et al., 1994). Although the total number of cases of malaria in India has stabilized somewhat over the past ten years, there has been an increase in the number of P. falciparum cases (Pattanayak et al., 1994). 65% of malaria infections in India are caused by P. vivax and 35% are caused by P. falciparum (Kabilan, 1997). P. falciparum malaria has a shorter average incubation phase in the mosquito vector, thus speeding up transmission between people by limiting the time in the interim phase. P. falciparum also causes the most fatal type of malaria (Pampana, 2002).

The estimated economic loss due to malaria in India from 1990-1993 is $506.82 million to $630.82 million (Sharma, 1996c). India has spent up to 25% of its health budget on malaria control from 1977-1997, and starting in 1997, India planned to spend $40 million on malaria control, a 60% increase from the previous year. This expenditure is part of a five year program aimed to target 100 districts where 80% of all P. falciparum cases occur (Jayaraman, 1997)70-80% of the malaria control money in India is spent on insecticides (Dhingra et al., 1998).India started using DDT to control malaria in 1946. In 1953, when 70 million cases and 0.8 million deaths occurred due to malaria (NMEP, 1996), the National Malaria Control Program was created. This program was renamed the National Malaria Eradication Program (NMEP) in 1958 due to the success of DDT and the commitment to malaria eradication in India at that time. The NMEP believed that it could eradicate malaria in seven to nine years, but malaria began to re-emerge in 1965 (Dhingra et al., 1998).After 1965, malaria rates in India rose gradually and consistently with a peak of 6.47 million cases in 1976 (NMEP, 1996). This resurgence of malaria caused India to begin an attempt to control rather than eradicate malaria in 1977 with the Modified Plan of Operation (MPO) which also comprised the P. falciparum Containment Programme (PfPC).The PfPC aimed to contain the spread of falciparum malaria, which is the most commonly resistant and most deadly strain of malaria (Satpathy et al., 1997).During MPO, chloroquine distribution was extended through Fever Treatment Deport and Drug Distribution Centers in addition to the other ways that malaria drugs had already been distributed.MPO also only used residual insecticides in areas with an API (Annual Parasite Index) above two (Satpathy et al.1997).

This method still relied mainly on spraying pesticides and distributing anti-malarial drugs, although there was also an attempt to get more local officials involved in anti-malarial activities and an increase in research (Barai et al., 2002).By 1985, it seemed as though the NMEP would succeed in controlling malaria because there were only 2 million cases of malaria and the incidence rate had stabilized. India has, however, experienced more epidemics and deaths from malaria in the 1990's along with the creation of new malaria paradigms (Dhingra etal 1998).In 1994, there were large-scale epidemics of malaria throughout India, and since then malaria mortality has increased. Although the total number of cases of malaria has remained relatively constant for the last five years, outbreaks have increased the number of malaria deaths (Dhingra et al., 1998). P. falciparum cases have also consistently increased from 9.73% of malaria cases in 1977 to 34.5% of cases in 1995 with a peak of 43.3% in 1991 (NMEP, 1996). In 1995, India implemented a Malaria Action Plan (Satpathy et al., 1997).Resistance to pesticides was first noted in India in 1959. However, it was only as resistance increased in a real extent and amount, that it started to affect the success of the eradication program. In the 1960s, because the eradicate program was doing so well, malaria research stopped. Also, as resistance to DDT increased, so did the use of alternative insecticides, which later cause the emergence of vectors resistant to those insecticides. As of 1996, individuals of Anculicifacies, one of the six most important vectors of malaria in India, had been found resistant to DDT in 18 states and 286 districts, to HCH (hexachlorobenzene) in 16 states and 233 districts, and to Mutation in 8 states and 71 districts. An. Stephens, another important malaria vector in India, was found resistant to DDT in 7 states and 34 districts, to HCH in 6 states and 27 districts and to malation in 3 states and 8 districts (Sharma, 1996c).

The use of some of the same pesticides in agriculture could have increased the speed with which malaria-transmitting mosquitoes became resistant (Dhingra etal 1998).

Not only does resistance limit the effectiveness of pesticides in malaria control, but pesticide prices are increasing and India only makes 30% of its DDT domestically. Therefore, pesticides are not an economically unsustainable malaria control technique for India (Sharma, 1996c). Pesticides are also toxic to humans and the environment. Currently, 70% of all insecticides in India are DDT and BHC (benzene hex chloride), and their use is increasing at a rate of 6% a year in India. Both of these pesticides are persistent, and accumulate in Soil, water, and biological organisms, and thus were banned in the US. Due to the increasing use of DDT and BHC in India, food contamination is expected to increase. However, the NMEP reports that there has been "no adverse reaction of DDT on human health" (NMEP, 1996).

2.3.2 Regional Studies on Malaria and weather influence

In Africa for example Houghton (1994) observed that the weather was drier than at present, particularly in lands now semi-and or sub-humid rainfall being a third of the present amount and temperature between 4 – 6^{oC} lower. The Sahara desert was smaller, size and Lake Chad bigger cultural, environment and hydrological Indications, observed Nicholson (1989) all suggest that from Mauritania cast-ward to Ethiopia, conditions significantly more humid than the current one prevailed from the thirteen century.

According to Najera etal (1998) said that malaria transmission differs in intensity regularity depending on the weather elements such as rainfall patterns, proximity of mosquito breeding sites and mosquito species. Some regions have a fairly constant number of cases throughout the year whereas in other areas malaria season, usually coinciding with the rainy season. Similarly, Freeman etal (1996) said that large and devastating epidemics can occur in areas where people have had little contact with malaria parasites, and be trigger and therefore have little or no immunity. These endemics can be triggered by weather conditions and further aggravated by complex emergencies or natural disasters. In a similar study, in a similar study, Oaks etal (1991) said that the mosquito that carry malaria breed in warm stagnant water if it's below about 15^{oC} then they can't survive, and if it is too dry then can't survive. So they need hot and rainy weather, with stagnant water stagnant water forming, for example in pools or water but.Similarly,Freeman(1994) said that malaria is influence by weather especially when there stagnant water due to rain or drain that plugged.

According to Ogunkayode etal (1999) said that "the risk of epidemic in Africa increases dramatically shortly after a season of good rainfall-when the heat and humidity allow mosquito populations to thrive. By using a number of climate models, weather predictions could be used to calculate the severity of an epidemic, months before its occurrence. Weather and its effects on food security, water and quality and the distribution of ecological systems may have wide ranging and potentially adverse effects on human health.

2.3.3 Time-series studies

Mean temperature, night-time temperature, temperature in combination with rainfall, and mean November and December temperature, were found to be related to malaria in Zimbabwe, the Debre Zeit sector of Ethiopia, Rwanda, and the Northwest Frontier Province in Pakistan, respectively (Freeman and Bradley, 1996; Freeman, 1995; Loevinsohn, 1994; Bouma et al., 1996). In Pakistan, rainfall along with humidity in December, predicted malaria rates fairly well (Bouma et al., 1996). In a more qualitative study, climate and forest clearing were alleged to be related to malaria rates in the Usambara Mountains of Tanzania (Matola et al., 2001). One study in the highlands of Kenya claimed that climate was not a factor in malaria transmission there because average temperature and rainfall did not change during the time that malaria rates changed. According to the study, deforestation might have been a reason behind changes in malaria transmission in the highlands of Kenya (Kigotho, 1997).

Another study in Kenya found that soil moisture correlated with the human-biting rate of malaria vectors with a two-week time lag which was explained as the length of time it takes for mosquito larvae to develop. This same study also found that soil moisture correlates with entomological inoculation rate (which is the product of the human-biting rate and the proportion of female mosquitoes carrying infective parasites in their salivary glands ready to be delivered to the next host) with a six-week time lag. Six weeks is the amount of time necessary for the development of the infective parasites in the mosquito plus the length of time the mosquito survives (Patz et al., 1998).

2.3.4 Studies of Epidemics

Three studies of epidemics of malaria in different areas of the highlands of Kenya found that increased rainfall was related to the epidemic, although one of the studies also claimed that increasing drug resistance had an effect, and another study found that increasing temperature and relative humidity were also involved (Freeman etal, 1996)

An epidemic in Ethiopia was attributed to higher temperatures, rainfall and relative humidity than in previous years. The study of this epidemic also noted that although the epidemic was associated with higher rainfall, this was not always true for that area because in 1993 there was excess rainfall but no malaria epidemic, whereas in 1984-5, there was high malaria incidence but very little rainfall (Ogunkayode,1999).One study of a malaria epidemic in the highlands of Madagascar claimed that the epidemic was caused by anthropogenic climate change, but no statistics were shown to defend this assertion (de Zulueta, 1994). Two other studies of highland malaria epidemics in Madagascar related these epidemics to lack of anti-malarial medications, lack of control techniques, and low levels of immunity in the population due to little previous exposure to malaria (Freeman, 1994) found that increasing temperatures were related to malaria in a highland area of Burundi. Near the Manyuchi dam in Zimbabwe, high winter temperatures were found to be related to increases in malaria rates, but many other factors could be confounding this result (Freeman,1994).In Irian Jaya, malaria epidemics in the highlands correlated to population movements and increased mosquito breeding grounds while meteorological variables remained constant (Anthony et al., 1992; Bangs et al., 1996).

A large group of studies relate the El Niño Southern Oscillation (ENSO) to malaria epidemics. Many areas have experienced periodic malaria epidemics every five to eight years, which may have been related to the ENSO cycle. Malaria epidemics in the former British Punjab, Pakistan, Sri Lanka, the highlands of Uganda, Columbia, Argentina, Ecuador, Peru, and Bolivia were proposed to be associated with ENSO cycles (Bouma et al., 1994; Bouma and vander Kaay, 1995; Bouma et al., 1995).

The results of all of these studies reveal that more research needs to be done on the causes of epidemics or increases in malaria transmission, taking into account all of the factors that could be relevant to malaria. It is important to add that, although many of these studies found a link between climatic variables and malaria, it is hard to extrapolate each of those findings to an assertion that anthropogenic climate change is the cause of the changes in meteorological variables that were found to be related to changes in malaria rates. These changes could be smaller time scale changes which could just be related to inter annual variability or just changes in weather. Understanding the relationships between climate and malaria in an area may allow prediction of when there are likely to be malaria epidemics.

2.3.5 Modeling

Several mathematical and computer models have attempted to link all of the factors that affect malaria transmission in order to predict the effect of predicted global climate change on malaria. One such model relates variables associated with human-induced climate change (temperature, precipitation, relative humidity, and wind), environmental factors (drought and desertification, sea level rise, changing vegetation, and agricultural practices), the parasite development rate, the vector population (death rate, breeding places, density, and insecticide resistance), and the human population (migration, spread of drug resistance, change in immune status, and spread of pathogens into new areas) (Martens, 1998).

Vectorial capacity is often used to determine the degree of malaria risk posed by the specific vectors in the area (Singh et al., 1990). Martens (1998) created an equation that calculates the vectorial capacity multiplied by the duration of the infectious period in humans, which is called the basic reproduction rate (Ro) of malaria in the area. The factors that are involved in the calculation of Ro include: the ratio of mosquitoes to people, the number of mosquito bites per person per day, and the efficiency with which an infected mosquito infects a human, the chance that a mosquito becomes infected during a blood meal, the incubation period, and the daily survival probability of the mosquito. Indirect factors that affect the ones that are listed above include: the availability of breeding sites which is related to precipitation, human population density, human population migration; the feeding habits of the mosquitoes; the presence of other animals on which the mosquitoes feed; human exposure which can be affected by the use of bed nets or other interventions; temperature; the immunological and nutritional status of the population; the effectiveness of medical treatment; natural enemies of the mosquitoes; and control efforts. This model is further complicated by algorithms that predict changing genetic adaptations in the parasite and vector that lead to resistance.

This model predicts that the number of people in developing countries that are likely to be at risk of malaria infection will increase by 5-15% because of climate change, depending on which the Global Circulation Model (GCM) and climate change scenario is used. The areas that are expected to have the most increase in malaria transmission are ones that are at the fringes of transmission now. These areas, because they have low levels of immunity, will likely experience epidemics unless they are able to use control efforts to effectively reduce the impact of the epidemics, this model, however, still needs to be better validated (Martens, 1995).

2.4 An Overview of weather influence and Malaria in Nigeria

2.4.1 Nigeria and Weather influence

In Nigeria for example, Freeman (1995) carried out a study on the distribution on malaria in Nigeria in relation to weather-climate and vegetation zones. They discovered that the disease throughout the country has a seasonal pattern base on the local weather and climate of the zone. They also observed that everywhere in Nigeria the severity of the disease transmission varies from year to year depending on the local rainfall conditions affecting surface water availability. Adefolalu (2000) was able to show that the effects of harmattan dust on human health were not much of a problem before 1975. at Akure, In 1981/82, when about 45% of annual cases of respiratory problems occurred during the harmattan, the monthly totals of In-patients were 70 and 88 in February and March 1982 and a total number of in and out patients range between 36 and 177 per month during the period. In warring available medical records for November to march of the harmattan season of 177 to 1980 gave an average of between 27 and 63 In-patients per month over the three-year period. The Incidence of deaths, Injuries, psychological disorders, and exposure to chemical pollutants in water supplies would Increase if extreme weather events (e.g., droughts and floods were to become more frequent and Indeed, it did. In 1995 and 1996, 8,300 and 8340 lives were, lest respectively to weather events (Nicholson, 1989). China lost about 2 million house and over 2,000 baits sank.

El-nino was found to exert great global burden on natural disasters, especially on drought and related food shortages. It also linked to world food crises because it affects many countries at the same time (McMichael, 1996).Rainfall anomalies in West Africa are also related to El Niño (southern oscillation (ENSO) events Ogunkayode, (1999). The Indirect affects Include Increase in the potential transmission of vector borne diseases (e.g., malarias, yellow fever and some viral encephalitis cause by extension of the ranges and seasons of vector organisms.

Weather elements would also accelerate the maturations of certain Infection parasites (e.g. The malaria organism) some Increases In non-vector borne Infectious diseases such as salmonellosis, cholera and other food and water-related Infections could occur, particularly in tropical and subtropical regions because of climatic Impacts on water distribution, temperature and micro-organisms there are other likely Indirect effects, which Include diseases in asthma, allergic disorders, cardio respiratory diseases and associated deaths. These might result from climate-: Induced changes in pollens and spores and from temperature. Increases that enhance the formation, persistence and respiratory Impact of certain air pollutants. Exposure to air pollution and stressful weather events combine to Increase the likely-hood of morbidity and mortality. Despite great advancement in technology, sophistication in medical procedures in European countries, and of courses its position on the globe and relatively low temperature, experience resurgence of malaria. The resulting increase in global temperatures now alters the complex web of systems that allow life to thrive on earth, such as cloud clover, rainfall, wind patterns, ocean currents and the distribution of plant and animal species. In other words, more of the sun's energy is being trapped in the atmosphere and much more of the world's carbon (in the form of carbon dioxide) is resting in the air rather than in trees, soil and subterranean deposits. As a result, we now have frequent forms of coastal flooding; more heat waves, storms and drought; less frost, snow and polar ice; more people at risk of food and water shortage; reduced habitat for many plant and animal species and more people exposed to infectious diseases, for instance malaria.

The deplorable situation is already having a devastating impact on the health and living conditions of peoples in the tropical regions, where diseases like malaria and yellow fever have become rampant. In the Arid regions on the other hand, cerebrospinal meningitis, measles and small pox virus killer diseases are now prevalent. To put it succinctly, weather events has increased the frequency of floods, warming and drought, all of which are factors in disease transmission. Of course, the impact is seriously being felt in Nigeria. It is evident that from the mangroves and rainforests on the Atlantic Coast in the South to the Savannah in the North bordering the Sahara, Nigeria has a variety of ecosystems. While excessive flooding in recent times has impacted negatively on farming in coastal communities, desertification is simultaneously rampaging the Sahel. Traditionally, desertification in the Sahel has been blamed on overgrazing practices of the local population. But recent evidence suggests that the bigger problem really is the influence of weather. Rainfall in the Sahel has been declining steadily since the 1960s, resulting in the loss of farmlands and more frequent conflicts between farmers and herdsmen over decreasing land. It is not in doubt that its impact is severely affecting livelihoods in Nigeria by altering seasonal rainfall patterns. Consequently, streams and springs are drying up, causing major reductions in crop yields leading to severe food shortages.

From another dimension, this has also worsened the situation in Nigeria's fragile power sector. Insufficient rainfall and low groundwater recharge rate especially lower volume of water in the rivers and dams have greatly impaired hydroelectricity generation. Given that this source of water alone (rainfall) accounts for about 36% of Nigeria's energy source, what comes out is a picture of a gloomy future especially if decisive actions are not immediately taken to address this problem.

