

ASSESSING THE INCIDENCE TREND OF MALARIA, MEASLES, MENINGITIS, AND PNEUMONIA IN THE FCT, NIGERIA

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Abstract

Tropical regions of Africa are highly susceptible to various infectious diseases, which frequently manifest as epidemics. These outbreaks are often driven by climatic variations that enhance disease transmission rates. The study assesses the Incidence Trend of Malaria, Measles, Meningitis, and Pneumonia in the Federal Capital Territory (FCT), Nigeria. A multiple strata or hierarchical random sampling technique was employed. The study stratified the FCT based on the six area councils, from which purposive selection of both government and private hospitals was done. Only hospitals with available monthly records from 2005 to 2019 were

Introduction

Background to the Study

Tropical areas of Africa are particularly prone to a number of infectious diseases such as malaria, cholera and measles, all of which are sensitive to climatic variability (Morse, 2005). Often these diseases occur as epidemics which may be triggered by variations in climatic conditions that accelerate disease transmission rates. Disease incidence, spread and possible health consequences command increasing attention based

included. The study used secondary data obtained from hospital records for the target diseases. Descriptive statistics were used to describe the incidence data, and time series and multiple regression tests were employed to analyse trends. The results shows that Malaria incidence peaked between June and December, with the highest in August, monthly incidence ranged above 1000 cases, with a positive correlation between malaria and relative humidity ($R^2 = 0.4285$). for measles, the peak period was from February to May, with March recording the highest number of cases (39.13). Incidence dropped significantly during the rainy months ($R^2 = 0.4726$). for meningitis, the highest incidence was recorded in March (55.8 cases). The disease was more prevalent during the dry season, with low occurrences during the rainy months ($R^2 = 0.4285$). and pneumonia, incidence was highest during the dry months (January to May), with peaks in June and July. Pneumonia showed a fluctuating pattern throughout the year, with a significant relationship with rainfall (p-value = 0.0245). The findings revealed that malaria is the most prevalent disease, particularly during the rainy season, while measles, meningitis, and pneumonia were more common during the dry season. Climatic factors such as temperature, humidity, and rainfall significantly influenced disease patterns, with a strong correlation between malaria incidence and relative humidity. Thus, concluding that climatic variability plays a critical role in the incidence of diseases in FCT, Nigeria. The study recommended that government should improve public health interventions, and health education campaigns are essential to raise awareness of disease prevention during peak seasons for these diseases.

Keywords: Climate, Infectious diseases, Incidence, Hospitals, and Health

On research-based evidence and trends that climate and weather variability will continue to alter the pattern of average climatic conditions although trends within specific geographic regions remain uncertain (Intergovernmental Panel on Climate Change, 2007).

Such alteration in weather patterns have resulted to unpredictability including an increased frequency of rainfall that is associated with an increased occurrence of floods, landslides, debris and mudflows especially in parts of South-pacific Asian countries such as Bangladesh, Nepal and India (Luber & prudent, 2009).

Climate variability is potentially the greatest threat to human health with direct and indirect influence on existence of man (Chretien et al., 2015). Climate change entails alternations in one or more climate variables including temperature, precipitation, relative humidity, wind, and sunshine. These changes in climatic conditions may impact the survival and reproduction of disease pathogens and hosts, as well as the availability and means of their transmission. Climatic variations and extreme weather events have profound impact on infectious diseases and infectious agents, such as protozoa, bacteria and viruses and associated vector organisms such as mosquitoes, ticks and sand-flies are devoid of thermostatic mechanisms, and reproduction and survival rates are thus strongly affected by fluctuations in air temperature (Kovats, 2001; Gubler, et al 2001).

It was unequivocally established by IPCC in 2013, that anthropogenic activities of man stretch the atmospheric fabric resulting to alteration of the earth's climate (Hegerl- Zwiers, et al., 2006; Ingram, 2006). Observational data shows that since the 1950s, the atmosphere and ocean have warmed, sea levels have risen, and GHG concentration is increasing (IPCC, 2013). Reoccurrence of climate change can result to diseases due to change in climatic condition of the area (Kama et al., 2024). The average global trend of land and ocean warming is between 1880 and 2012 is 0.85°C, with the last three decades being the warmest within the period, while the average sea level rise is about 0.19m (IPCC, 2013).

