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Relationship between Climatic Variables and Incidence of Malaria and Asthma in Keffi Local Government Area of Nasarawa State, Nigeria

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Keywords: relationship, variables, incidence, climatic, asthma, malaria.

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Abstract- There has been a significant upsurge in global warming phenomenon in the recent times than ever. This resulted from the alteration of global climatic variables i.e., temperature, rainfall, relative humidity e.t.c. This study assess the trends of climatic variables in Keffi from 2003-2018. (Temperature, rainfall and relative humidity). The method was used to source data from mega and reputable institution for the purpose of this research. Where malaria data was sourced from the PHC unit, Keffi Local Government Council. Asthmatic data was retrieved from federal medical center (FMC) Keffi. Whereas, those climatic variables were obtained from the Nigerian Meteorological Agency (NIMET), FCT Abuja. The study finds out the trends and impacts of climatic variables on climatic sensitive diseases. Which are principally in the aspect of an existing relationship and impacts of climatic parameters on malaria/asthma. As explained by U.S Center for Disease Control (CDC). Climate is the key and basic determinant of the distribution of malaria in the world. Explains "climate can influence all three components of the life cycle. It is thus, a key determinant in a geographic distribution and seasonality of malaria (U.S Center for Disease Control 2017). It added that, "even if malaria has been eliminated from an area, if rainfall, humidity and temperature persist, there is danger that the disease can be reintroduced (U.S CDC 2017). The work also reviews that, "climate change are altering patterns of temperature and precipitation, potentially affecting the regions of malaria" (Olson et' al 2009). Findings has also revealed that, logging of trees from massive agricultural practices and timber traders contribute to rising of temperature over the years. Findings analyzed from the retrieved data revealed that, rising temperature, relative humidity and declination in rainfall poses impacts on malaria and asthma in Keffi and the world-over, over the years. Marking a clear relationship between the two. The research wholesomely concluded by reiterating some abative measures to ravaging impacts of climatic variables on malaria/asthma and also on human health and comfort has been in the heart of the people. But unfortunately this has been the ultimate focus on government and people living in Keffi over the years. Thus, this calls for concerted effort and more commitment from both government and individual. Not putting down a lend of helping hand from NGOs, elites and stake-holders to win the fight.

Keywords: relationship, variables, incidence, climatic, asthma, malaria.

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I. Introduction

Human health vulnerability at the expense of climatic variables (temperature, rainfall and relative humidity) has continues to be of intense concern in all the countries of the world. Clear indications has therefore proven that the negative effects incurred from the increasing Temperature, rainfall and relative humidity etc has been on the high side. These can be clearly perceived via the rapid increase of infection i.e malaria/asthma resulting from the influence of these climatic elements, which both could be direct and indirect effects resulted from the depletion of the ozone to climatic variation. For example, increasing global warming. Whereby, increasing temperature becomes an added advantage to mosquito operation and also increasing malaria cases. Breeding grounds from precipitation and an aggravation of asthmatic cases from relative humidity and temperature modification. While the indirect could be gotten from the polluted air, water and food quality and quantity. i.e warm temperature can increase air and water (H_2O) pollution which in turn harm human health.

Human beings are exposed to climatic effects through changing weather patterns (for example, via frequent and intense events and also indirectly through changes in water, air, food quality and quantity (being a man's life dependence) ecosystem, agriculture, and economy. At these early stages the effects are small but are projected to progressively increase in all countries and regions of the world (IPCC, 2007). Simple example of this are rampant malaria cases today which are both contribution of vast effect of Temperature, Insolation and Rainfall. One may ask how, seasonal extension this days which results from the modification of climate variation is an added advantage to the periodic operation and proliferation of mosquitoes thereby, resulting to high malaria/relative humidity infections.

The effects of climatic elements i.e temperature, Insolation and Rainfall, relative humidity on human health are essentially the consequences of natural trend (processes) taking place on our social milieu (habitats) whose effects remain unsurpassed in recent years. While on the other hand, are exacerbated by humanitarian actions and inactions and the generality of the impact of man on the environments.

Climate variation as a matter of reality, does not affect not only malaria/asthma (though being the primary target of this research) but also regulates man's social life e.g day-to- day activities such as economic activities, commercial transaction, agriculture, industrial and education etc, to some extent, both fauna and flora activities (lives).

Therefore, positive aspect of climates important (Temperature, Insolation and Rainfall) etc cannot be completely forgotten, though may just be meager compare to its negative side. Ayoade (1998) said and I quote "the impacts of climate variation on society may be positive (benevolent or desirable) and negative (malevolent or undesirable). Yet climate is both a hazard and a resource depending on time, and the values and types of climatic parameters involved". Despite its capacity to serve as a resources to man, unfortunately man ignorantly and deliberately augments the gaseous contents in the atmosphere (Green House Gasses). The drastic effects of human health vulnerability of climate (as mentioned earlier) includes infectious diseases such as; malaria, pneumonia, asthma, heat stroke, eczema, cardiovascular attack, influenza, bronchitis, diarrhea, as well as skin cancer and cataract of the eyes (eye blurred vision) among others.