2.4.2 General considerations on malaria

Malaria is a common and life-threatening disease in many tropical and subtropical areas. It is currently endemic in over 100 countries, which are visited by more than 125 million international travellers every year. Each year many international travellers fall ill with malaria while visiting countries where the disease is endemic, and well over 10,000 fall ill after returning home. Fever occurring in a traveller within three months of leaving a malaria-endemic area is a medical emergency and should be investigated urgently.

2.4.3 Cause

Human malaria is caused by four different species of the protozoan parasite Plasmodium: Plasmodium falciparum, *P. vivax, P. ovale* and *P. malariae*.

2.4.4 Transmission

The malaria parasite is transmitted by various species of Anopheles mosquitoes, which bite mainly between sunset and sunrise.

2.4.5 Nature of the Disease

Malaria is an acute febrile illness with incubation period of 7 days or longer. Thus, a febrile illness developing less than one week after the first possible exposure is not malaria. The most severe form is caused by *P. falciparum,* in which variable clinical features include fever, chills, headache, muscular aching and weakness, vomiting, cough, diarrhoea and abdominal pain; other symptoms related to organ failure may supervene, such as: acute renal failure, generalized convulsions, circulatory collapse, followed by coma and death. It is estimated that about 1% of patients with *P. falciparum* infection die of the disease. The initial symptoms, which may be mild, may not be easy to recognize as being due to malaria.

It is important that the possibility of falciparum malaria is considered in all cases of unexplained fever starting at any time between the seventh day of first possible exposure to malaria and three months (or, rarely, later) after the last possible exposure, and any individual who experiences a fever in this interval should immediately seek diagnosis and effective treatment. Early diagnosis and appropriate treatment can be life-saving. Falciparum malaria may be fatal if treatment is delayed beyond 24 hours. A blood sample should be examined for malaria parasites. If no parasites are found in the first blood film but symptoms persist, a series of blood samples should be taken and examined at 6-12-hour intervals. Pregnant women, young children and elderly travellers are particularly at risk. Malaria in pregnant travellers increases the risk of maternal death, miscarriage, stillbirth and neonatal death. The forms of malaria caused by other *Plasmodium* species are less severe and rarely life-threatening. Prevention and treatment of falciparum malaria are becoming more difficult because *P. falciparum* is increasingly resistant to various ant malarial drugs. Of the other malaria species, drug resistance has to date been reported for *P. vivax*, mainly from Indonesia (Irian Jaya) and Papua New Guinea, with more sporadic cases reported from Guyana. *P. vivax* with declining sensitivity has been reported for Brazil, Colombia, Guatemala, India, Myanmar, the Republic of Korea and Thailand. P. malaria resistant to

2.4.6 Geographical Distribution

The risk for travellers of contracting malaria is highly variable Latin America and the Caribbean, Asia and the Mediterranean region, the main urban areas, but not necessarily the outskirts of towns, are free of malaria transmission. However, malaria can occur in main urban areas in Africa and India. There is usually less risk of the disease at altitudes above 1,500 metres, but in favourable climatic conditions it can occur at altitudes up to almost 3,000 metres. The risk of infection may also vary according to the season, being highest at the end of the rainy season (Anthony etal, 1992).

2.5 Malaria Situation in Nigeria

As contained in National Anti malaria treatment (2005) malaria which is an Infectious disease caused by the parasite of the genus plasmodium is the most common cause of hospital attendance in all age groups in all parts of Nigeria. It is also one of the four commonest causes of child hood mortality in the country, the other three being acute respiratory Infection (pneumonia), diarrhoea and measles. It is estimate that 50% of the population has at least one episcope of malaria each year while children under 5 have on the average of 2-4 attacks in a year. Malarias have severe negative effects on maternal health and birth outcomes. It causes maternal anaemia Increase miscarriage and how birth weight. Plasmodium (p) falciparum is the most predominant parasite specie accounting for about 98% of malaria cases in the country due to favourable environmental conditions. P malariae usually occurs as a mixed Infection with P. Falciparum. Anopheles gambiae is the main vector of malaria in Nigeria but A funestus and an, arabiensis are also commonly encountered. A melas is found in the coastal areas.

Malaria is characterized by a stable, perennial transmission in all parts of the country. Transmission is higher in the wet season, than in the dry season. This seasonal difference is more striking in the northern part of the country.

2.5.1 Economic Burden

Malaria Impedes human development and is both a cause and consequence of under development. Every year, the nation loses over N132 billion from cost treatment and absenteeism from work, schools and farms. There is a high rate of malaria endemicity; the country carries over 15 of the sub-Saharan burden of the disease with a population of about 150 million and a growth rate of 3.2% per annum. The country looses about

1.15b due to treatment of malaria and other malaria related cases. (National Ant malaria Treatment, 2005)

2.5.2 Malaria situation analysis in Nigeria

As contained in malaria situation analysis-FMOH (2000)

- The perception of the cause of malaria is poor and few people in the community link mosquito to malaria.
- 80% of malaria cases are inadequately managed at community level by the facility and home based caregivers.
- 96% of care givers Initiated actions within 24 hours but only 15% of their actions are appropriate due to inadequate dosage.
- 60% of moths had no knowledge of the current management of convulsions. Only 5% referred such cases to hospital while most either go to traditional healers or use traditional home made concoctions.
- 85% of health facilities survey in rural areas had stock-out. None had pre-packaged drugs.
- Poor laboratory support in cyanosis of malaria and 40% of patients with
- Severe malaria dies to poor quality care.
- Treatment of malaria illnesses accounted for 46% of the curative health care cost Incurred by households with, a main of N330.00 per month.
- Record keeping and reporting malaria is poor in the country.

2.5.3 Epidemiology

Situated between 4^{oC} and 13^{oC} Northern latitude Nigeria has a suitable climate for malaria transmission throughout the country. The only exception is the area south of Jos in plateau state where some mountain peaks reach 1600m and the altitude of settlements lies between 1200 and 1400m. This area can be considered of low or very low malaria risk. These five ecological strata from south to North define vector species dominance, seasonality and intensity of malaria transmission. Mangrove swamps, rain forest, guinea-Sudan-and Sahel-savannah.Accordingly, this duration of the transmission season decreases from south to North, from perennial in the most of the south to only 3 months or less in the border region with Chad. The dominant species of malaria parasites is plasmodium falciparum (95%) with P. Ovale and P. Malaria playing a minor role with the latter being quite common as a double Infection in children.

Dominant vector species are Anopheles gambiae s.l and the A Funestus group with some other species plying a minor local vole A. Mooched, A, nili A, pharacensis, A, coustani, A, Hancock and A, longipalpis. Within the Anopheles gambiae complex A, gambiae S.S is the dominant species with A, arabiensis being found more often in the North and A. Melas only in the mangrove coastal zone. There are 86 studies from Nigeria suggests that entomological Inoculation rate (EIR) for A.Gambiae S.I ranges from 18 to 145 Infective bites per person per year and for A. Funestus from 12 to 54,Based on the climatic and ecological data and historical data on malaria parasite prevalence rate. The distribution of malaria prevalence rate suggests that malaria endemicity is highest around the two river valleys. Taking into account this distribution as well as the population density it can be estimated that approximately 30% of the population lives in areas of high to very high transmission Intensity and 67% in the moderate transmission zone and these proportions have been used in the calculations. It results in an estimated number of fever and malaria episodes per person and year of at 3.5 and respectively for children under 5 and 0.5 for those 5 years, and older and a total of 70-110 million clinical cases per year. The current malaria related annual deaths for children less than 5 years of age are estimated at around 300,000 and 11% of maternal mortality. Malaria's economic Impact is enormous with about N132 billion lost to malaria annually in form of treatment costs, prevention, and loss of man hours. (National Anti malaria Treatment, 2005).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

The data for this research work were collected from both the primary and secondary sources. The primary source consists of the field work undertaken by the researcher while the secondary source consists of information from government parastatals, ministries, libraries and other relevant establishments. The study was based on three types of data.

(1) The prevalent data obtained through the used of questionnaire administration.

(2) The in and- out patients data treated for malaria.

(3) The seasonal variation of Rainfall and temperature data of the study area.

3.1.1 Method of data Collection

Questionnaire distribution was based on the number of units' endemic of malaria disease in Makera, Kpakungu and Chanchaga in minna metropolis. A total of 110 questionnaires were randomly administered, Fourty, thirty and forty Questionnaires per each area respectively the questionnaires were filled and returned. The responses of recipients to each of the questions in the questionnaires form the data for analysis.

3 1.2 Data on prevalence of malaria

The data on malaria prevalence obtained for the month of January to December of each year from 1983-2007 and from 1994-2007.The surveys were carried out to record respondents age, sex, occupation, level of education, marital status, duration of residence, the number of persons infected household, duration of infection, severity of the infection,etc were determined and recorded. An infected person was considered incapacitated if, although, found mobile he or she was unable to perform effective routine or daily obligations such as going to office,market,school,farm,shop etc.

3.1.3 The in and-out patients data treated for malaria

The data were obtained from three medical centres: General hospital at Makera were for the month of January to December of each year for the period of 25years (1983-2007).While the data for IBBSH-NAMCITY at Chanchaga and Unity Clinic at Kpakungu were only available for the month of January to December (1994-2007) of each year for the period of 14years respectively.

3.1.4 Climatic data

The climatic data were also extracted from various sources: such as climate change centre and Dept of geography, Federal University of Technology Minna. These data include: rainfall and temperature. The climatic parameters were collected on daily, and monthly, basis for the period of 1983-2007. The data collected lent themselves to the analysis of the statistical relationship between various climatic parameters and number of malaria cases

3.2 Data analysis

3.2.1 Regression and Correlation Analysis

The simple linear regression and correlation analysis were used to determine the relationship between climatic parameters and the number of malaria cases in the study area. The variant used express the relationship between the dependent and independent variables as

$$y = \beta_o + \beta_1 x$$

To determine β_o, β_1 and □

$$\beta_o = \bar{y} - \beta_1 \bar{x}$$

Where $\bar{y} = \frac{\sum y}{n}$

$$\bar{x} = \frac{\sum x}{n}$$

$$\beta_1 = \frac{n\sum_{i=1}^{n} xy - (\sum_{i=1}^{n} x)(\sum_{i=1}^{n} y)}{n\sum_{i=1}^{n} x^2 - (\sum_{i=1}^{n} x)^2}$$

$$y = \beta_o + \beta_1 x$$

$$y = (\bar{y} - \beta_1 \bar{x}) + \frac{n\sum_{i=1}^{n} xy - (\sum_{i=1}^{n} x)(\sum_{i=1}^{n} y)}{n\sum_{i=1}^{n} x^2 - (\sum_{i=1}^{n} x)^2}$$

$\sum x$ = sum of the mean of the climatic parameters (independent variables)

$\sum y$ = sum of the mean of the malaria cases

$\sum xy$ = sum of the product of the rainfall/ temperature and malaria cases

n = number of observations (number of years)

x = climatic parameters (independent variable)

y = cases of malaria disease (dependent variable)

The Correlation Analysis is given as

$$r = \frac{n\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

Where $\sum x$ = sum annual/monthly rainfall total

$\sum y$ = sum of the cases of the diseases

$\sum x^2$ = sum of the squared values for variable x

$\sum xy$ = sum of the product of corresponding x and y values

n = number of observation (number of years)

r = coefficient.

CHAPTER FOUR

RESULTS

4.0 Introduction

The Result of the study includes the following tables below that indicate the Questionnaire responses from the study areas. The questionnaire was essentially aimed at identifying unknown problems relating to the disease, study area and influence of weather in minna metropolis. Questionnaire distribution was based on the number of units' endemic of malaria disease in each area .A total of 110 questionnaires were randomly administered, fourty, thirty and forty Questionnaires per each area respectively and a total of 95 (86.4%) were filled and of these 78 respondents or (82.1%) of total sample were suffering from malaria diseases (see table 4.2).Responses and data analysis been carried out. Emphasis here was made on those Questionnaire items that are directly relevant to the objective of the study. As such effort was made at analysing them as briefly as possible .Descriptive statistic, i.e. tables, bar charts and graphs were equally used to analyse some of the data

4.1 Endemic areas

The three endemic areas has other smaller units with Makera ward having four, Kpakungu with three and Chanchaga with three.

Table 4.1 Endemic units in the three areas.

Makera	Kpakungu	Chanchaga
1. Yoruba road	1.Central Kpakungu	1.Kangiwa
2. Igbo road	2.Soge A	2.Gbakwaita
3. Hospital road	3 Soge B	3.Kadina
4. Ketarengwari road		

Source: Author's field survey, 2008

4.2 Number of administered and retrieved questionnaire

Questionnaires were administered to the different units in the three areas selected but not all of the questionnaires were retrieved as some respondent were not ready.

Table 4.2 Number of Questionnaires Administered and Retrieved in the three areas.

Area	Number of units	Number of Questionnaire Administered	Number of Questionnaire Retrieved	Percentage per Area	Percentage study Area
Makera	4	40	35	87.5	18.8
Kpakungu	3	30	25	83.3	22.7
Chanchaga	3	40	35	87.5	18.8
Total	10	110	95		60.3

Source: Author's field surveyed, 2008

4.3 Index of endemicity

The endemic index was generated from the values derived in the retrieved questionnaire.

Table 4.3 Index of endemicity

Area	C Number of units	Y Number of respondents	X Number of infected subjects	Percentage per Area	Over all Percentage (Study area)	$C \times \frac{X}{Y}$ (Index of endemicity)
Makera	4	35	29	82.9	30.5	3.3
Kpakungu	3	25	22	88	23.2	2.6
Chanchaga	3	35	27	77.1	28.4	2.3
Total	10	95	78		82.1	8.2

Source: Author's field survey, 2008

4.4 Malaria endemic in Makera

Makera area has four unit/ward each of which the number of infected persons was surveyed.

Table 4.4 Malaria endemicity in Makera Area

Name of units	Number of infected Persons	Percentage in Makera Area	Percentage Over all (study area)
1.Yoruba road	8	27.6	10.3
2.Igbo road	8	27.6	10.3
3.Hospital road	7	24.1	9.0
4.Ketarengwari road	6	20.7	7.7
Total	29	100	37.3

Source: Author's field survey 2008

4.5 Malaria endemic in Kpakungu

Kpakungu is represented by three units/wards each with its percentage of infected persons.

Table 4.5 Malaria endemicity in Kpakungu

Name of unit	Number of infected persons	Percentage rating in Kpakungu	Over all Percentage in study Area
Central Kpakungu	8	36.4	10.3
Soge A	7	31.8	9.0
Soge B	7	31.8	9.o
Total	22	100	28.3

Source: Author's field survey, 2008

4.6 Malaria endemic in Chanchaga.

Chanchaga also has three units/wards and the number of infected persons and their percentages were derived from the questionnaire.

Table 4.6 Malaria Endemicity in Chanchaga Area

Number of units	Number of infected persons	Percentage rating in Chanchaga Area	Over all Percentage in study Area.
1.Kangiwa	12	44.4	15.4
2.Gbakwaita	6	22.2	7.7
3.Kadina	9	33.3	11.5
Total	27	100	34.6

Source: Author's field survey, 2008

4.7 Malaria cases by season per areas.

There is variation in the number of malaria cases going by the different season and area.

Table 4.7 Number of malaria cases by seasons per Areas

Area	Number-March Dry season	April-July Early rainy season	August-October Late rainy season	Total
Makera	5	16	8	29
Kpakungu	3	13	6	22
Chanchaga	4	16	7	27
Total	12	45	21	78
Percentage	15.4	57.7	26.9	loo

Source: Author's field survey, 2008

4.8 Prevalence of Malaria disease by sex.

Prevalence of malaria shown by the three areas is more pronounced in the female sex group.

Table 4.8 Prevalence of malaria disease by sex

Sex	Makera	Kpakungu	Chanchaga	Total	Percentage
Male	12	12	12	36	46.1%
Female	17	10	15	42	53.8
Total	29	22	27	78	100

Source: Author's field survey, 2008

4.9 Prevalence of Malaria by age

Prevalence of malaria by age was derived from the different age groups identified in the field.

Table 4.9 Prevalence of Malaria Disease by Age

Age group(years)	Number of subjects interviewed	S	Percentage per Age group	Percentage of total sample (over all)
<10	25	23	92	29.5
11-25	20	15	75	19.2
26-55	25	19	76	24.4
>55	25	21	84	26.9
Total	95	78		100

Source: Author's field survey, 2008

4.10 Comparison of Malaria disease prevalence among age group.

The questionnaire enables the comparison of malaria disease prevalence among age group in the three areas.

Table 4.10- Comparison of the prevalence of malaria disease among age groups in the three areas.

	Makera	Kpakungu	Chanchaga		
Age group	Number of infected persons	Number of infected persons	Number of infected persons	Total	Percentage
>10	11	7	5	23	29.5
11-25	4	4	7	15	19.2
26-55	6	5	8	19	19.24
>55	8	6	7	21	26.6
Total	29	22	27	78	100

Source: Author's field survey, 2008

4.11 Productivity before Malaria infection.

Productivity before malaria infection in the three area were generated based on the amount earned per annum.