A traditional model of infectious disease causation, known as the Epidemiologic Triad is depicted in Figure 1. The triad consists of an external agent, a host and an environment in which host and agent are brought together, causing the disease to occur in the host. A vector, an

organism which transmits infection by conveying the pathogen from one host to another without causing disease itself, may be part of the infectious process (Gostin & Wiley, 2016).

The traditional epidemiologic triad model, transmission occurs when the agent leaves its reservoir or host through a portal of exit, is conveyed by a mode of transmission to enter through an appropriate portal of entry to infect a susceptible host (Chadha, et al. 2006). Transmission may be direct (direct contact host-to-host, droplet spread from one host to another) or indirect (the transfer of an infectious agent from a reservoir to a susceptible host by suspended air particles, inanimate objects (vehicles or fomites), or animate intermediaries (vectors).

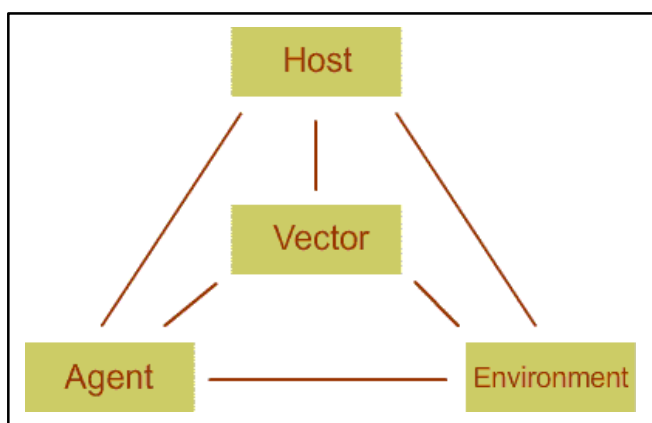


Figure 1: Epidemiologic Triad of Disease Causation (Gostin & Wiley, 2016).

A number of models of disease causation have been proposed. Among the simplest of these is the epidemiologic triad or triangle, the traditional

model for infectious disease. The triad consists of an external **agent**, a susceptible **host**, and an **environment** that brings the host and agent together. In this model, disease results from the interaction between the agent and the susceptible host in an environment that supports transmission of the agent from a source to that host (Gostin & Wiley, 2016). Agent, host, and environmental factors interrelate in a variety of complex ways to produce disease. Different diseases require different balances and interactions of these three components. Development of appropriate, practical, and effective public health measures to control or prevent disease usually requires assessment of all three components and their interactions (Gostin & Wiley, 2016).

Human understanding of the relationship between climate and diseases dates back to 384-322 BC, but the in-depth understanding of the interaction was only achieved through the fast progression of modern technology, and also the ability of man to understand the weather and climate system to the extent of forecasting and predicting the future weather and climate (WHO, 2003). Before the emergence of anthropogenic climate change, both epidemiologists and climatologists paid little attention to climate-disease relationships (WHO, 2005a). Most studies have focused mainly on investigating the risk factors for infectious diseases in individuals, not populations. According to published research (Pascual, Bouma, & Dobson, 2002; Koella, Pascual, & Yunus, 2005a) climate is playing a vital role in the spread of many infectious diseases. Some of these diseases include social risk factors that are driving the transmission and outbreak of these diseases is of great importance, because this will help authorities in the allocation of both human and financial resources in their efforts to control outbreaks (Mabaso, Craig, Ross, & Smith, 2007).

A range of infectious (particularly vector-borne) diseases are geographically and temporally limited by environmental variables such as climate and vegetation patterns. Climatic factors' impact on infectious diseases can be divided into three main effects: on human behaviour; on the disease pathogen; on the disease vector, where relevant:

Disease pathogens; for infectious diseases where the pathogen replicates outside the final host (i.e. in the environment or an intermediate host or vector), climate factors can have a direct impact on the development of the pathogen. Most viruses, bacteria and parasites do not replicate below a certain temperature threshold (e.g. 18 °C for the malaria parasite *Plasmodium falciparum* and 20 °C for the Japanese encephalitis virus; Mellor & Leake, (2000). Ambient temperature increases above this threshold will shorten the development time of the pathogen.