For a long time, much of the efforts utilized, in the management and limiting the eminence (future) impacts of climate variation on malaria/asthma has being more of adaptation and mitigation, has been referred to as emergency relief assistance or disaster management, humanitarian aids, and disaster prevention such as the efforts of Intergovernmental Panel on Climate Change (IPCC), Environmental Protection Agency (EPA). Each of these elements and many others had, in their own respect, has a certain reactive focus of emergency/climatic infectious issues and vast amounts of money are still spent annually on response to situations of disaster/climatic related cases (ISDR, 2002).

Like most countries of the world, Nigeria has not been thoroughly left behind in issues related to these, appropriately putting mechanism such as national disaster plan at alert. Strongly affiliating and adhering to the IPCC's objectives, putting in place the National Emergency Management Agency (NEMA) has not been found wanting to or in handling these issues. Consequently, when affected persons in around our locality are acknowledged, they both rush relief and assistance to such people, i.e distributions of mosquitoes nets (treated insecticides net) to hospitals and private parastatals and also governments of all levels, free distribution of drugs and treatments of some climatic infected cases i.e pneumonia skin cancer etc. Unfortunately, these attempts decreased and the victims are left on their own. Often, these may not be able to continue forever. Therefore, the lasting and best dimension of remedying these problem is by at first, scrutinizing the causes, creating awareness so as to establish individual precaution and limiting the climatic future vulnerability on our health, environments etc.

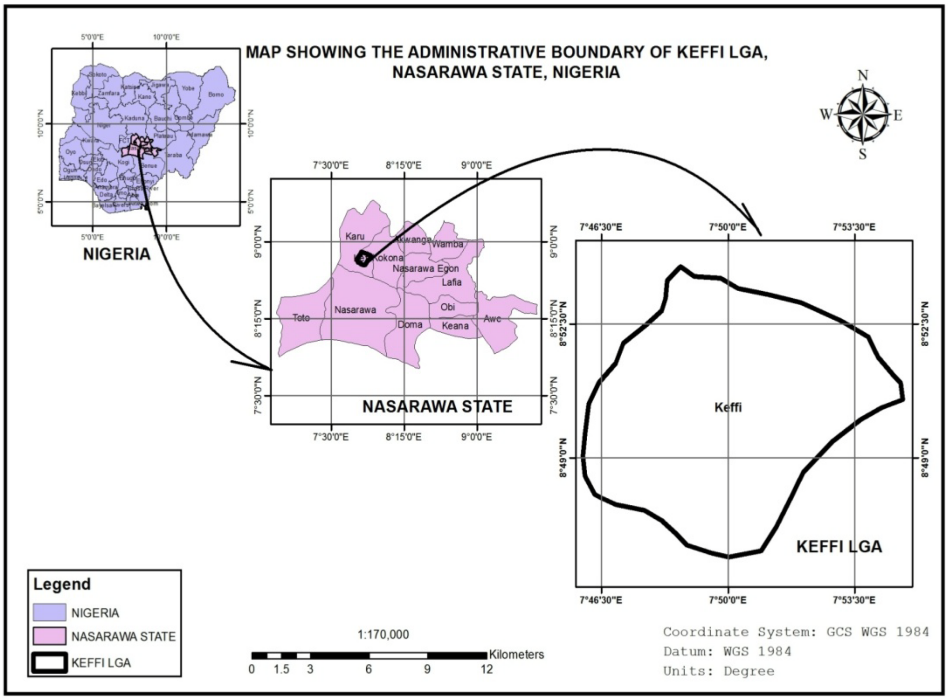
Because the damage caused so far by this trend (Human Health vulnerability from climatic elements and his environments are of unimaginable proportions as the inhabitants in the habitats remain powerless even when there shall be no means of them refusing inhabiting their habitats (since climate is influential to both inhabitants above and beneath the earth surface).

Therefore, the aforementioned alternative pointed out needs/ attention to over-rid these trends of climatic variation (rainfall, temperature and relative humidity) and its substantial influence on malaria/asthma whereby human health and comfort is impacted.

II. Materials and Methods

a) Location

The geographical entity known as Keffi local government area of Nasarawa state, Nigeria, was existing since 1802, located west ward of the state. It lies at the intersection of latitude 6°50′N and longitude 7°50′E. It is bounded to the north by Panda Development Area and to the East Kokona Local Government Area. While to the West Karu Local Government Area and Nasarawa Local Government Area at the South. (fig.1). It has a total land area of about 140.47km^2. The town has a substantial parcel of land area reserved for developmental (residential) purposes by the state government. Some of these parcel of land extended to the southern hemisphere of the area use largely for farmland. With its hinterland extended and networked all around it. According to National Population Commission 2006 census, reported Keffi has a population of 92.664. That encompasses of 47.801 male, and female 44.862 with total of 10,674 households. (NPC, 2006).