Table 4.11 Income or productivity before malaria infection.

Area	>200,000 Per annum	N150-200,000 per annum	N100-150,000 per annum	N50-100,000 per annum	<N50,000 per annum	Total
Makera	6	5	8	4	6	29
Kpakungu	5	3	6	3	5	22
Chanchaga	6	5	7	4	5	27
Total	17	13	21	11	16	78
Percentage	21.8	16.7	26.9	14.1	20.5	100

Source: Author's field survey, 2008

4.12 Productivity during Malaria infection.

Productivity during malaria infection was also generated based on the answers to the questionnaire.

Table 4.12 Income or productivity during malaria infection

Area	>N200,000 Per annum	N150-200,000 per annum	N100-150,000 Per annum	N50-N100,000 Per annum	<N50,000 per annum	Total
Makera	3	6	7	5	8	29
Kpakungu	1	2	7	5	7	22
Chanchaga	2	4	6	7	8	27
Total	6	12	20	17	23	78
Percentage	7.7	15.4	25.6	21.8	29.5	100

Source: Author, s field survey, 2008

4.13 Duration of infection

Variation in the duration of malaria infection in the three areas of study.

Table 4.13 Duration of infection

Duration (Weeks)	Makera	Kpakungu	Chanchaga	Total	Percentage
1-2	8	5	10	23	29.5
3-4	10	6	6	22	28.2
5-6	6	7	7	20	25.6
>8	5	4	4	13	16.7
Total	29	22	27	78	100

Source: Author's field survey, 2008

4.14 Severity of Malaria infection in the areas

How severe the malaria infection was in the three communities of study with their percentages.

Table 4.14 Comparison of severity of malaria infection in the three areas.

Degree of illness	Makera	Kpakungu	Chanchaga	Total	Percentage
Very severe	9	8	16	33	42.3
Not very severe	15	5	6	26	33.3
Minor	5	9	5	19	24.4
Total	29	22	27	78	100

Source: Author's field survey, 2008

4.15 Problems enhancing Malaria severity.

So many factors contribute to the enhancement of malaria infection severity.

Table 4.15 Comparison of problems enhancing malaria severity in the three areas.

Problems	Makera	Kpakungu	Chanchaga	Total	Percentage
Poverty	16	5	12	33	42.3
Ignorance	4	3	1	8	10.2
Poor sanitation	6	10	9	25	32.1
Late coming to hospital	3	4	5	12	15
Total	29	22	27	78	100

Source: Author's field survey, 2008

4.16 Occupation of subject infected by malaria

Different people have different occupation and the infection of malaria is more pronounced in some specific jobs or occupation.

Table 4.16 Occupation of subjects infected by Malaria Disease

Area	Civil servants		Unemployed		Tailor		Trader		Student/ Apprentice		Driver		Barber		Farmer		Tot
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	
Makera	14	48.3	4	13.8	1	3.4	2	6.9	3	10.3	1	3.4	2	6.9	2	6.9	29
Kpakungu	9	40.9	3	13.3	2	9,1	2	9.1	2	9.1	2	9.1	1	4.5	1	4,5	22
Chanchaga	12	44.4	5	18.5	2	7.4	2	7.4	1	3.7	2	7.4	2	7.4	1	3.7	27
Total	35		12		5		6		6		5		5		4		78
Percentage	44		15.4		6.4		7.7		7.7		6.4		6.4		5.1		100

Source: Author's field survey, 200

4.17 Mean Malaria cases and Rainfall

A line graph shows the relationship of mean malaria case and rainfall in general hospital.

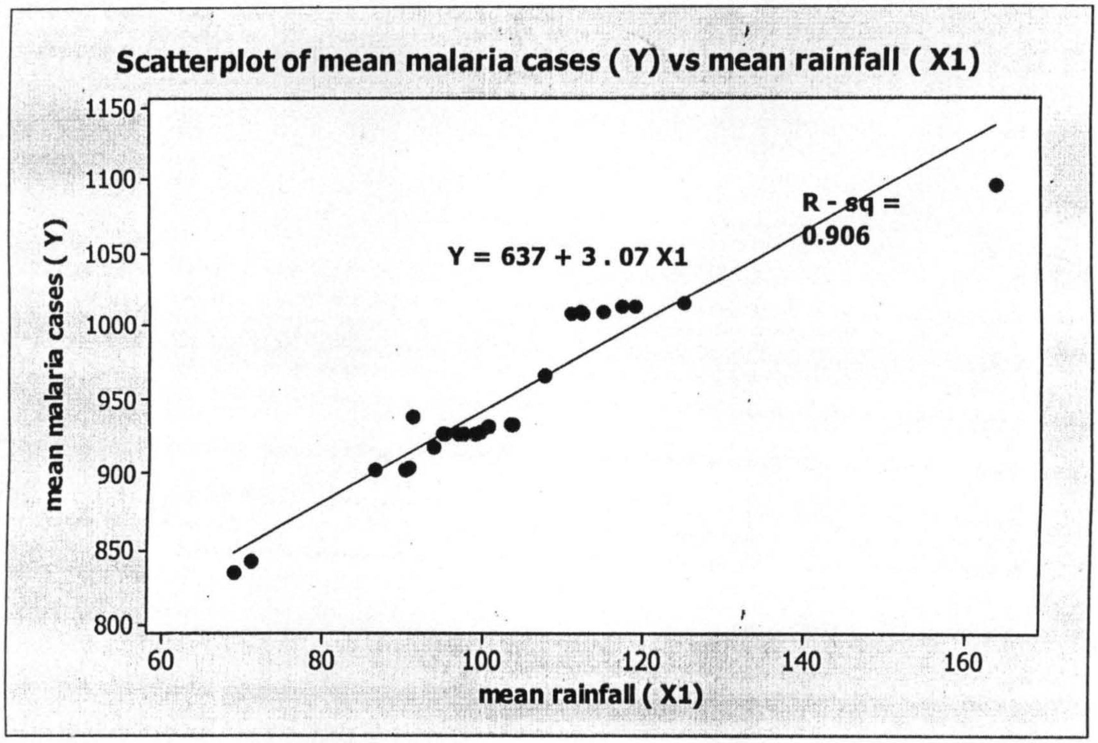

Fig: 4.1 Scatter plots of mean malaria cases against mean rainfall (X1)

4.18 Mean Malaria and mean temperature

Temperature data was used to plot a line graph against the mean malaria case in the general hospital.

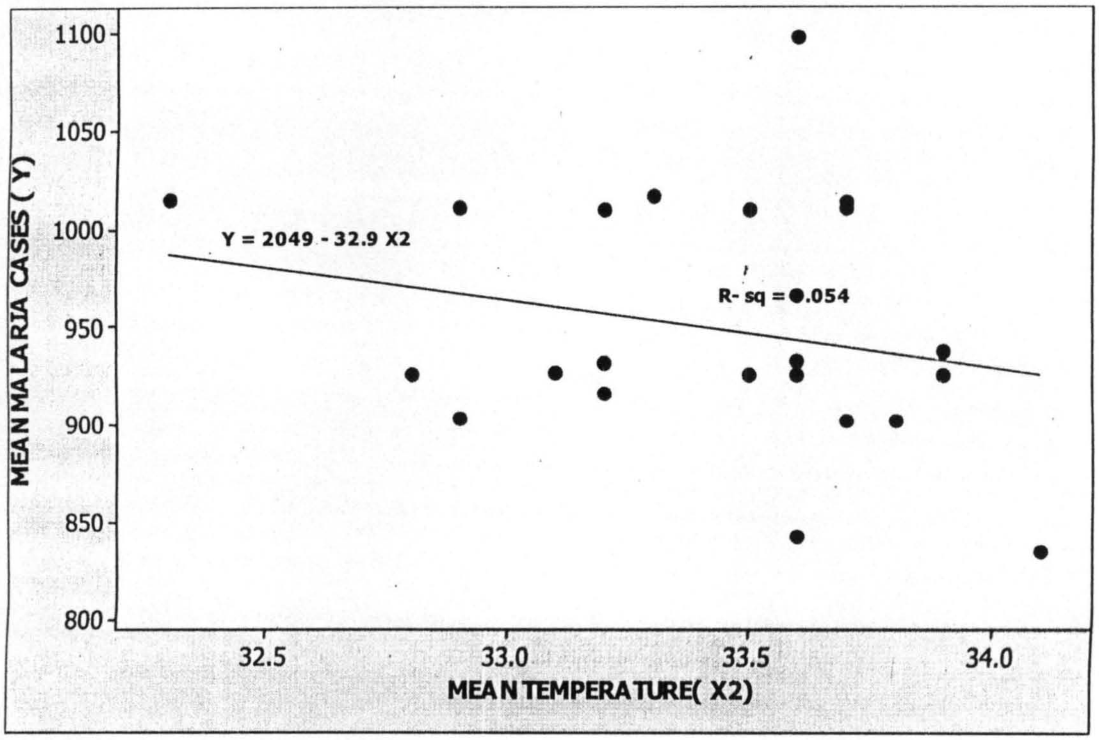

Fig: 4.2 Scatter plots of Mean Malaria cases against mean Temperature (X2)

4.19 Mean Malaria against mean rainfall XII

A line graph shows the relationship of mean malaria case and rainfall in Unity hospital Minna.

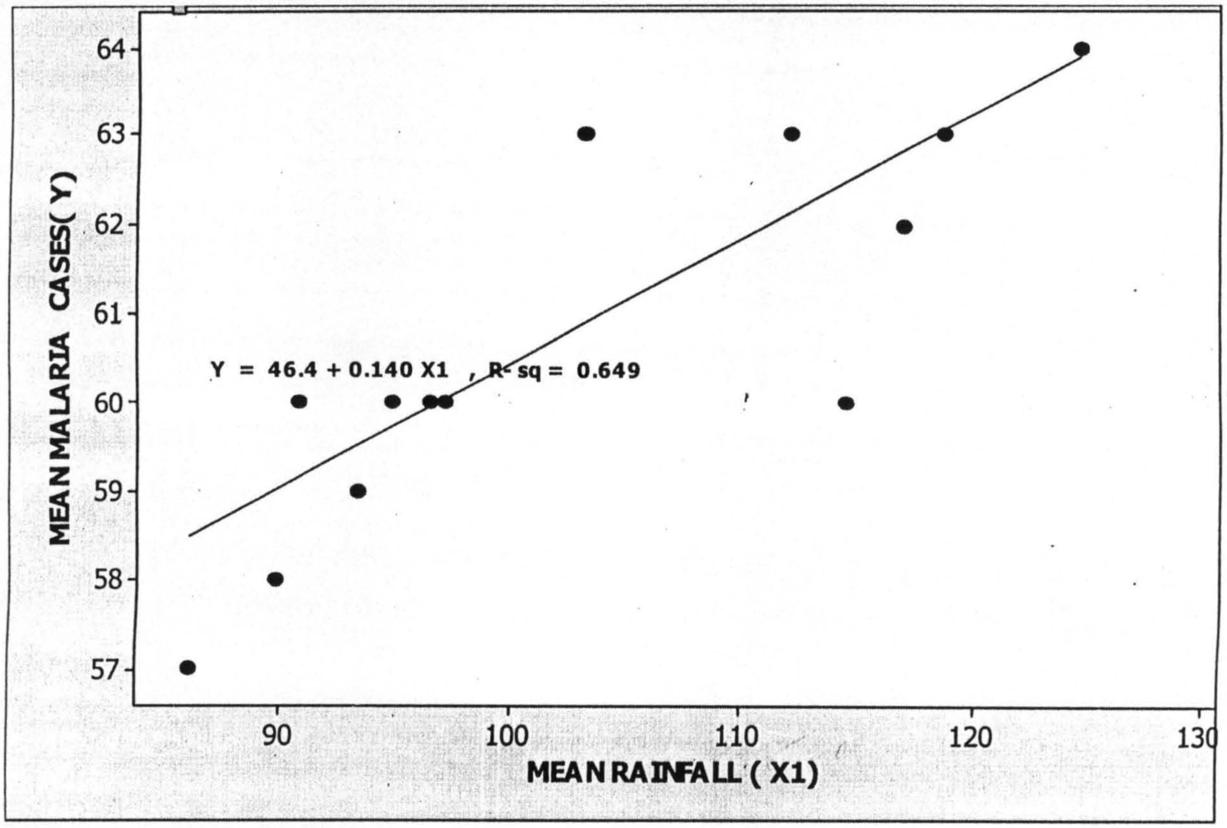

Fig: 4.3 Scatter plots of mean malaria cases against mean rainfall (X1)

4.20 Mean malaria cases and temperature X2

Temperature data was used to plot a line graph against the mean malaria case in the Unity hospital

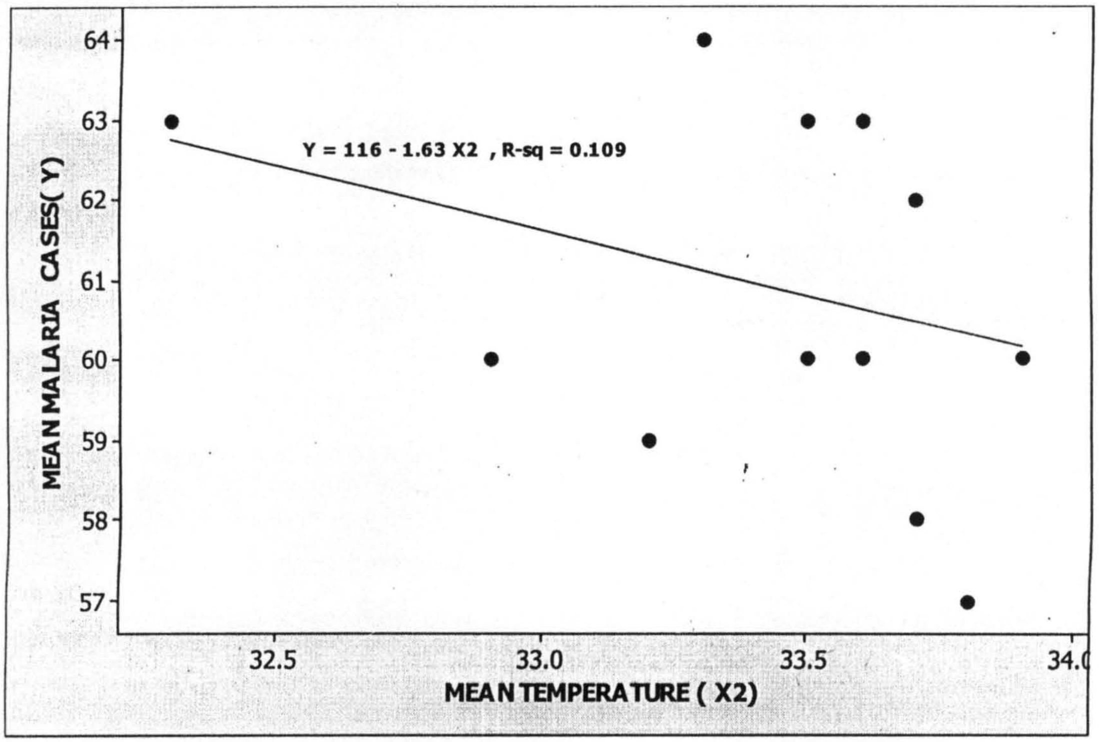

Fig: 4.4 Scatter plots of mean malaria cases against mean temperature (X2)

4.21 Variation in mean malaria and rainfall.

A line graph shows the relationship of mean malaria case and rainfall in IBB hospital Minna.