Disease vectors; the geographical distribution and development rate of insect vectors is strongly related to temperature, rainfall and humidity. A rise in temperature accelerates the insect metabolic rate, increases egg

production and makes blood feeding more frequent (Mellor & Leake 2000). The influence of rainfall also is significant, although less easy to predict. Rainfall has an indirect effect on vector longevity through its effect on humidity; relatively wet conditions may create favourable insect habitats, thereby increasing the geographical distribution and seasonal abundance of disease vectors. In other cases, excess rainfall may have catastrophic effects on local vector populations if flooding washes away breeding sites.

Human behaviour; climate variability directly influences human behaviour, which in turn can determine disease transmission patterns. Drainage systems require more attention to maintenance, as some sections were observed to be blocked, creating habitats for insects like mosquitoes, which can spread infectious diseases among the students (Alhassan, Kama, & Alhassan, 2023). Human-related factors such as population movements and agricultural practices also can have considerable impact on disease patterns at various spatial scales. For example, the prevalence of malaria and leishmaniasis sometimes is strongly related to irrigation schemes and deforestation (Campbell-Lendrum et al., 2001, Guthmann et al., 2002). Arguably, the importance of non-climatic factors should be assessed and compared to that of climate variability in order to justify the development of climate-based EWS for infectious diseases. The relative contributions of climatic and non-climatic risk factors in explaining temporal variability in disease incidence will, to a large degree, determine the practical utility of a climate-based EWS. Increase incidence of communicable disease that may spread to city dwellers from the work place (Kama et al., 2019).

Climatic elements affect the timing or intensity of outbreak of diseases sensitive to weather in the study area with high exposure and risk of fatalities due to the levels of ignorance. This is suspected to increase number of hospitalizations and death rates. This problem has not been addressed in the forgoing literature. Thus, the need for accurate forecast of climatic elements and disease incidences in FCT to enable planning, intervention and mitigation measures for public health challenges within

the study area and the country at large. These findings will provide insight on the possible strategies for human society to cope, adapt, prepare and mitigate for the impact of climate change in influences incidence of diseases in the study area.

STUDY AREA

Location and Size

Federal Capital Territory (FCT), Abuja is the capital city and seat of government of the Federal Republic of Nigeria. FCT Abuja lies between 8 o 27'–9 o 20' N and 7 o 25'–7 o 45' E and is located in the center of Nigeria, with a land area of 8,000 sq. km. It is bordered by the States of Abuja (East), Kaduna (North), Niger (West) and Kogi (South) and situated at an elevation of 476 m above sea level (Oluwafemi & Oluwayinka, 2020; Owolabi, Ogunsajo, Bodunde, & Olubode, 2020). The study area lies between Latitude 8o 56' 48" N and 9 o 1' 48" N and Longitude 7 o 17' 00" E and 7 o 22' 12" E.

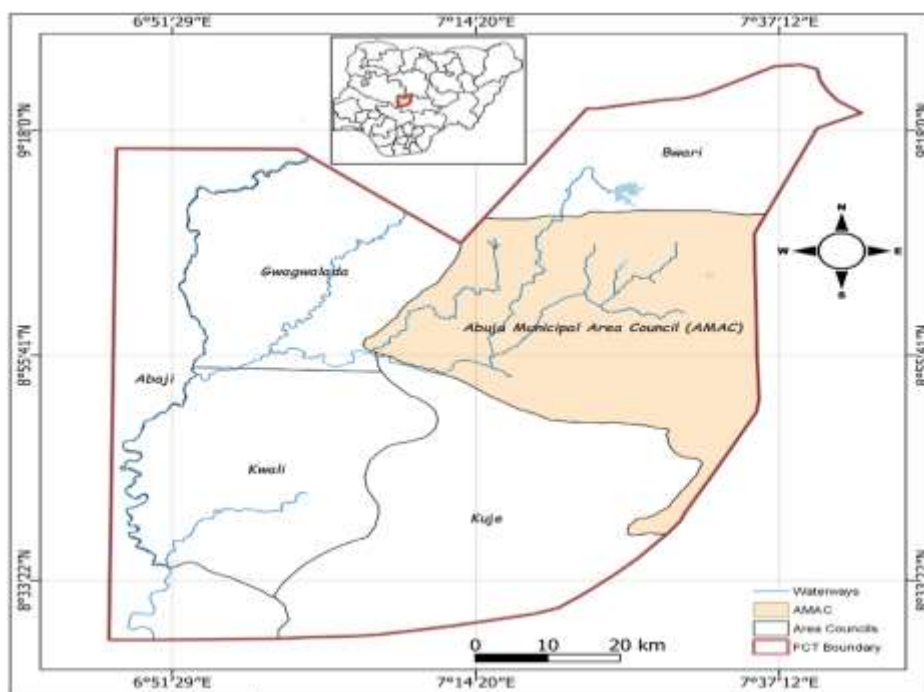


Figure 2: Map of FCT showing AMAC

Source: Nsuk Lab, 2021.

Climate

The climate of Abuja Municipal Area Council, which experiences tropical wet and dry season (Balogun, 2001). Abuja Municipal Area Council experiences a warm humid rainy season and a cold dry season yearly. The rainy season begins from April and ends in October, during which day-time temperature is between 28°C and 30°C, while nighttime temperature varies between 22°C and 23°C (Sawyerr et al., 2017a). In the dry season, daytime temperature is as high as 38°C, while nighttime temperatures can drop to 12°C.

Rainfall in Abuja Municipal Area Council is influenced by the Jos Plateau. Total annual rainfall varies from 1100 mm to 1600 mm, while relative humidity is about 30% in dry season and 70% in wet season (Chimereze et al., 2016). The prevailing wind direction are south to south westerly and north easterly respectively for the months of June/July and December/January, while on the average, wind speed is about 3.0 and 4.6 Knots in the months of June/July and 1.5 to 3.7 knots for December/January (Sawyerr et al., 2017b).

Soil and Vegetation

The soil in the study area shows high level of variability comprising mainly of sand, silt, clay and gravel. Alluvial soils are predominantly found in the valleys of the various Rivers within Abuja Municipal Area Council but highly concentrated at the valley of River Usuma. The water table around the area where this soil type dominates is usually very high. It has well decomposed organic matter content in the surface layer; its texture is heavier with depth as the weathered parent material is approached (Ebisintei et al., 2015). The soils within this area are generally moist and poorly drained almost all year round and to a great extent support farming due to its various natures (Sawyerr et al., 2017b).

Study area falls within the Guinea Savanna Vegetation Zone of Nigeria. Trees such as *Antiriseria africana*, *Anthocleistanoblis*, *Ceibapentandra*, *Cola gigantea*, *Celtis spp.*, *Chtorophora excels*, *Piptadenianum africanum*,

Lophira on alata, *Temlinalia ivorensis*, *Triplochiton scleroxylon* and *Dracaena arborea* dominate the area (Magaji & Mallo, 2020). The dominant vegetation of the area is classified into three savannah types, as follows:

Types and Sources of Data

The major data source for this study was secondary data obtained from hospitals. Other secondary data sources included journals, books, articles, newsletters, internet, magazines, published and unpublished materials. The types of data required include information on;

Medical records of both inpatients and outpatients treated for malaria, measles, meningitis and pneumonia in Federal Capital Territory hospitals for the period were obtained from Health Department of each Area Council for Government and Private Health Facilities, National Hospital, and University of Abuja Teaching Hospital Gwagwalada.

Population, Technique and Sample Size

The target population has about 767 Health facilities spread across the six area councils which comprises of the tertiary, secondary and primary sectors respectively for both Government owned and Private Health Facilities. A multiple strata or hierarchical random sampling technique was employed which entailed stratifying the Federal Capital Territory based on the existing six area councils, from which purposive selection of both government and private hospitals within the six area councils in the Federal Capital Territory was adopted. In all the area councils, only hospitals that submitted their monthly records and met the criteria set at the reconnaissance stage that provided available records of cases for malaria, measles, pneumonia and meningitis were selected, including the various health departments in all the area councils, National Hospital, and University of Abuja Teaching Hospital, Gwagwalada.