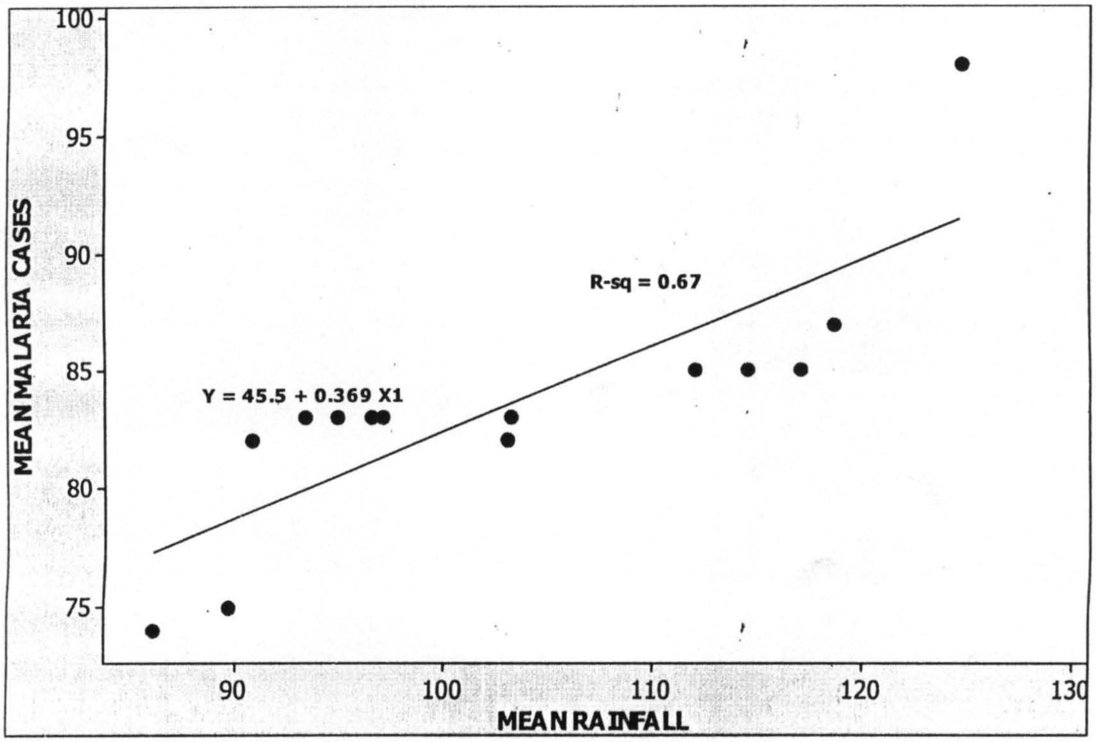

Fig: 4.5 Scatter plots of mean malaria cases against mean rainfall

4.22 Variation of mean malaria and mean temperature

Temperature data was used to plot a line graph against the mean malaria case in the IBB hospital.

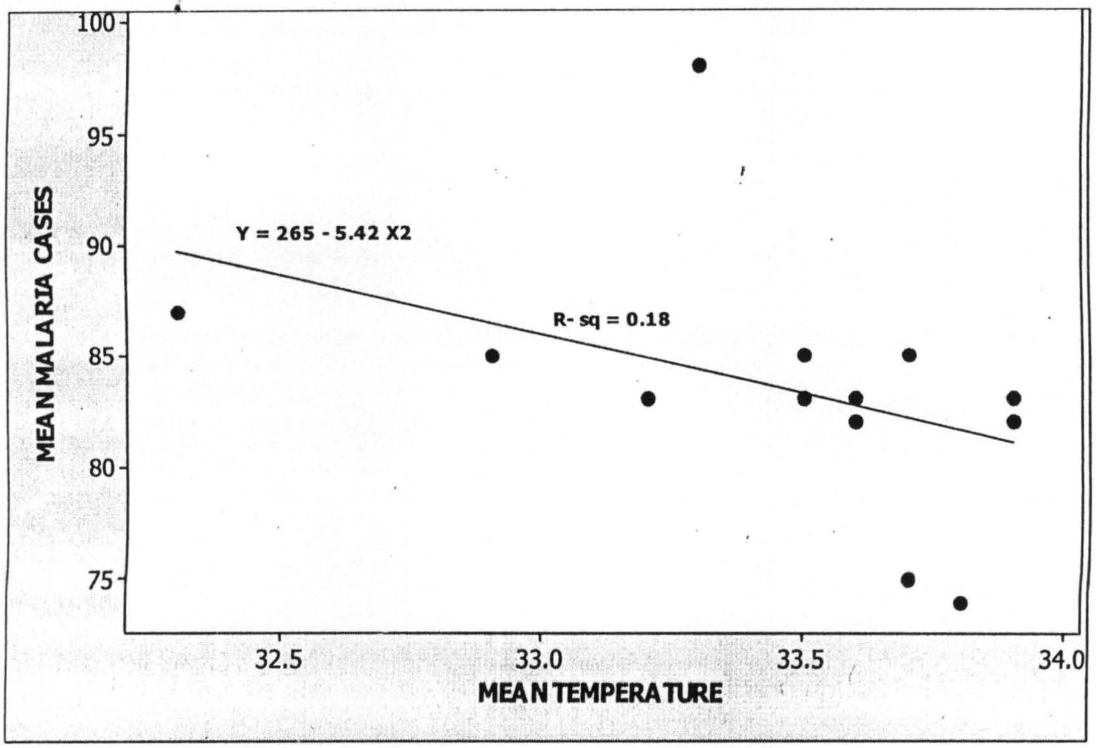

Fig: 4.6 Scatter plots of mean malaria cases against mean temperature

4.22 Variation of mean malaria and mean temperature

Temperature data was used to plot a line graph against the mean malaria case in the IBB hospital.

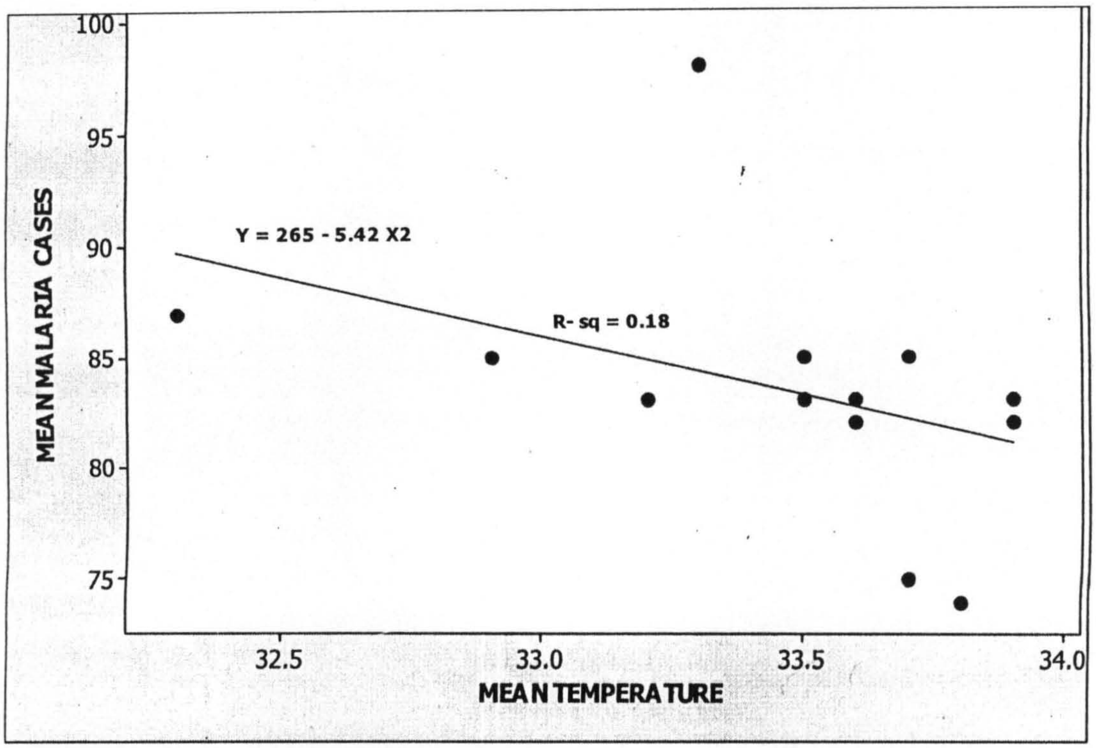

Fig: 4.6 Scatter plots of mean malaria cases against mean temperature

CHAPTER FIVE

DISCUSSION, CONLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter deals with discussion of results, draws up the summary of the research work, the conclusions based on the findings and recommendations made also on the findings, to deal with the situation.

5.2 DISCUSSION

As stated earlier, Questionnaire distribution was based on the number of units' endemic of malaria disease in each area .A total of 110 questionnaires were randomly administered, fourty, thirty and forty Questionnaires per each area respectively and a total of 95 (86.4%) were filled and of these 78 respondents or (82.1%) of total sample were suffering from malaria diseases (see table 4.2).The responses to the questionnaires from the three areas are interpreted and discussed here under: -

5.2.1 General distribution pattern of malaria infection

The three areas under study were Makera; Kpakungu and Chanchaga.These areas were subdivided into units.The units under Makera were Yoruba road, Igbo road, Hospital road and ketarengwari Road.Kpakungun units were Central Kpakungu, Soge A and Soge B.While Chanchaga units were: Kangiwa, Gbakwaita and Kadina. The field survey carried out during the study period revealed that Ten Units in the three Areas are currently endemic of malaria disease.Table 4.1 shows the various endemic units in each area of study. Makera area appeared to be the most endemic with four units while Kpakungu and Chanchaga had three endemic units each (see table 4.1).

5.2.2 Salient features in individual Area covered by the study

5.2.3 Makera Area

Using the index of endemicity (see table 4.3) Shows that Makera Area with an endemicity of 3.3 was not only the most endemic Area in terms of units infected but also in terms of absolute number of subjects infected during the surveyed. Makera With a total of 29 of the 78 infected subjects accounted for 37.2% of the infected persons found during the study in the three areas. The units (Yoruba and Igbo road) in Makera area with a total of 8,8 of infected persons respectively, currently account for 10.3% each over all total recorded in the study area (see table 4.4).Thus, from the index of endemicity table Makera stood out clearly as the hyper-endemic area in the study area.

5.2.4 Kpakungu Area

A total of 22 persons were infected in the three endemic units of central Kpakungu, Soge A and Soge B in Kpakungu area. This accounted for 28.2% of the total number of cases .Kpakungu had an endemicity index of 2.6 (see table 4.3).The table 4.5 shows that the unit of central Kpakungu accounted for 36.4% of the 22 infected subjects in Kpakungu. Soge A and B accounted for 31.8, 31.8 respectively of the infected persons and 9.0% each of over all percentage in the area.

5.2.5 Chanchaga Area

Thirty five (35) Questionnaires were retrieved from Chanchaga area and 27 respondents were infected with malaria disease.Table 4.6 shows that this figure represented 34.6% of the total malaria cases in the study area. The three units, Kangiwa, Gbakwaita and Kadina were the endemic units during the study.Kangiwa accounted for 44.4% (12) of the cases in Chanchaga Area while Gbakwaita and Kadina accounted for the remainder percentage of 22. 2 % (6) and 33.3% (9) respectively. Chanchaga has an endemicity index of 2.3 (see table 4.3).This section tried to satisfy part of the first objective by giving a spatial pattern of the spread of the malaria disease in the study area.

5.3 Variations in malaria cases

The index of endemicity is a quantative expression of the number of the infected persons as against the number of respondents in all the units in each area This is expressed as;

I.E = Index of Endemicity

C=Number of infected units in each area.

X= Number of infected persons

Y= Number of respondents

The implication of this formula was given as hyper-endemic when the calculated I.E is more than or equal to 2.0; highly endemic when the calculated index is between 1.35 and 1.9, midly endemic when the Index is between 1.25 and 1.40 and hypo-endemic when the index is between less than 1.0 and 1.20, the index of endemicity has a direct proportional relationship with the incidence of malaria Disease that is why malaria is the most endemic in all the three study area (Makera, Kpakungu and Chanchaga) of index of endemicity 3.3, 2.6 and 2.3 respectively were classified as hyper-area because their index of endemicity values were more than 2.0 Based on the calculated I.E for each area Makera with highest I.E (3.3) has the highest Spread of malaria disease followed by Chanchaga (2.3) and Kpakungu with the least potential of the Spread of malaria disease in the area.

5.3.1 Seasonal Distribution of malaria Disease

Since the study area is located in the guinea savannah two main seasons predominate, wet (rainy) and dry season. The critical periods with respect to malaria infestation were dry season, early rainy season and late rainy season. During the dry season as observed in table 4.7(which is between November and March) recorded the least number of 15.4%of malaria cases, followed by the late rainy season (August to October) with a record of 26.9% cases of malaria. The early rainy season (April to July) recorded the highest number of cases of malaria disease, 57.7% in the stud area during the surveyed. The transmission period of malaria coincided with early rainy Season (April to July) because of the sufficient stagnant water, bush/dirty environment which serves as breeding sites for mosquitoes. The transmission and infection of malaria disease are a function of the three critical periods of the year. It has long been recognised that weather exert a profound influence on the prevalence and spread of certain disease. Adefolalu (1999) observed that the link between weather and disease is illustrated by the seasonality of such a disease.

5.3.2 Prevalence of malaria disease by sex

Table 4.8 reveals that there was a significant different between male and female infect rate. The combined infection in the three areas for male was 46.1% (with 36 infected males) while that of female was 53.8 %(with 42 infected females) whereas, Makera and Chanchaga area recorded slight higher prevalence rate in female. (17 And 15 infected persons respectively).There is no difference in males' prevalence rate in the three Areas, Makera, Kpakungu and Chanchaga (with 12, 12 and 12 infected males respectively) It is clear and obvious from table 4.8 that both sexes are equally infected. But since female youths and pregnant women are having very reduced immunity in their body systems could be the cause of the high rate of infection in females. Kabilan (1997) reported that pregnant women are highly susceptible to malaria since their natural defence mechanisms are reduced during pregnancy.

5.3.3 Prevalence of Malaria Disease by Age and Economic implications

Table 4.9 shows that while children below 10 years of age accounted for the highest percentage (29.5%) of the total infected persons in the three areas. The adolescence age accounted for 19.2% Of the over all total sample, the older subjects accounted for the remaining 51.3% of the total sample. Of the 25 children interviewed 92. % (23) were infected and of the older from the range of 26-55 and >55 years, 25 each were inter viewed and 19 and 21 were infected respectively. (See table 4.9) shows that the observed highest prevalence rate in children below age 10years was only reflected in the combined study but the comparative study of the various Areas. The Comparative study of the prevalence of malaria by age in the three Areas in table 4.10 revealed that subjects above 10years had lower prevalence rate. Children under 10years in Makera accounted for 37.9% while Kpakungu and Chanchaga accounted for 31.8% and 18.5% respectively. The observed higher prevalence among children under 10years and older subjects above 55 years may be due to their lower immunity in their body systems to withstand the malaria infection Kabilan (1997) reported that in endemic regions where transmission is high, people are continuously infected until they acquired such an immunity; children under the age of 1-5years are highly vulnerable to the disease. This may be the reason why children below 10 years of age accounted for the highest percentage (29.5%) of the total infected persons in the three areas.The children less than 10years and older above 55years accounted for 29.5% (23) and 26.9% (21) respectively. The disease was found to be less endemic in the adolescence (11-25) the youths and adults (26-55) these groups incidentally represented the major productivity age groups. These age Groups together accounted for 34(43.6%) of the 78 infected subjects. In Makera area for Instance, the adolescent, youths and adult age groups accounted for 21(72.4%) out the 29 Infected persons in the area while Kpakungu and Chanchaga, it was 16 (72.7%) and 20 (74.1%) respectively. The infections of the malaria disease on these age groups had a negative impact on the Productivity and development of the infected areas. The prolonged illness affects the Productivity and caused poverty and misery.

5.3.4 Comparison of income or productivity of infected persons before and during infection.

A comparative study of the income of the infected person before and during infection is shown in table 4.11 and 4.12 respectively. It was observed that the Number of those who earned over N200, 000 before infection dropped from 17(21.8%) to 6(7.7%) during infection similarly, the number of those who earned between N100-N150, 000 and the number of those who earned <N50, 000 increases from 16(20.5%) before infection to 23 (29.5%) during infection. This trend was observed in the three areas of study. Thus, the per capital income in the three areas covered is drastically reduced by malaria infestation implying that poverty level of Infected subjects will be high which in turn will make it difficult to access medical treatment.

5.3.5 Duration of infection

As shown in table 4.13, the duration of the infection ranged from 1-8 weeks. About 29% their period lasted for 1-2weeks. 28.2% subjects had their infection period lasting Between 3-4weeks, while 25% and 16.7%had their period lasted for 5-6 and >8weeks respectively.In all the three areas of study, the bulk of the subjects had an infection period of 1-2weeks .The Prolonged illness due to malaria disease had important socio-economic consequences on the affected units. This is because it usually leads to low productivity of good and services.