Methods of Data Collection

An application for medical records was submitted to the Ethical Committee of each Hospital selected for the study. A proposal for the study was attached to each application for approval with all necessary requirements

for obtaining clearance by the hospital management. The process of data collection took several months of intensive collaboration with the relevant units and departments at the data collection points within the study area. The disease incidence data proved more difficult to process due to incomplete data sets extracted at some hospitals which could only provide monthly data records instead of daily records.

Data Analysis

The data was processed using several procedures and analytical techniques. Diseases data were inputted and processed using Statistical Package for Social Science (SPSS) version 25 and Microsoft Excel 2016. Thus, the data collected for the study was analysed using both descriptive statistics and inferential statistics. line graphs, and maps were used to summarise the data. Descriptive statistics such as percentage, proportion, total values, and averages were then used to describe the data.

Time series analyses, and multiple regression test were used to analyse the disease incidence. This technique was employed because they are complimentary to one another in the context of this study.

RESULTS AND DISCUSSION

Malaria Incidence in FCT from 2005-2019

Malaria is the most prevalent disease in the study area, with the frequency and intensity of its occurrence being unparalleled by the frequency of the incidence of other diseases. The trend shows positive increase, with a relatively steep slope and R-square of 0.4285. The incidence of malaria disease is apparently highest during the rainy months of May to December. There is however a reduction of the disease incidence in the month of September, which indicates that, the incidence of malaria peaks in the month of August. Kama, (2022) also revealed that malaria is associated with the rainy season while meningitis is common during the hot periods. Weather elements affect the timing or intensity of the outbreak of diseases that are sensitive to weather in the study area which the people are

ignorant of and this seem to be the quite reason for ill health, increased hospitalization and death rate in the study area (Kama, 2022).

However, the incidence of malaria is generally more between the months of June and December in the study area. Malaria incidence in the study area is above 1000 cases every month of the year. This finding agrees with findings in a study by Tanser et al., (2003) which indicated that high temperatures, especially extreme heat, do not favour transmission of mosquitoes and a study by Tian et al., 2015, found that beyond a given threshold of heat, mosquito breeding and development are negatively impacted and therefore transmission of malaria is reduced. Malaria has a positive coefficient with relative humidity and rainfall, while minimum temperatures have a negative coefficient.