5.3.6 Comparative of severity of malaria infection in the three areas.

The comparative study of the prevalence of malaria by severity in all the three areas in table 4. 14 revealed that 33(42.3%) of infected subjects were very severely suffering from malaria disease. For instance, 9 (30%), 8 (36.4%) and 16 (59.3%) were very severely suffering from malaria in Makera, Kpakungu and Chanchaga respectively. While 26 (33.3) and 19 (24.4%) accounted for not very severe and minor respectively (see table 4.14)

5.3.7 Comparison of problem enhancing malaria severity in the three areas.

A comparative study of the prevalence of malaria by problems enhancing severity in the three areas in table 4.15 revealed that poverty and poor sanitation accounted for the bulk of the subjects had an infection with 33(42.3%) and 25(32.1%) respectively. Late coming to hospital and ignorance accounted for 12(15.4%) and 8 (10.2%) respectively (see table 4.15

5.3.8 Occupation of subjects infected by malaria Disease.

The bulk of the infected respondents were civil servants. This is obviously so because of the setting of the study area (i.e. state capital).About 44% of these infected was civil servants. This distantly followed by unemployed who accounted for 15.4% of the infected subjects. Both traders and students/apprentice accounted for 7.7%, while tailors, driver and barber accounted for the same percentage 6.4%.Farmer has the least percentage (5.1%) (See table 4.61).In each of the study area, the occupation of civil servants accounted for over 4o% of the various occupations.Infacts, in Makera area, civil servants accounted 48.3% of the total number of the infected persons. While in Kpakungu and Chanchaga the records were 40.9% and 44.4% civil Servants infected in each area respectively. (See table 4.11)

5.4 STATISTICAL MODEL

A simple linear regression model of this form $y = a+bx+\Sigma'$ is used for the study annual mean malaria cases (y) against annual mean rainfall and mean temperature (x_1). Regression analysis deals with the examination of functional relationship between variables and drawing inferences about the relationship. It is useful in ascertaining probable form of relationship between variables. In this study, the dependent or response variable (y) is the mean malaria cases while the independent variable is the mean rainfall and mean temperature respectively

5.4.1 GENERAL HOSPITAL MINNA

5.4.1.1 Mean malaria cases against mean rainfall

Considering the regression for General Hospital Minna. The regression equation:-

Mean malaria cases (y) = 637 + 3.07 mean rainfall (x_1)........... (1)

I.e. $y = 637 + 3.07x$

Where y = mean malaria

x = mean rainfall

Let us consider this following of the mean rainfall and the corresponding mean malaria cases.

If $x_1 = 10$

$y_1 = 667.7$

$x_2 = 25$

$y_2 = 713.75$

$x_3 = 40$

$y_3 = 759$

From the above, it indicates that as rainfall (mean rainfall, x) increases more malaria (mean malaria, y) cases are recorded; this is an indication that the rainfall affects malaria prevalence.

The coefficient of determination, R-square is 0.906. This shows about 90.6% of the variations in the reported cases of malaria is explained by the above model (i.e. accounted for by the mean rainfall) leaving this remaining 0.4% unaccounted for and due to other sources. This shows the model is all that good. (See section 4.3)

The hypotheses are:

Ho: the regression line does not fit the data.

Hi: the regression line fit data

From the analysis of variance (section 4.3) since the P- value = 0.000 is less than $\alpha = 0.05$.

If the $P < \alpha$ where $\alpha = 0.05$, i.e. 5% level of significance, we reject the null hypothesis and accept the research hypothesis. And also the statistical significance of this variable was also tested using t-ratio test and found that the t-calculated (45.56) > tabulated t-value (1.714) we shall reject the null hypothesis and conclude that the regression line fit the data. This assertion is explained in section 4.3 .Where the trend of the data as the rainfall increases the cases of malaria also increases. According to Patz etal (2004) rainfall affects malaria transmission because it increases relative humidity and modifies temperature and it also affects where and how much mosquitoes breeding can take place.

The Pearson correlation of mean malaria cases (y) and mean rainfall (x_1) = 0.95, which is positive and very strong correlation (see section 4.3).This is also revealed in figure 4.12 where the regression line shows the residuals to be closer to the line of best fit implying that rainfall has a greater effect as a cause of malaria.

5.4.1.2 Mean malaria cases against mean Temperature

The regression equation:-

Mean malaria cases (y) = 2049 – 32.9 mean temperature x_2........... (2)

I.e. $y = 2049 - 32.9x$

Where y = mean malaria

x = mean temperature

Let us consider the following mean of temperature and the corresponding mean of malaria cases.

If $x_1 = 30$

$y_1 = 1062$

$x_2 = 35$

$y_2 = 897.5$

$x_3 = 50$

$y_3 = 404$

From the above, it indicates that as temperature (mean temperature, x) increases, the prevalence of malaria (mean malaria, y) cases tends to decrease downward. This is an indication that the temperature does rarely affect malaria prevalence.

The coefficient of determination, R-square is 0.054.This shows only about 5.4% of the variation in the reported cases of malaria is explained by the above model (i.e. accounted for by the mean temperature) leaving the remaining 94.4% uncounted for and due to other sources .This shows that the model is not all that good(see section 4.4)

The hypotheses are:

H_0: The regression line does not fit the data.

H_1: The regression line fit the data.

From the analysis of variance (section 4.4) since the P- value = 0.0262 is greater than $\alpha = 0.05$.

If the $P > \alpha$ where $\alpha = 0.05$, i.e. 5% level of significance, we accept the null hypothesis and reject the research hypothesis. And also the statistical significance of this variable was also tested using t-ratio test and found that the t-calculated (-1.18) < tabulated t-value (1.714) we shall accept the null hypothesis and reject the research hypothesis and conclude that the regression line does not fit the data. This assertion is explained in section 4.4.Where the trend of the data as the temperature increases the cases of malaria decreases.

The mean temperatures are within 32.3-34.1(see appendix 16) which are very low. According to Nagpal etal (1995) temperature within this range does not allow mosquitoes. He maintained that the larvicidal factor(s) of Anopheles mosquito is more active at high temperature (35- 37^{oC}) as compared to low temperature (23-25^{cC}).From the appendix 16 the highest mean temperature is 34.1^{oC} and the lowest is 32.3^{oC} this may be the reason why temperature data during the period of this study has no significance effect on malaria epidemic and this could also due to the region at which the study area is located. Other places like Sokoto and Maidugari temperature may have significance effect because of the high temperature of those regions.

The Pearson correlation of mean malaria cases (y)and mean temperature (X_2) = -0.233,which is negative and very low and weak correlation (see section 4.4).This is also revealed in figure 4.13 where the regression line shows the residuals to be further away from the line of best fit implying that temperature does rarely affects malaria transmission.

5.4.2 UNITY CLINIC MINNA

5.4.2.1 Mean malaria cases (y) against mean rainfall (X1)

The regression equation:-

Mean malaria cases (y) =46+0.140 mean rainfall (X_1) .... (3)

I.e. y=46.4+0.140X

Where y = mean malaria

x= mean rainfall

Let consider the following of the mean rainfall and the corresponding mean malaria cases.

If $x_1 = 15$

$y_1 = 4.8$

$x_2 = 25$

$y_2 = 49.9$

$x_3 = 45$

$y_3 = 52.7$

From the above, it indicates that as rainfall (mean rainfall, x) increases more malaria (mean malaria, y) cases are recorded; this is an indication that the rainfall affects malaria prevalence.

The coefficient of determination, R-square is 0.64. This shows about 64.9% of the variations in the reported cases of malaria is explained by the above model (i.e. accounted for by the mean rainfall) leaving this remaining 35.1% unaccounted for and due to other sources. This shows the model is all that good. (See section 4.6)

The hypotheses are:

Ho: the regression line does not fit the data.

Hi: the regression line fit data

From the analysis of variance (section 4.6) since the P- value = 0.001 is less than $\alpha = 0.05$.

If the $P < \alpha$ where $\alpha = 0.05$, i.e. 5% level of significance, we reject the null hypothesis and accept the research hypothesis. And also the statistical significance of this variable was also tested using t-ratio test and found that the t-calculated (8.16) > tabulated t-value (1.782) we shall reject the null hypothesis and conclude that the regression line fit the data. This assertion is explained in section 4.6 .Where the trend of the data as the rainfall increases, the cases of malaria also increases. According to Nagpal etal (1995) Anopheline mosquitoes breed in water habitats and different Anopheline mosquitoes prefer different types of water bodies which to breed.

The Pearson correlation of mean malaria cases (y) and mean rainfall (X_1) = 0.81,which is positive and very strong correlation (see section 4.6).This also revealed in figure 4.3.where the regression line shows the residual to be closer to the line of best fit implying that rainfall has a greater effects as a causes of malaria.

5.4.2.2 Mean malaria cases (y) against mean temperature

The regression equation:-

Mean malaria cases (y) =116-1.63 mean Temperature (X_2)........... (4)

I.e. $y=116-163X_2$

Where y = mean malaria

x = mean temperature

Let us consider the following mean of temperature and the corresponding mean of Malaria cases.

If $x_1 = 21$

$y_1 = 81.77$

$x_2 = 29$

$y_2 = 68.73$

$x_3 = 41$

$y_3 = 49.17$

From the above, it indicates that as temperature (mean temperature, x) increases, the prevalence of malaria (mean malaria, y) cases tends to decrease downward. This is an indication that the temperature does rarely affect malaria prevalence. The coefficient of determination, R-square is 0.109.This shows only about 10.9%of the variation in the reported cases of malaria is explained by the above model (i.e. accounted for by the mean temperature) leaving the remaining 89.1% uncounted for and due to other sources .This shows that the model is not all that good(see section 4.7)

The hypotheses are:

H_0: The regression line does not fit the data.

H_1: The regression line fit the data.

From the analysis of variance (section 4.7) since the P- value = 0.0250 is greater than α = 0.05.

If the P > α where α = 0.05, i.e. 5% level of significance, we accept the null hypothesis and reject the research hypothesis. And also the statistical significance of this variable was also tested using t-ratio test and found that the t-calculated (-1.28) < tabulated t-value (1.782) we shall accept the null hypothesis and reject the research hypothesis and conclude that the regression line does not fit the data. This assertion is explained in section 4.7.Where the trend of the data as the temperature increases the cases of malaria decreases.

The mean temperatures are within 32.3-34.1(see appendix 16) which are very low. According to Matola etal (2001)"many people associate the warm temperature with mosquito numbers."**Temperature means nothing"** he said .Water means everything". This may be the reason why the temperature data for this study does not have significance effect.

The Pearson correlation of mean malaria cases (y) and mean temperature (x_2) = -0.33, which is negative and very low or weak correlation (see section 4.7) .This is also revealed in figure 4.2 where the regression line shows the residuals to be further away from the line of best fit implying that temperature does rarely affects malaria transmission base on this data.

5.4.3 IBBS HOSPITAL

5.4.3.1 Mean malaria cases (y) years mean rainfall

The regression equation:-

Mean malaria cases (y) = 45.5+0.369 mean rainfall (X_1)................ (5)

I.e. $y = 45.5+0.369X$

Where y = mean malaria

x= mean rainfall

Consider the following of the mean rainfall and the corresponding mean malaria cases.

If x = 35

Y = 58.41

X = 45

Y = 62

X = 60

Y = 67.64

From the above, it indicates that as rainfall (mean rainfall, x) increases more malaria (mean malaria) cases are recorded; this is an indication that the rainfall affects malaria prevalence. The coefficient of determination, R-square is 0.674. This shows about 67.4% of the variations in the reported cases of malaria is explained by the above model (i.e. accounted for by the mean rainfall) leaving this remaining 32.6% unaccounted for and due to other sources. This shows the model is all that good.

The hypotheses are:

Ho: the regression line does not fit the data.

H_1: the regression line fit data

From the analysis of variance since the P- value = 0.000 is less than $\alpha = 0.05$.

If the $P < \alpha$ where $\alpha = 0.05$, i.e. 5% level of significance, we reject the null hypothesis and accept the research hypothesis. And also the statistical significance of this variable was also tested using t-ratio test and found that the t-calculated (8.67) > tabulated t-value (1.782) we shall reject the null hypothesis and conclude that the regression line fit the data. This assertion is explained in section 4.8.1 .Where the trend of the data as the rainfall increases, the cases of malaria also increases. Accordingly to Pampana (2002) rainfall also affects malaria transmission because it increases relative humidity and modifies temperature, and it also affect where and how much mosquitoes breeding can take place.

The person correlation of mean malaria cases (y) and mean rainfall (x_1) = 0.82, which is positive and very strong correlation. This also revealed in figure 4.16 where the regression line shows the residuals to be closer to the line of best fit implying that the rainfall has a greater effects as a cause of malaria.

5.4.3.2 Mean malaria cases against mean temperature

The regression equation:-

Mean malaria cases (y) = 265 – 5.42 mean temperature x_2 .... (6)

I.e. $y = 265 - 5.42\ x$

Where y = mean malaria

x = mean temperature.

Let us consider the following mean of temperature and the corresponding mean malaria cases. If $x_1 = 32$

$y_1 = 91.56$

$x_2 = 38$

$y_2 = 59.04$

$x_3 = 47$

$y_3 = 10.26$

From the above, it indicates that as temperature (mean temperature, x) increases, the prevalence of malaria(mean malaria, y) cases tends to decrease downward. This is an indication that the temperature does rarely affect malaria prevalence.

The coefficient of determination, R-square is 0.18This shows only about 18%of the variation in the reported cases of malaria is explained by the above model (i.e. accounted for by the mean temperature) leaving the remaining 82% uncounted for and due to other sources .This shows that the model is not all that good(see section 4.7)

The hypotheses are:

H_0: The regression line does not fit the data.

H_1: The regression line fit the data.

From the analysis of variance (section 4.8.2) since the P- value = 0.131 is greater than α = 0.05.If the $P > \alpha$ where $\alpha = 0.05$, i.e. 5% level of significance; we accept the null hypothesis and reject the research hypothesis. And also the statistical significance of this variable was also tested using t-ratio test and found that the t-calculated (-1.77) < tabulated t-value (1.782) we shall accept the null hypothesis and reject the research hypothesis and conclude that the regression line does not fit the data. This assertion is explained in section 4.8.2.Where the trend of the data as the temperature increases the cases of malaria decreases. The mean temperatures are within 32.3-34.1(see appendix16) which are very low. According to Nagpal etal (1995) temperature within this range does not allow mosquitoes. He maintained that the larvicidal factor(s) of Anopheles mosquito is more active at high temperature (35- 37^{oC}) as compared to low temperature (23-25^{cC}).From the appendix....the highest mean temperature is 34.1^{oC} and the lowest is 32.3^{oC} this may be the reason why temperature data during the period of this study has no significance effect on malaria epidemic and this could also due to the region at which the study area is located. Other places like Sokoto and Maidugari temperature may have significance effect because of the high temperature of those regions.

The Pearson correlation of mean malaria cases (y) and mean temperature (X_2) = - 0.42, which is negative and very low or weak correlation. Further results are shown in the appendix ax briefly discussed here

The line-graph in the appendix 6 show the mean annual rainfall trend against year in the study area (Makera area) over a period 25years (1983-2007).The graph show an increase in mean annual rainfall in the year 1990 with the highest value of 163.61mm.Whereas there is a decrease in mean annul rainfall in the year 1987 with the lowest value of 68.62mm.The graph show a general flow trend pattern mean annual rainfall from the year 1994 to 2007.

The line-graph in the appendix 7 show the mean annual temperature trend against year in the study area (Makera area) over a period of 25years (1983-2007).The graph show an increase in mean annual temperature in the year 1987 with the highest value of 34.1^{oC} .The graph show a general flow trend pattern of mean annual temperature fro the year 1990 to 2005.And suddenly decrease to 32.3^{0C} in 2007 been the lowest value of mean annual temperature in Makera area. The line-graph in the appendix 8show the mean annual rainfall trend against year in the study area (Kpakungu) over a period of 14years (1994-2007).The graph started with the highest value of 124.57mm of mean annual rainfall in the year 1994.The graph show a decrease in mean annual rainfall in the year 2003 with value of 86.04mm which is the lowest value. There is an increase in mean annual rainfall from 2004 to 2007.

The line graph in appendix 9 show the mean annual temperature trend against year in the study area (Kpakungu) over a period of 14years (1994-2007).The graph show a general flow trend pattern of mean annual temperature from the year 1995 to 2005 where the mean annual temperature decrease in the year 2006 to 2007 with the value of $32.9\text{-}32.3^{oC}$ respectively.

The line-graph in appendix 10 show the mean annual rainfall trend in the study area (Chanchaga area) over a period of 14years (1994-2007).The graph show the highest mean annual rainfall in the year1994 with the value of 124.57mm.The graph show a general flow trend pattern of mean annual rainfall from the year 1996 and suddenly there is a decrease in the year 2003.The graph show an increase in mean annual rainfall from 2004 to 2007.

The line-graph in appendix 11 show the mean annual temperature trend in the study area (Chanchaga area) over a period of 14years (1994-2007)The graph show a general flow trend pattern of mean annual temperature from the year 1994-2005 where the mean temperature value suddenly decrease in the year 2006-2007 with value of 32.9-32.3^{oC} respectively.

5.4.4 INFERENCE

The statistical analysis carried out revealed a strong relationship between the selected climatic parameters and the endemicity of malaria disease in the study area. Simple linear regression analysis selected one critical climatic parameter (rainfall) that is reliable in predicting the endemicity of malaria in the study area. These finding have underscored the importance of temperature effectiveness as critical factors affecting the prevalence of malaria disease in the study area in particular and Malaria endemic areas in general. The model put forward should therefore be further exploited in planning future activities for eradication of malaria disease in more ways than medication.