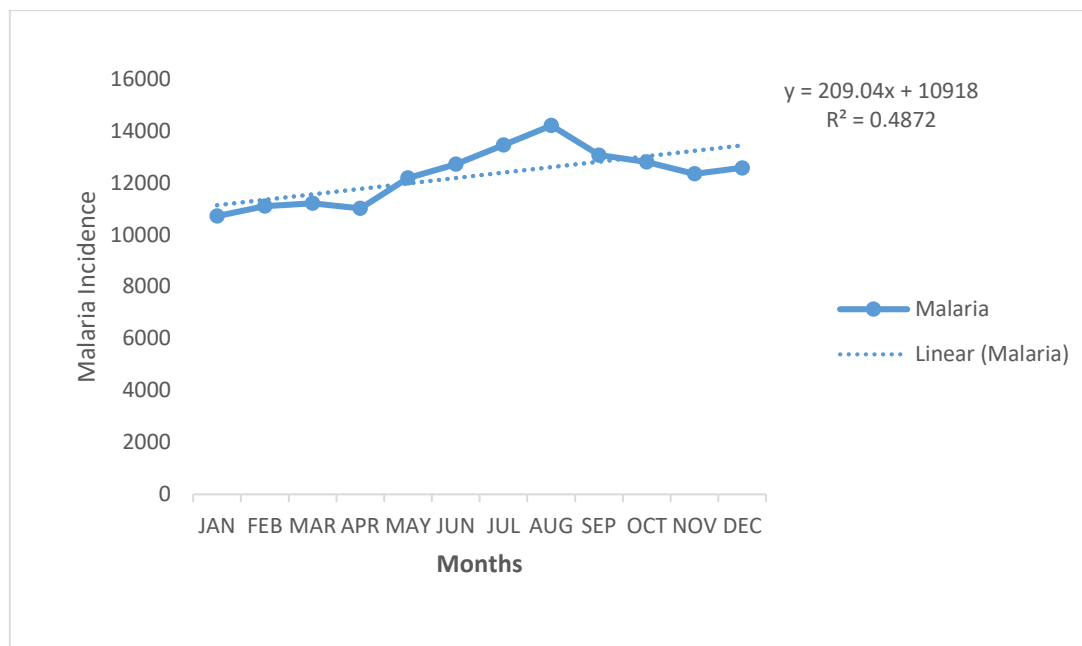


Figure 3: Mean Monthly Incidence of Malaria in FCT (2005-2019)

Source: Fieldwork, 2021

Measles Incidence in FCT from 2005-2019

The incidence of measles in the study area as presented in Figure 4 shows that the months of February, March, April, and May recorded the peak

periods of incidence of measles. The remaining months show a fluctuating pattern, which had at least up to twelve (12) recorded cases per month. This is because, the months of January to May appear to be particularly significant periods of the year for the occurrence of measles with March recording the highest (39.13). The months of June to December are particularly low incidence period with July showing a small but unremarkable rise within a minimum recorded case of 31.13 per month. The R-square $R^2 = 0.4726$ shows a positive value, which apparently means there are more cases of Measles during the dry season of the year than the rainy season over the study period (2005-2019). This finding agrees with reports for Akure Nigeria, by Akinbobola and Omotosho (2010) that the incidence of Measles is particularly prevalent in Akure during the hot dry season, with optimum temperature range of 32°C to 34°C. The temperature regimes for these areas in Nigeria do not differ much with that of the study area.

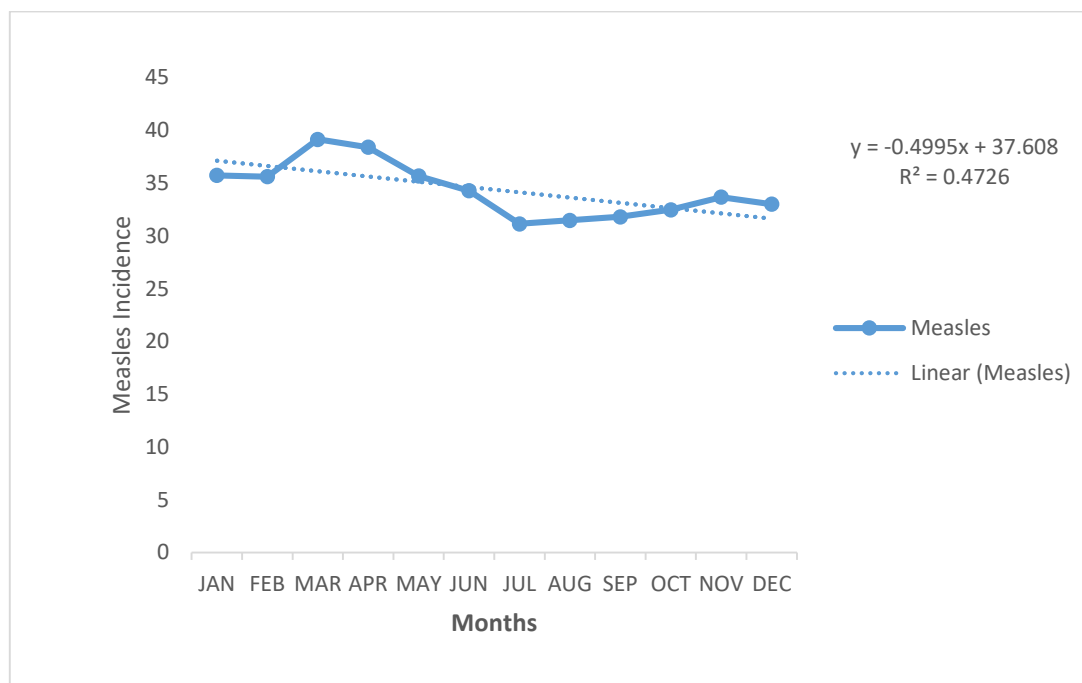


Figure 4: Mean Monthly Incidences of Measles in FCT (2005-2019)