5.4.5 MAJOR FINDINGS OF THE STUDY.

The major findings of the study include:-

(i) As shown in the appendices, monthly patterns of malaria disease are closely associated with monthly total rainfall, in mm

(ii) -For rainfall, there was a direct proportional relationship, because the months of May to September (rainy season) when the maximum rainfall was experienced during the period also recorded highest number of malaria cases. While the months October to April (dry season) with relatively very low rainfall also recorded very low monthly malaria case. As observed in table 4.7 there was seasonality in the incidence of malaria disease in terms of rainfall.

(iii) -The incidence of mean malaria cases and mean temperature exhibited inverse relationship during the study period in the study area in dry season months October-April, when temperatures were very high the incidence of malaria cases was low while in the rainy season months when there was drop in the temperature the number of malaria cases was very high. The temperature thus drop during the rainy season was still high enough to ensure the survival of the mosquitoes and malaria transmission.

(iv) Poverty and poor sanitation as problems enhancing malaria severity in the three areas accounted for the bulk of the subjects had an infection. And civil servants and unemployed as occupational of subjects infected by malaria in the three areas accounted for the bulk of the infected respondents.

In summary, the climatic element of rainfall directs proportional relationship with incidence of malaria while temperature has inverse relationship with incidence of malaria disease during the study area. This study has shown that there is an establishment relationship between the incidences of malaria disease and climatic parameters. Based on the above identified relationship between malaria disease and climatic parameters rainfall was selected as the most efficient parameter used in the prediction of malaria disease and served as an early warning system to the health workers. The selection of rainfall parameter was based on regression, specifically simple linear regression using p-values in the elimination procedure.

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(iii) -The incidence of mean malaria cases and mean temperature exhibited inverse relationship during the study period in the study area in dry season months October-April, when temperatures were very high the incidence of malaria cases was low while in the rainy season months when there was drop in the temperature the number of malaria cases was very high. The temperature thus drop during the rainy season was still high enough to ensure the survival of the mosquitoes and malaria transmission.

(iv) Poverty and poor sanitation as problems enhancing malaria severity in the three areas accounted for the bulk of the subjects had an infection. And civil servants and unemployed as occupational of subjects infected by malaria in the three areas accounted for the bulk of the infected respondents.

In summary, the climatic element of rainfall directs proportional relationship with incidence of malaria while temperature has inverse relationship with incidence of malaria disease during the study area. This study has shown that there is an establishment relationship between the incidences of malaria disease and climatic parameters. Based on the above identified relationship between malaria disease and climatic parameters rainfall was selected as the most efficient parameter used in the prediction of malaria disease and served as an early warning system to the health workers. The selection of rainfall parameter was based on regression, specifically simple linear regression using p-values in the elimination procedure.

5.5 SUMMARY

This study, has investigated the influence of weather (climatic parameters) in the Pattern of spread of malaria disease in minna metropolis. The study analysed and quantified the relationship between the incidence of malaria disease and the variables. The study observed that three Areas (Makera, Kpakungu Chanchaga) with total units of ten were currently endemic of malaria disease (see table 4.1).The infection has not been given the appropriate priority to control it effectivenss.Transmission of malaria disease takes place mostly during the early rainy and late rainy seasons hence the highest record coincide with these seasons leading to low productivity. The climatologically analysis was carried out based on the identified climatic parameters namely, rainfall and temperature. Simple linear regression analysis was used to identify the climatic parameters influencing the prevalence of malaria disease in the study area. This study has tried to identify the pattern and intensity of spread of malaria disease in terms of space, seasons, aged etc. And finally, the study tried to quantify the relationship between prevalence of malaria disease and climatic parameters in the study area. Models were developed for reliable predictions of out breaks and more accurate early warning systems (EWS)

The outcome of the study has revealed that the per capital income in the three areas covered is drastically reduced by malaria infestation implying that poverty level of infected subjects will be high which in turn will make it difficult to 'access' medical treatment. The study has also shown that the stagnant water and bush environment serve as breeding sites for mosquitoes which in turn affect human health.

5.5.1 IMPLICATIONS OF THE MAJOR FINDINGS

The findings of this study imply that as human population increases, need for increased different food also increases, creating increased health problems that must be eliminated. A concerned, honest, focused political leadership and an enlightened follower ship need to be entrenched to ensure a healthy environment that is supportive to living.

5.6 CONCLUSION

The interaction between climatic factors and their biological influence on mosquito and parasite life cycle is a key factor in the association between weather and malaria .These factors should be considered in the development of malaria early warning system. The study has indicated that the three areas have endemicity problems. The study further revealed that certain necessary measures and policy decisions have to be adequately taken to ensure that the existing problems are dealt with and further occurrence is minimized, if not forestalled all together.

5.7 RECOMMENDATIONS

As a result of the implications highlighted in the study on climatic parameters influencing The endemicity of malaria in Minna Metropolis and Niger state, the following are Recommended for the eradication of malaria disease:-

(i) More attention should be given to climatic parameters.Malaria disease to understand the climatic mechanisms that affect the incidence and spread of malaria.

(ii) Steps should be taken to integrate climatologically techniques, which provide Information on a day-to-day basis and disease -weather relationship to predict the Prevalence of disease in different environment.

(iii) The disease can be eliminated or minimised through the sanitation of drainage, our environment and provision of logistical support from other vital organisation e.g. WHO, UNICEF etc.Communities should also embark on the use of treated mosquitoes nets and anti Malaria drugs.

(iv) The local method of treating managing malaria disease is crude, unsafe and has resulted in serious complications, including death. The practice should be discourage through the introduction of environmental education on the implication of malaria disease in Minna metropolis and Niger state as a whole. Effective prevention and control of malaria therefore requires the education of the community members.

(V) In terms of health and socio –economic consequences, there is no doubt that Malaria is a very serious disease. Experience, however, has showed that the willingness of affected Population to take simple measures with proven effectiveness to control the disease does not match the sufferings and losses suffered by this population. Climatic Parameters should also be incorporated in trying to eradicate malaria disease.

(vi) The attainment of this recommendation will go a long way to reduce the incidence and impact if not completely eradicate malaria disease,

5.8 SUGGESTIONS FOR FUTURE RESEARCH

Further studies will be required on the influence of other weather elements on malaria epidemic in minna metropolis.

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APPENDIX 1

QUESTIONNAIRE ON MALARIA DISEASE IN MINNA METROPOLIS

Department of Geography,

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P M B 65 Bosso Campus Minna,

05 May, 2008.

QUESTIONNAIRE ON MALARIA DISEASE IN MINNA METROPOLIS

(Please tick or commence where necessary)

1 Age of respondents:-

(1) <10 years ☐ (2) 11 -25 years ☐ (3) 26-55years ☐ (4) >55 ☐

2 Residential Area ....

3 sex ....

4 Marital status: (a) Single ☐ (b) married ☐ (c) Divorce ☐ separated ☐

(f) Windowed ☐

5 Educational level attained:-

(I) No formal education ☐

(ii) Primary School ☐

(iii) Secondary/Tech.Schhool ☐

(iv) Polytechnic / NCE ☐

University Level ☐

6 Religion:-

(A) Islam ☐ (b) Christianity ☐ (c) others (specify)…………………

7 Occupation: - (specify)………………………………………………………………

8 Period of stay in Residential area:-

(1) < 2 years ☐ (2) 2-4 years ☐ (3) 4-10 years ☐ (4) 10-50 years ☐

9 What do you think could be the causes of malaria?

(a) Dirty environment ☐ (b) stagnant water ☐ (c) others (specify)…………………..

10 How often do you sanitize your environment? (a) Daily ☐ (b) weekly ☐ (C) monthly ☐ (d) yearly ☐

11 Which type of sanitation exercise do you carry out?

(a) Weeding of grasses ☐ (b) clearing of drainage ☐ (c) others (specify)………………………

12 What method (s) of malaria prevention do you practice?

(a) Use of insecticide ☐ (b) use of treated mosquitoes' net ☐ (c) use of untreated net ☐ (c) I don't use any at all ☐

13 If any method is adopted where/who is the source

(a) Self ☐ (b) community ☐ (c) gov't ☐

14 In case or in a situation of malaria outbreak, which of medication do you undergo

(a)Taking Anti malaria ☐ (b) going to hospital ☐ (c) others (specify)..........

15 Do you know the mode of malaria transmission? (a) Yes ☐ (b) No ☐

16 If yes, what is the mode of the transmission? (Specify if possible).....................................

17 When (during the year) is the disease most common?

(1) Dry season (Nov-Mar) ☐ (2) early rainy season (April-Jul) ☐ (3) late rainy season (August –Oct) ☐

18 Are you presently infected with Malaria? (a) Yes ☐ (b) No ☐

20 Duration of the infection:

(a) 1- 2weeks ☐ (b) 3- 4weeks ☐ (c) 5- 6weeks ☐ (c) > 8 weeks ☐

20 The number of persons infected in the household

(1) Zero ☐ (2) 1 - 2 ☐ (3) 2 - 4 ☐ (4) 4-10 ☐ 5) All ☐

22 Severity of the infection:-

(1)Very severe ☐ (2) not very severe ☐ (3) Minor ☐

23 Type of medication:-

(1) Native ☐ (2) Clinic ☐ (3) Specialist Hospital ☐ (4) Health Centre ☐

24 approximate annual income (or productivity equivalent) before infection:

(1)>N200, 0000 P.A ☐ (2) N150-200,000PA, ☐ (3) N50-100,000P.A ☐

(4) <50,000 ☐

25 Approximate Annual income (or productivity equivalent) after affection:

(1)>N200, 000/year ☐ (2) N150-200,000/year ☐ (3) N100-150,000/year ☐

(4)N50, 000-5000/year ☐ (5) <N50, 000 ☐

27 What age limit is mostly affected by malaria?

(a) < 10years ☐ (b) 11-26years ☐ (c) 26-55years ☐ ≥55years ☐

28 Why such age ……………………………………………………………

29 What type of sex is mostly affected by malaria? (1) Male ☐ (2) female ☐

Why such sex……………………………………

34 How regularly should patients apply drugs?

(1)Daily ☐ (2) Weekly ☐ (3) monthly ☐

35 Are costs of treatment subsidised by the government? Yes………..No……………

36 If yes, what is the percent? of subsidy? (1)0-10% ☐ (2)10-20% ☐ (3)20-30%

(4)30-40% ☐ (5) over 40% ☐

37 Is application oral or intravenous? (1) Oral ☐ (2) Intravenous ☐

38 If oral, state frequency per: (1) day ☐ (2) week ☐ (3) Month ☐

39 If intravenous, state frequency of visit to clinic: (1) daily ☐ (2) weekly ☐

(3)Monthly ☐

40 Are the drugs readily available in the community? (1) Yes ☐ (2) No ☐

41 If no how long do patients have to wait?

(1) one week ☐ (2) 1-2weeks ☐ (3) 2-4weeks ☐ (4) Over 4weeks

42 How knowledgeable are the people on the mode of transmission of malaria disease?

(1) Highly knowledgeable ☐ (2) Fairy/moderates knowledgeable ☐

(3) Ignorant ☐

43 Since the disease is preventable, what efforts has minna made Enlighten the

People on the ways to advert the disease? (1) Public enlightenment campaign ☐

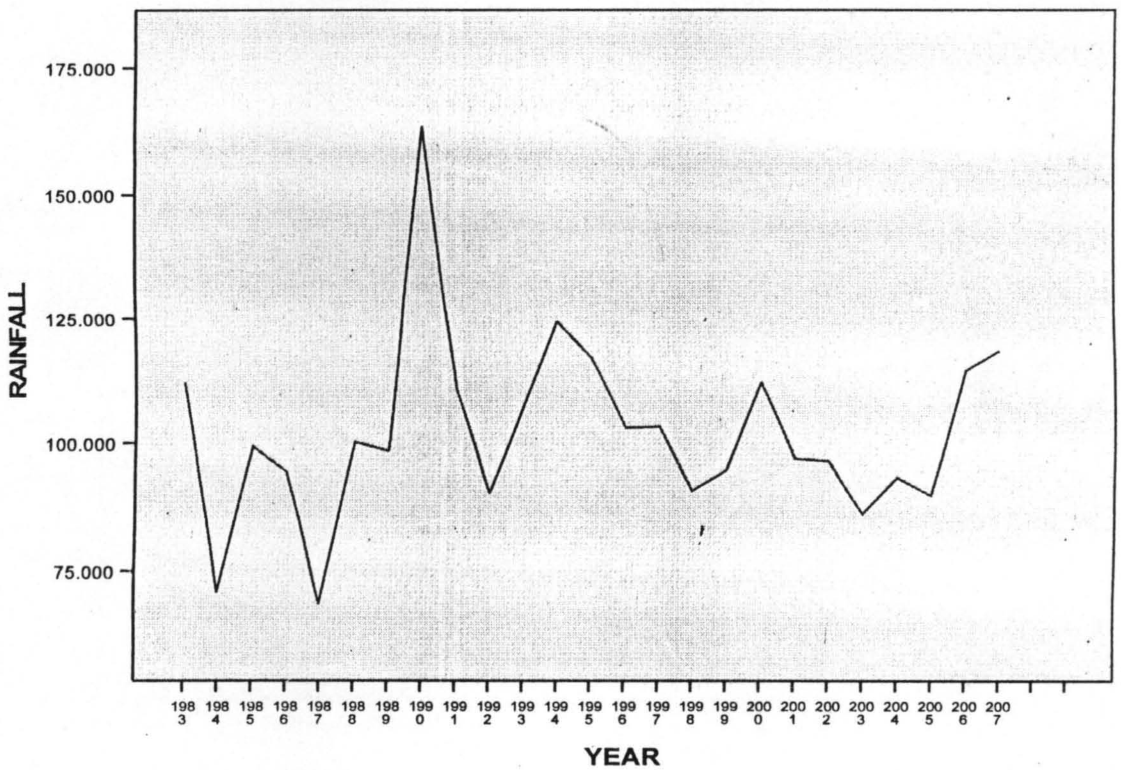
(2) Media ☐ (3) mass mobilization ☐ (4) others (specific) ☐

44 From your observation state the problems enhancing the severity of the disease in

Minna metropolis..

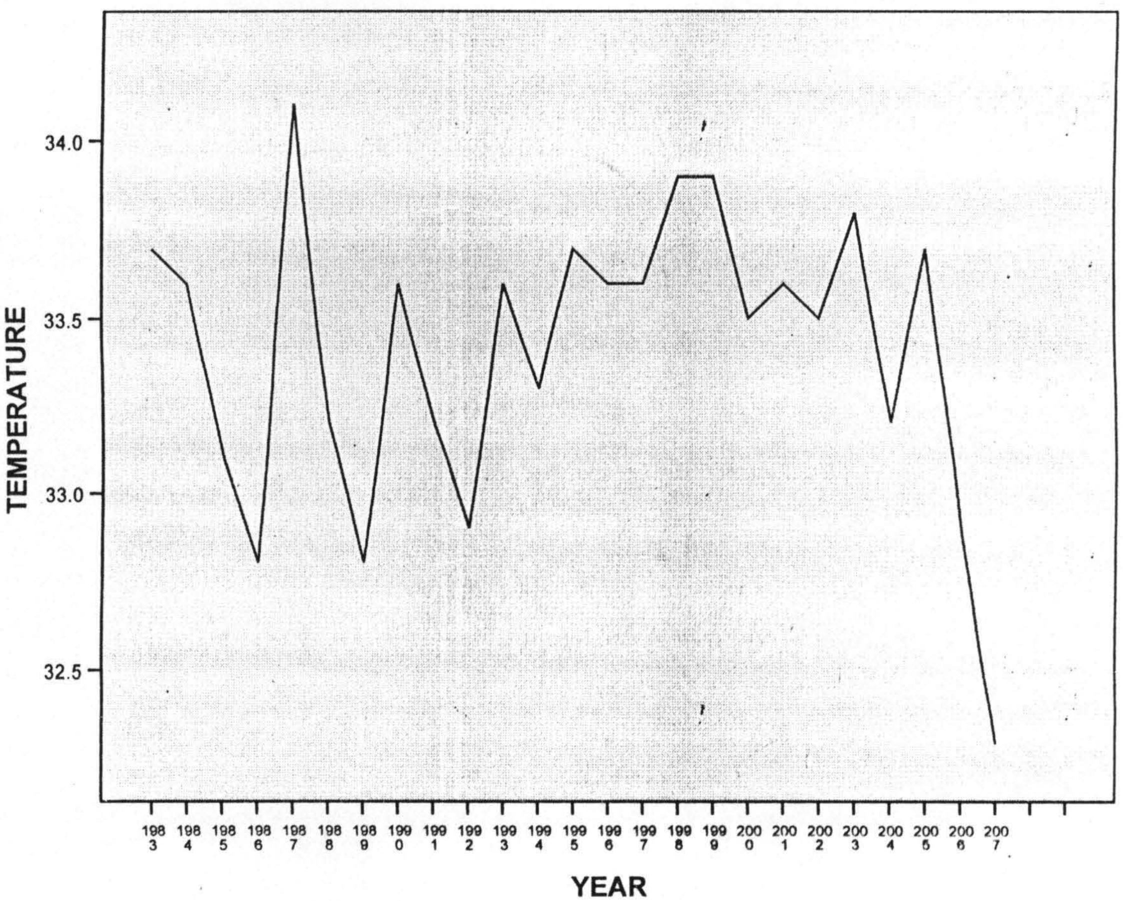
APPENDIX 2

Line-Graph of mean rainfall against year-General Hospital Minna



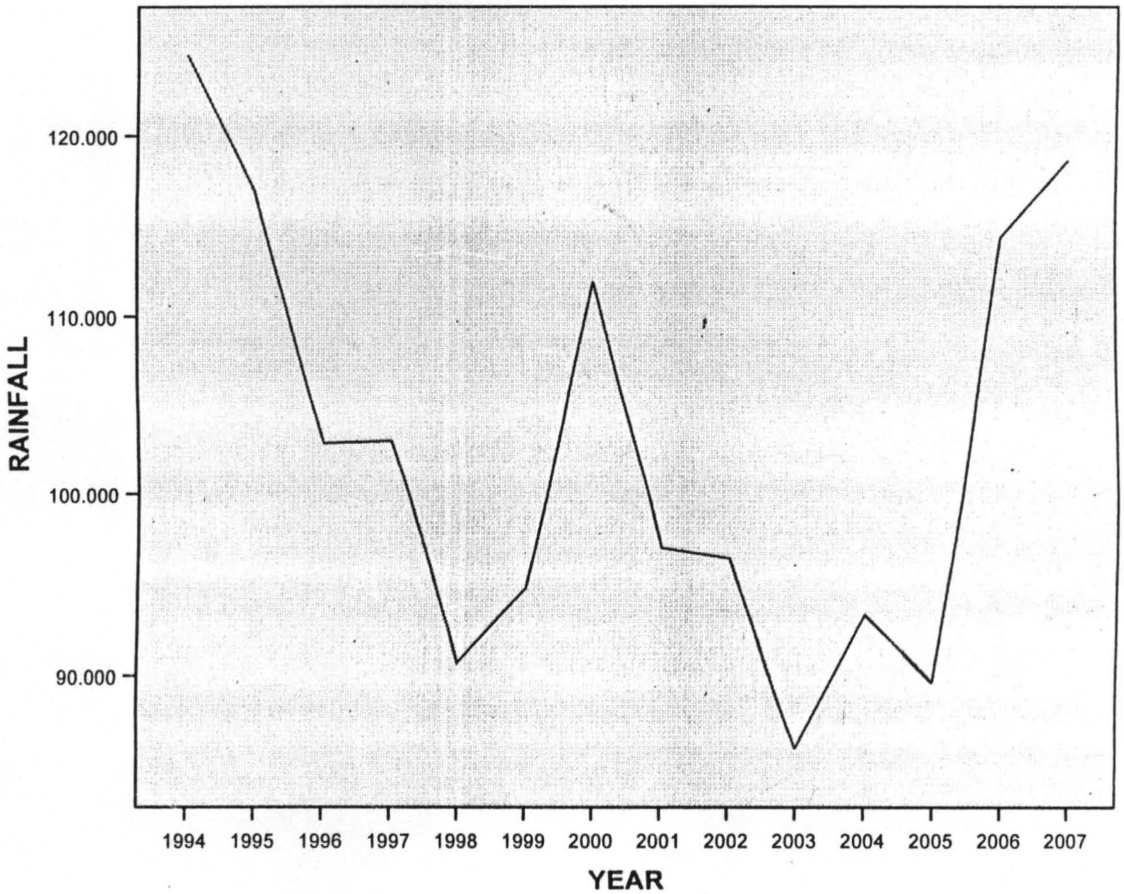
APPENDIX 3

Line-Graph of mean temperature against year-General Hospital minna



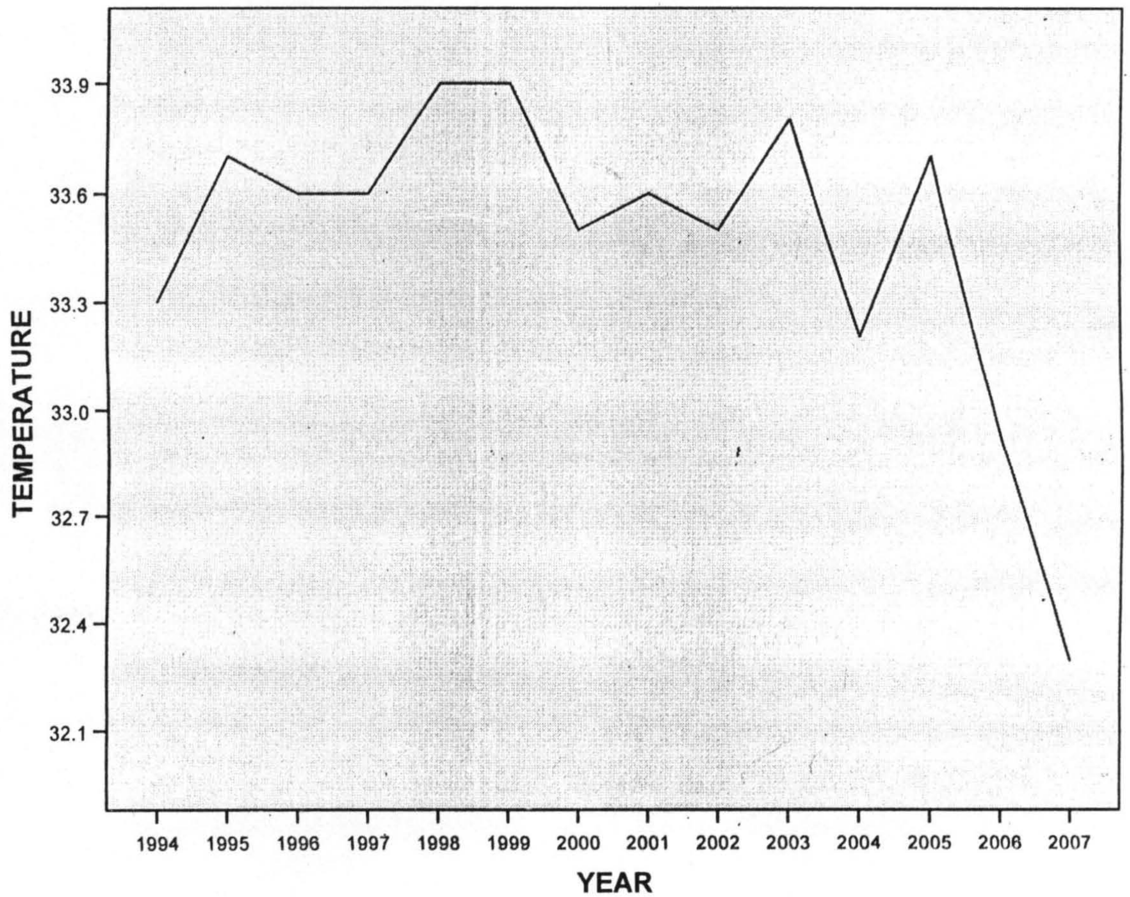
APPPENDIX 4

Line-Graph of mean rainfall against year-Unity Clinic minna



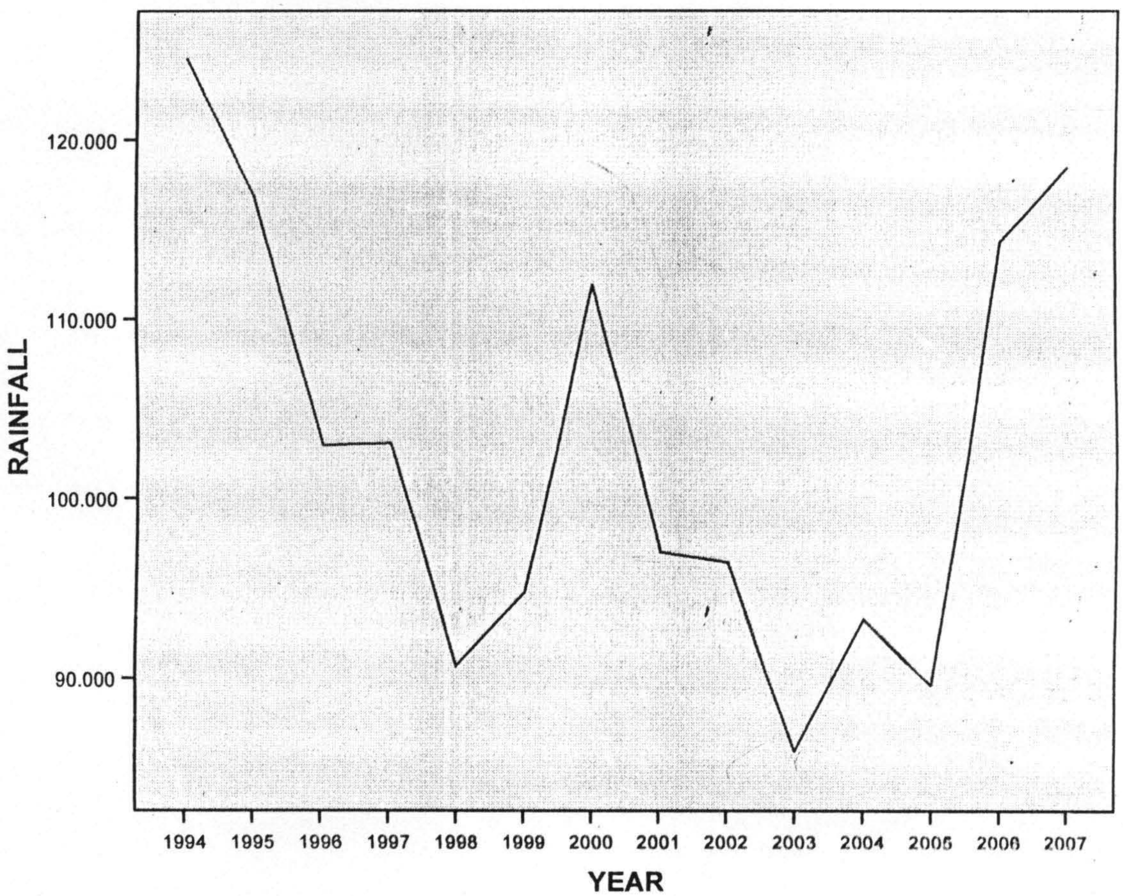
APPENDIX 5

Line-Graph of mean temperature against year-Unity Clinic minna



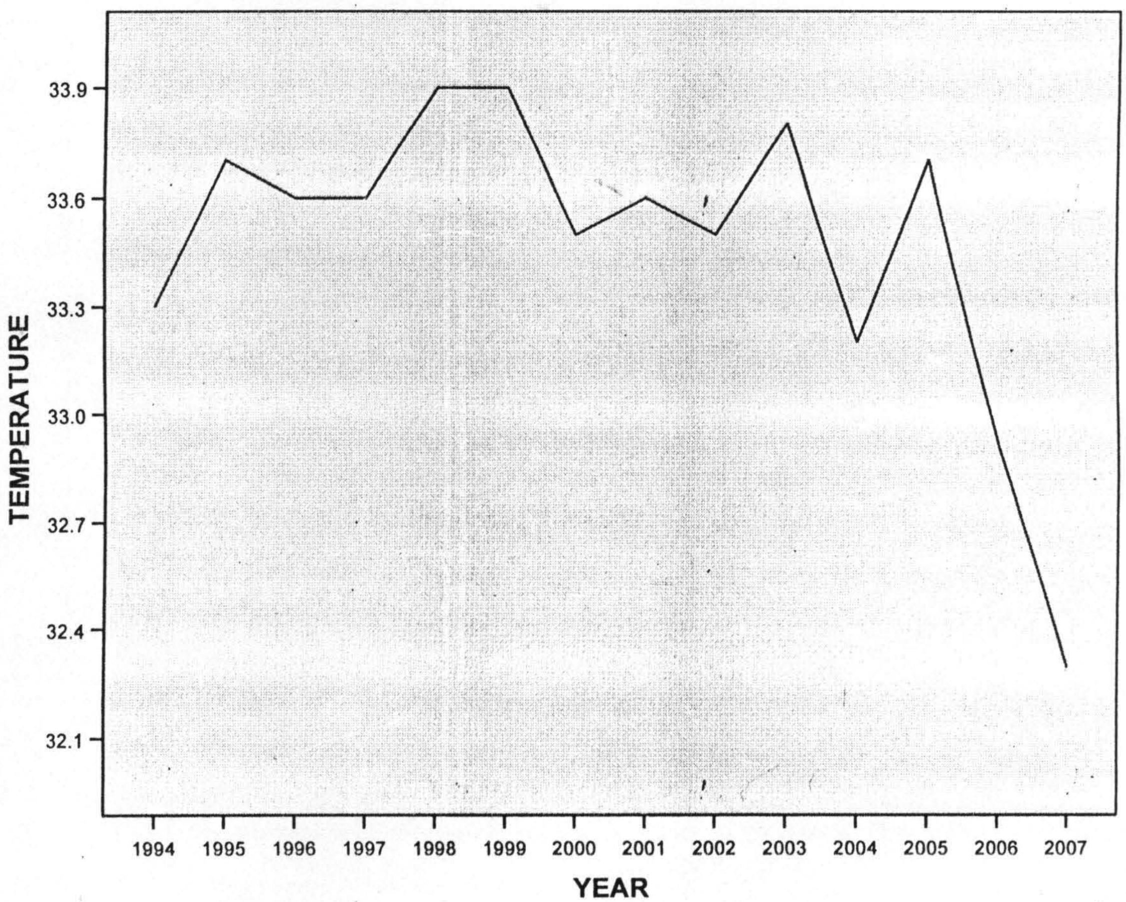
APPENDIX 6

Line-Graph of mean rainfall against year-IBBS Hospital minna



APPENDIX 7

Line-Graph of mean temperature against year-IBBS Hospital minna



APPENDIX 8

CALCULATIONS DONE FOR THR SELECTED DATA SETS

Regression Analysis: mean malaria cases against mean rainfall (X1)

The regression equation is

mean malaria cases (Y) = 637 + 3.07 mean rainfall (X1)

Predictor	Coef	SE Coef	T	P
Constant	636.85	21.39	29.78	0.000
mean rainfall (X1)	3.0679	0.2060	14.89	0.000

S = 18.7329 R-Sq = 90.6% R-Sq (adj) = 90.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	77851	77851	221.85	0.000
Residual Error	23	8071	351		
Total	24	85922			

Unusual Observations

	mean rainfall	malaria cases				
Obs	(X1)	Y)	Fit	SE Fit	Residual	St Resid
8	164	1098.00	1138.79	13.19	-40.79	-3.07RX

R denotes an observation with a large standardized residual.

X denotes an observation whose X value gives it large influence.

Correlations: mean malaria cases against mean rainfall (X1)

Pearson correlation of mean malaria cases (Y) and mean rainfall (X1) = 0.952

P-Value = 0.000

Regression Analysis: mean malaria cases against mean temperature

The regression equation is

mean malaria cases (Y) = 2049 - 32.9 mean temperature (X2)

Predictor	Coef	SE Coef	T	P
Constant	2048.7	954.2	2.15	0.043
mean temperature (X2)	-32.88	28.56	-1.15	0.262

S = 59.4329 R-Sq = 5.4% R-Sq (adj) = 1.3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	4680	4680	1.32	0.262
Residual Error	23	81242	3532		
Total	24	85922			

Unusual Observations

Obs	mean temperature (X2)	malaria cases Y)	Fit	SE Fit	Residual	St Resid
8	33.6	1098.0	944.0	13.1	154.0	2.66R
25	32.3	1015.0	986.8	33.7	28.2	0.58 X

R denotes an observation with a large standardized residual.

X denotes an observation whose X value gives it large influence.

Correlations: mean malaria cases against mean temperature (X2)

Pearson correlation of mean malaria cases against mean temperature (X2) =

-0.233

P-Value = 0.262

UNITY CLINIC, MINNA

Regression Analysis: Mean Malaria cases against mean Rainfall (X1)

The regression equation is

Mean Malaria cases (y) = 46.4+0.140 mean Rainfall (X1)

Predictor	Coef	SE Coef	T	P
Constant	46.420	3.083	15.06	0.000
Mean rainfall (X1)	0.14031	0.02977	4.71	0.001

S = 1.32103 R-Sq = 64.9% R-Sq (adj) = 62.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	38.773	38.773	22.22	0.001
Residual Error	12	20.941	1.745		
Total	13	59.714			

Unusual Observations

	mean Rainfall	malaria Cases				
(Obs	(X1)	Y)	Fit	SE Fit	Residual	St Resid
13	114	60.000	62.476	0.493	-2.476	-2.02R

R denotes an observation with a large standardized residual.