Source: Fieldwork, 2021

Meningitis Incidence in FCT from 2005-2019

Figure 5 shows that the highest (55.8) mean monthly meningitis incidences were observed in March and a low mean incidence of 28.0 cases in August. The recorded number of in patients that were treated for meningitis increased on average from year to year. The R-square $R^2 = 0.4285$ showed a positive value which means that meningitis incidence is more prevalence in hot and dry months as clearly shown in figure 5. The low reported incidences of meningitis were recorded in 2018 and on the other hand, the high incidence of recorded cases of meningitis was in year 2005. The findings are supported by Molesworth (2002) that described meningitis as a disease of dry seasons in dry places. The periods of likelihood of occurrence of Meningitis are usually during the dry months and ends with the coming of the rainy season as opined by Chowdhury et.al, 2018.

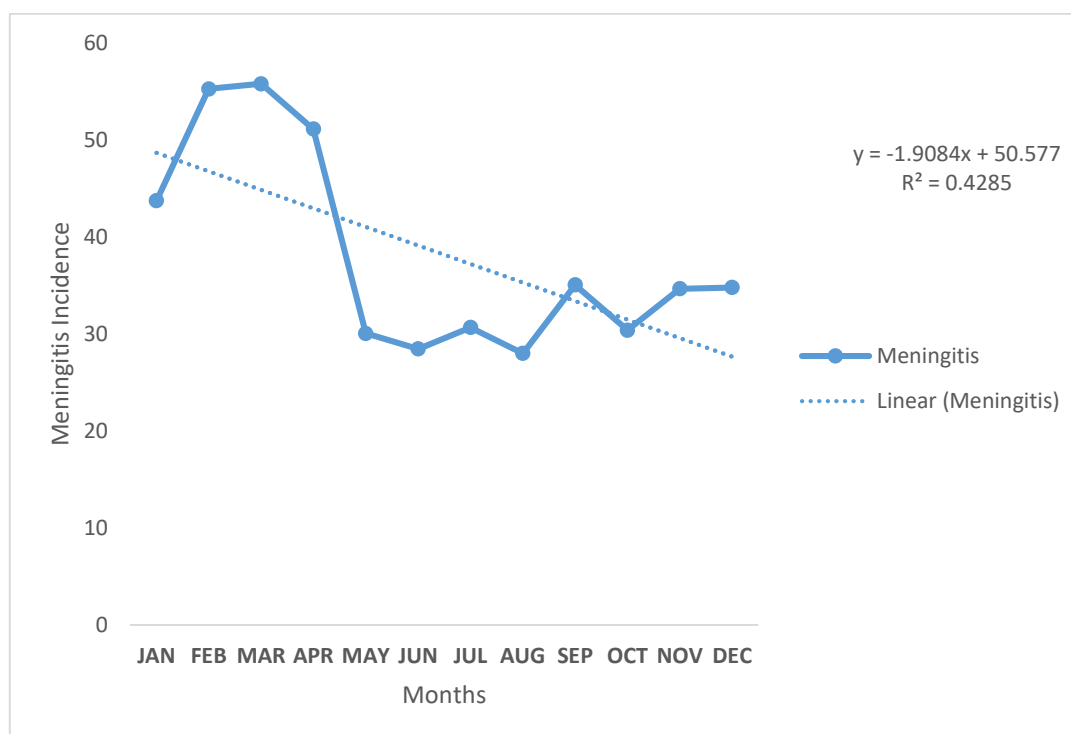


Figure 6 Mean Monthly Incidence of Meningitis in FCT (2005-2019)