Correlations: mean malaria cases against mean rainfall (X1)

Pearson correlation of mean malaria cases (y) and mean rainfall(X1) = 0.81

P-value = 0.001

Regression Analysis: mean malaria cases against mean temperature

The regression equation is

mean malaria cases(y) = 116 - 1.63 mean temperature (x2)

Predictor	Coef	SE Coef	T	P
Constant	115.50	45.20	2.56	0.025
mean temperature (x2)	-1.633	1.350	-1.21	0.250

S = 2.10613 R-Sq = 10.9% R-Sq (adj) = 3.4%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	6.485	6.485	1.46	0.250
Residual Error	12	53.229	4.436		
Total	13	59.714			

Unusual Observations

	mean temperature	malaria cases				
(Obs	(X2)	Y)	Fit	SE Fit	Residual	St Resid
14	32.3	63.000	62.758	1.670	0.242	0.19 X

X denotes an observation whose X value gives it large influence.

Correlations: mean malaria cases against mean temperature (X2)

Pearson correlation of mean malaria cases (y) and mean rainfall(x2) = -0.33

P-value = 0.250

IBBS HOSPITAL

Regression Analysis: mean malaria cases against mean rainfall

The regression equation is

Mean malaria cases (y) = 45.5 + 0.369 mean rainfall (X1)

Predictor	Coef	SE Coef	T	P
Constant	45.473	7.665	5.93	0.000

mean rainfall 0.36889 0.07401 4.98 0.000

S = 3.28418 R-Sq = 67.4% R-Sq (adj) = 64.7%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	268.00	268.00	24.85	0.000
Residual Error	12	129.43	10.79		
Total	13	397.43			

Unusual Observations

Obs	mean rainfall	malaria cases	Fit	SE Fit	Residual	St Resid
1	125	98.000	91.426	1.829	6.574	2.41R

R denotes an observation with a large standardized residual.

Correlations: mean malaria cases against mean rainfall (X1)

Pearson correlation of mean malaria cases (y) and mean rainfall(x1) = 0.82

P-value = 0.000

Regression Analysis: Mean Malaria cases against mean Temperature

The regression equation is

Mean Malaria cases = 265-5.42 Mean Temperature(X1)

Predictor	Coef	SE Coef	T	P
Constant	264.9	111.8	2.37	0.036
Mean Temperature	-5.421	3.342	-1.62	0.131

S = 5.21171 R-Sq = 18.0% R-Sq (adj) = 11.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	71.49	71.49	2.63	0.131
Residual Error	12	325.94	27.16		

Total 13 397.43

Unusual Observations

mean malaria

Obs temperature cases

Temp	Cases	Fit	SE Fit	Residual	St Resid
1 33.3	98.	84.32	1.50	13.68	2.74R
14 32.3	87.00	89.74	4.13	-2.74	-0.86 X

R denotes an observation with a large standardized residual.

X denotes an observation whose X value gives it large influence.

Correlations: mean malaria cases against mean temperature (X2)

Pearson correlation of mean malaria cases (y) and mean rainfall (x2) = -0.42

P-value = 0.131

APPENDIX-9

Monthly Record of in and out-patient treated for malaria cases in IBBSH-NAMCITY (1994-2004)

MONTHS	YEAR													
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
JAN	40	63	39	36	37	38	46	73	37	32	51	30	38	43
FEB	68	70	53	51	73	56	64	57	38	33	54	38	41	85
MAR	99	93	70	65	99	85	76	72	47	34	46	50	64	53
APRL	110	59	77	79	89	79	86	63	76	67	73	63	81	83
MAY	80	89	96	91	100	92	97	83	86	78	87	72	82	76
JUN	122	84	109	98	119	78	106	96	93	81	93	90	98	85
JUL	125	99	98	93	111	98	84	101	121	108	107	81	110	115
AUG	134	110	120	109	80	103	113	120	120	110	121	112	111	121
SEPT	108	89	108	103	93	120	102	106	109	100	106	102	113	111
OCT	98	90	110	91	69	96	93	103	108	89	104	99	105	109
NOV	92	96	69	105	79	83	98	73	84	90	88	100	83	95
DEC	98	79	42	75	40	69	55	54	81	67	66	61	89	64

Source: Record Section IBBSH-NAMCITY, Minna.

APPENDIX 10

Monthly Record of in and out-patient treated for malaria cases in Unity clinic Minna (1994-2007)

MONTHS	YEAR													
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
JAN	38	39	37	40	37	39	38	43	39	34	38	36	35	40
FEB	51	43	51	53	48	48	50	47	47	39	44	41	49	52
MAR	63	62	54	46	46	58	61	55	48	45	52	45	45	60
APRL	74	64	75	72	63	68	75	61	67	65	62	60	51	78
MAY	68	73	68	70	52	66	65	70	66	64	68	66	67	65
JUN	58	69	70	63	70	69	48	63	67	54	57	52	71	49
JUL	59	54	55	47	71	69	70	57	51	70	52	70	71	68
AUG	79	84	80	80	73	69	84	74	78	75	82	72	69	70
SEPT	76	68	72	70	72	73	75	71	76	70	70	64	76	77
OCT	74	71	62	76	65	54	69	75	74	58	59	61	71	74
NOV	73	66	82	77	60	65	64	62	64	66	66	71	65	78
DEC	55	56	44	56	58	42	51	47	46	50	60	59	50	49

Source: Record section Unity Clinic, Minna.

APPENDIX 11

Mean annual rainfall, temperature and malaria cases unity clinic minna

Year	Mean Rainfall	Mean Temperature	Mean Malaria cases
1994	124.57	33.3	64
1995	116.95	33.7	62
1996	102.94	33.6	63
1997	103.08	33.6	63
1998	90.724	33.9	60
1999	94.775	33.9	60
2000	111.967	33.5	63
2001	96.992	33.6	60
2002	96.425	33.5	60
2003	86.04	33.8	57
2004	93.3	33.2	59
2005	89.71	33.7	58
2006	114.43	32.9	60
2007	118.575	32.3	63

Compiled by Author-2008

APPENDIX 12

Mean annual rainfall, temperature and malaria cases IBBSH-NAMCITY Minna

(1994-2007)

Year	Mean Rainfall	Mean Temperature	Malaria cases
1994	124.57	33.3	98
1995	116.95	33.7	85
1996	102.94	33.6	82
1997	103.08	33.6	83
1998	90.724	33.9	82
1999	94.775	33.9	83
2000	111.967	33.5	85
2001	96.992	33.6	83
2002	96.425	33.5	83
2003	86.04	33.8	74
2004	93.3	33.2	83
2005	89.71	33.7	75
2006	114.43	32.9	85
2007	118.575	32.3	87

Compiled: by Author-2008

APPENDIX 13

Mean annual rainfall, temperature and malaria cases General Hospital Minna (1983-2007)

YEAR	Mean Rainfall	Mean Temperature	Malaria cases
1983	111.79	33.7	1011
1984	70.925	33.6	843
1985	99.28	33.1	928
1986	94.47	32.8	927
1987	68.62	34.1	835
1988	100.2	33.2	933
1989	98.47	32.8	927
1990	163.61	33.6	1098
1991	110.47	33.2	1010
1992	90.13	32.9	904
1993	107.3	33.6	967
1994	124.57	33.3	1017
1995	116.95	33.7	1014
1996	102.94	33.6	934
1997	103.08	33.6	934
1998	90.724	33.9	939
1999	94.775	33.9	927
2000	111.967	33.5	1010
2001	96.992	33.6	927
2002	96.425	33.5	927
2003	86.04	33.8	903
2004	93.3	33.2	918
2005	89.71	33.7	903
2006	114.43	32.9	1011
2007	118.575	32.3	1015

Compiled: by Author-2008

APPENDIX 14

Minna mean monthly maximum temperature deg.(1983-2007)

YEAR	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1983	31.6	37.5	38.1	37.7	36	30.9	29.5	29	30.3	33.2	35.6	34.8
1984	34.8	37	38.3	38.4	32	31.8	29.8	30	29.9	32	35	34.1
1985	35.7	35.5	37.5	35.4	33.7	29.9	28.2	29.4	29.7	32.1	35.7	34.6
1986	35	37.7	35.6	36.3	33.5	30.5	28.6	28.9	29.5	31.9	33.1	33.3
1987	35.5	37.7	37.1	37.9	36.9	31.4	30.5	29.9	30.5	32.2	35.2	35.1
1988	34	37.1	38.3	36.2	34.4	30.5	29.4	27.6	29.4	32.4	35.8	33.7
1989	32.8	34.9	37.4	36.6	31.8	30.7	29.1	28.8	29.2	31.6	35.6	34.5
1990	35.7	36.1	38.3	36.1	32.1	31.9	29.3	29.9	30.5	32.5	35.3	34.9
1991	35.5	37.4	37.6	35.6	31.4	29.7	29	30.8	30.1	31.7	35.4	34.1
1992	34.9	36.5	37.3	34.9	33.2	30.3	27.3	28.7	29.5	32.2	34.2	35.3
1993	33.5	36.8	36.6	37.6	34.9	31.3	29.7	29.4	30.7	32.5	34.6	35.3
1994	34.3	37.1	39.2	36.1	33.6	31.3	30.1	28.7	29.8	31.2	34.5	34.2
1995	34.2	37	38.9	37.2	33.6	31.9	30.3	29	30.6	32	34.4	34.7
1996	36.2	37.6	38.3	37.6	33.4	30.5	29.2	28.5	29.9	31.5	35	35.8
1997	38.8	36.8	37.1	35.4	32.2	30.8	29.6	30.2	30.8	31.7	34.9	35
1998	34.7	38.8	38.5	38.4	33.7	31.4	29.5	28.6	29.9	31.9	36.3	35.5
1999	35.4	37	38.3	37	34.2	31.4	29.1	28.6	29.5	31.3	35.7	34.9
2000	35.7	34.8	38.1	37.3	35.1	30.6	29.2	28.9	30.2	31.5	35.4	34.8
2001	34.8	36.1	38.9	36.3	33.7	30.9	29.1	28.3	29.5	33	36	36.4
2002	33.5	37	38.6	35.8	35.7	32	29.9	29.4	29.2	31.3	34.7	34.9
2003	35.3	38.2	39	36.6	34.7	31.2	29.8	28.8	29.8	31.8	35.5	35.2
2004	34.8	36.7	37.6	37.6	335	31	29.2	29	29.9	30	34.8	34.8
2005	33.7	38.3	39.4	37.6	33.7	31.4	29.4	28.8	30.5	31.5	35.1	34.6
2006	35.7	37.5	38.4	31.9	31.5	30.1	28.5	30.1	31.3	30	34.7	34.6
2007	33.7	37.2	38.2	36	32.8	30.3	29.5	18.2	30	31.7	34.7	35.4

Source: Airport meteorological Station, Minna.

APPENDIX 15

Minna mean monthly maximum temperature deg.(1983-2007)

YEAR	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1983	31.6	37.5	38.1	37.7	36	30.9	29.5	29	30.3	33.2	35.6	34.8
1984	34.8	37	38.3	38.4	32	31.8	29.8	30	29.9	32	35	34.1
1985	35.7	35.5	37.5	35.4	33.7	29.9	28.2	29.4	29.7	32.1	35.7	34.6
1986	35	37.7	35.6	36.3	33.5	30.5	28.6	28.9	29.5	31.9	33.1	33.3
1987	35.5	37.7	37.1	37.9	36.9	31.4	30.5	29.9	30.5	32.2	35.2	35.1
1988	34	37.1	38.3	36.2	34.4	30.5	29.4	27.6	29.4	32.4	35.8	33.7
1989	32.8	34.9	37.4	36.6	31.8	30.7	29.1	28.8	29.2	31.6	35.6	34.5
1990	35.7	36.1	38.3	36.1	32.1	31.9	29.3	29.9	30.5	32.5	35.3	34.9
1991	35.5	37.4	37.6	35.6	31.4	29.7	29	30.8	30.1	31.7	35.4	34.1
1992	34.9	36.5	37.3	34.9	33.2	30.3	27.3	28.7	29.5	32.2	34.2	35.3
1993	33.5	36.8	36.6	37.6	34.9	31.3	29.7	29.4	30.7	32.5	34.6	35.3
1994	34.3	37.1	39.2	36.1	33.6	31.3	30.1	28.7	29.8	31.2	34.5	34.2
1995	34.2	37	38.9	37.2	33.6	31.9	30.3	29	30.6	32	34.4	34.7
1996	36.2	37.6	38.3	37.6	33.4	30.5	29.2	28.5	29.9	31.5	35	35.8
1997	38.8	36.8	37.1	35.4	32.2	30.8	29.6	30.2	30.8	31.7	34.9	35
1998	34.7	38.8	38.5	38.4	33.7	31.4	29.5	28.6	29.9	31.9	36.3	35.5
1999	35.4	37	38.3	37	34.2	31.4	29.1	28.6	29.5	31.3	35.7	34.9
2000	35.7	34.8	38.1	37.3	35.1	30.6	29.2	28.9	30.2	31.5	35.4	34.8
2001	34.8	36.1	38.9	36.3	33.7	30.9	29.1	28.3	29.5	33	36	36.4
2002	33.5	37	38.6	35.8	35.7	32	29.9	29.4	29.2	31.3	34.7	34.9
2003	35.3	38.2	39	36.6	34.7	31.2	29.8	28.8	29.8	31.8	35.5	35.2
2004	34.8	36.7	37.6	37.6	335	31	29.2	29	29.9	30	34.8	34.8
2005	33.7	38.3	39.4	37.6	33.7	31.4	29.4	28.8	30.5	31.5	35.1	34.6
2006	35.7	37.5	38.4	31.9	31.5	30.1	28.5	30.1	31.3	30	34.7	34.6
2007	33.7	37.2	38.2	36	32.8	30.3	29.5	18.2	30	31.7	34.7	35.4

Source: Airport meteorological Station, Minna.

APPENDIX 16

Minna mean monthly maximum temperature deg.(1983-2007)

YEAR	JAN	FEB	MAR	APRL	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1983	31.6	37.5	38.1	37.7	36	30.9	29.5	29	30.3	33.2	35.6	34.8
1984	34.8	37	38.3	38.4	32	31.8	29.8	30	29.9	32	35	34.1
1985	35.7	35.5	37.5	35.4	33.7	29.9	28.2	29.4	29.7	32.1	35.7	34.6
1986	35	37.7	35.6	36.3	33.5	30.5	28.6	28.9	29.5	31.9	33.1	33.3
1987	35.5	37.7	37.1	37.9	36.9	31.4	30.5	29.9	30.5	32.2	35.2	35.1
1988	34	37.1	38.3	36.2	34.4	30.5	29.4	27.6	29.4	32.4	35.8	33.7
1989	32.8	34.9	37.4	36.6	31.8	30.7	29.1	28.8	29.2	31.6	35.6	34.5
1990	35.7	36.1	38.3	36.1	32.1	31.9	29.3	29.9	30.5	32.5	35.3	34.9
1991	35.5	37.4	37.6	35.6	31.4	29.7	29	30.8	30.1	31.7	35.4	34.1
1992	34.9	36.5	37.3	34.9	33.2	30.3	27.3	28.7	29.5	32.2	34.2	35.3
1993	33.5	36.8	36.6	37.6	34.9	31.3	29.7	29.4	30.7	32.5	34.6	35.3
1994	34.3	37.1	39.2	36.1	33.6	31.3	30.1	28.7	29.8	31.2	34.5	34.2
1995	34.2	37	38.9	37.2	33.6	31.9	30.3	29	30.6	32	34.4	34.7
1996	36.2	37.6	38.3	37.6	33.4	30.5	29.2	28.5	29.9	31.5	35	35.8
1997	38.8	36.8	37.1	35.4	32.2	30.8	29.6	30.2	30.8	31.7	34.9	35
1998	34.7	38.8	38.5	38.4	33.7	31.4	29.5	28.6	29.9	31.9	36.3	35.5
1999	35.4	37	38.3	37	34.2	31.4	29.1	28.6	29.5	31.3	35.7	34.9
2000	35.7	34.8	38.1	37.3	35.1	30.6	29.2	28.9	30.2	31.5	35.4	34.8
2001	34.8	36.1	38.9	36.3	33.7	30.9	29.1	28.3	29.5	33	36	36.4
2002	33.5	37	38.6	35.8	35.7	32	29.9	29.4	29.2	31.3	34.7	34.9
2003	35.3	38.2	39	36.6	34.7	31.2	29.8	28.8	29.8	31.8	35.5	35.2
2004	34.8	36.7	37.6	37.6	335	31	29.2	29	29.9	30	34.8	34.8
2005	33.7	38.3	39.4	37.6	33.7	31.4	29.4	28.8	30.5	31.5	35.1	34.6
2006	35.7	37.5	38.4	31.9	31.5	30.1	28.5	30.1	31.3	30	34.7	34.6
2007	33.7	37.2	38.2	36	32.8	30.3	29.5	18.2	30	31.7	34.7	35.4

Source: Airport meteorological Station, Minna