Source: Fieldwork, 2021

Pneumonia Incidence in FCT from 2005-2019

The incidence of pneumonia showed a slight decreasing trend over the years because pneumonia takes a longer time to manifest thus there aren't frequent new cases. The monthly distribution of incidences of pneumonia is irregular and fluctuates sharply followed by dips the next month. The months of January to May are usually the drier parts of the year and appear to be the most important for incidence of pneumonia with peaks in June and July. However, there are relatively stable incidences of pneumonia throughout the year. This may be as a result of low total reported incidences in the study area. Generally, the FCT has relatively high temperatures for most of the year, which may not be conducive for the occurrences of a high number of cases of pneumonia, usually associated with colder conditions. Among all the five climatic elements (sunshine, maximum temperature, minimum temperature, rainfall and relative humidity) only rainfall is significant at 0.0245 with adjusted R-square of 46.10% in the case of pneumonia.

The monthly distribution of pneumonia incidence showed an undulating trend, indicating that periods of high incidences are interspersed by longer periods of low number of cases. The months of May, June and July are the high points, while April, October and November reported low number of cases (Figure 7). In general, however, the trend equation indicated a negative equation: $y = -0.2967x + 167.88$, with rainfall p-values significance at 0.05. A study by Oluleye and Akinbobola (2010) on the role of temperature and rainfall on the incidence of pneumonia and malaria in Lagos also showed that rainfall relates positively to malaria whereas temperature has a negative relationship with pneumonia.

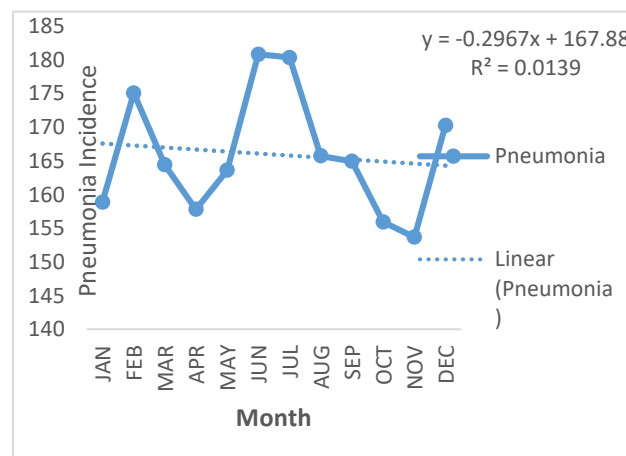


Figure 7: Mean Monthly Incidences of Pneumonia in FCT (2005-2019)**Source: Fieldwork, 2021****Conclusions**

The study on the incidence trend of malaria, measles, meningitis, and pneumonia in the Federal Capital Territory (FCT) highlights the significant impact of climatic factors on the prevalence and spread of these diseases. The findings demonstrate that malaria is particularly sensitive to rainfall and humidity, with peak incidences occurring during the rainy season. On the other hand, measles, meningitis, and pneumonia were more prevalent during the dry season, influenced by factors such as temperature fluctuations. The study reaffirms the need for integrated health strategies that consider the effects of climate variability on disease patterns, as changes in weather conditions are increasingly influencing the transmission rates of infectious diseases. Addressing these challenges is crucial for improving public health outcomes in the region.

Recommendations

- **Strengthen Disease Surveillance and Early Warning Systems:** The government should establish robust disease surveillance systems that incorporate climate data to predict and monitor disease outbreaks. This will enable timely interventions and reduce the burden of malaria, measles, meningitis, and pneumonia during high-risk periods.
- **Climate-Sensitive Health Policies:** Policymakers should develop and implement health policies that consider the effects of climate change on disease transmission. These policies should focus on preventive measures during peak disease periods, particularly for climate-sensitive diseases like malaria and meningitis.
- **Public Health Education and Awareness:** Public health campaigns should be intensified to educate the population on preventive measures during the rainy and dry seasons. Awareness programs on

the importance of early treatment and vaccination for diseases such as measles and meningitis should be prioritized.

- Improved Health Infrastructure: Strengthening health facilities, especially in rural areas, is essential to handle seasonal disease outbreaks. Increased funding for hospitals and health centers to manage surges in patient numbers during peak disease periods should be considered.

These recommendations, if implemented, would greatly reduce the incidence and impact of infectious diseases in the FCT and ensure better public health outcomes for the population.

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