Source: NAGIS, 2020

Fig. 1: Map of Keffi Local Government (Study area)

b) Methods of Data Collection

The research used secondary type of data. The method was used to source data from mega and reputable institutions, e.g., Federal Medical Centre (FMC) Keffi, PHC Unit, Keffi Local Government Council, Nigeria Meteorological Agency (NIMET). The method was adopted as a major tool to source the required documented data for the research.

In addition, the secondary data was also generated from the review of enormous relevant literatures in journals, textbooks, web pages and many other relevant published and unpublished materials as well. Where malaria data was retrieved or obtained from the health care unit (department) at the Keffi Local Government Council. As asthmatic data was retrieved from FMC and the climatic variables (data) was retrieved from the Nigeria Meteorological Agency (NIMET) FCT, Abuja.

This method was adopted and used in order to obtain or retrieve full data on climatic variables and malaria/asthmatic documented record. Hence, this may not be effectively and efficiently gathered or generated from the population via oral confrontation (interview).

c) Techniques of Data Analysis

Cooper and Schindler (2014), defined data preparation or analysis as the processes that ensure the accuracy of data and their conversion from raw form into classified forms appropriate for analysis. The analysis and interpretation of data used in this study was based on the research questions and objectives of the study. As earlier pointed out, the study elicits both quantitative and qualitative data. Hence, these data were processed and analysed both quantitatively and qualitatively. In analysing the quantitative data used in the study, the researcher employed the use of Microsoft Excel, IBM SPSS Statistical package version 26, and E-Views 10, to organize the data collected into manageable information that was understood. These data were edited by inspecting the data pieces. The data were then coded to facilitate data entry into the computer to allow for statistical analysis.

The analytical methods used in analysing the data was the univariate and bivariate methods. The univariate method of analysis used was the descriptive statistics. Explicitly, the descriptive statistics that was used, was the time series trend analysis. The bivariant method of analysis that was adopted was correlation and regression analysis.

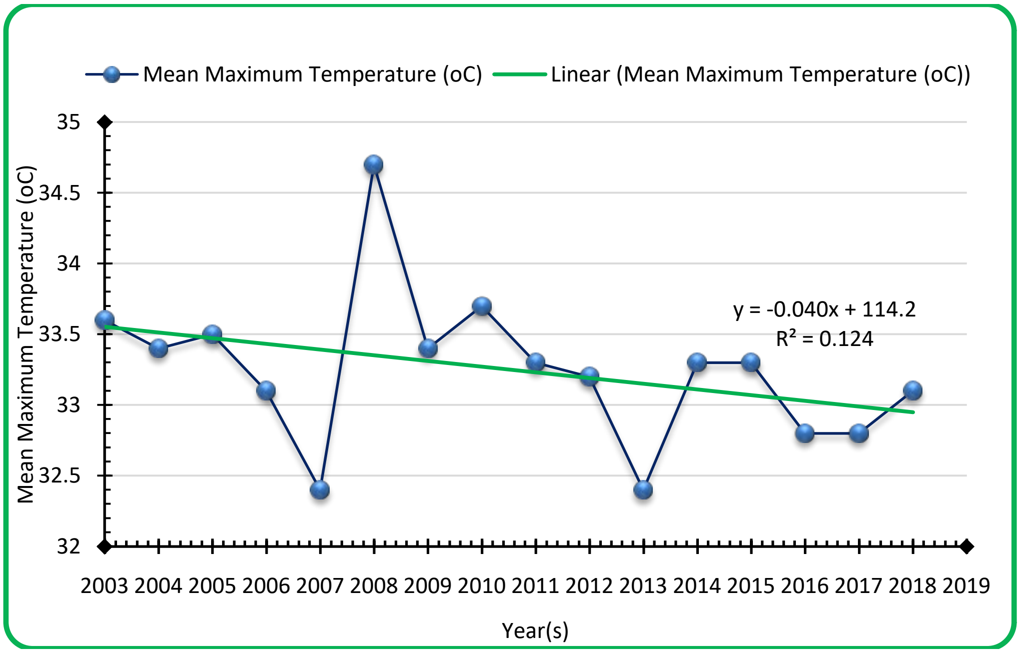
III. Results and Discussion

a) Climatic Variables Trends

i. *Maximum Temperature*

Figure 1 depict the trend of mean maximum temperature in the study area between 2003 and 2018. From the trend chart, it can be observed that the study area over the course of 16 years (2003-2018) has been experiencing a decreasing trend in average (mean) maximum temperature. From the cyclical nature of the trend plot, it can be observed that the year 2008 recorded the highest mean maximum temperature in the study area at 37.7°C, while the lowest mean maximum temperature was recorded in the year 2007 and 2013.

The average (mean) maximum temperature recorded during years (2007 and 2013) was 32.4°C respectively. The trend equation depicted in the trend chart indicated a goodness of fit of the trend plot, and thus implies a 12% variability in the mean maximum temperature in the study area as indicated by the value of r^2 (0.1243). The results here conform with the work of Okoroha (2018).



Source: Author's computation, 2021.

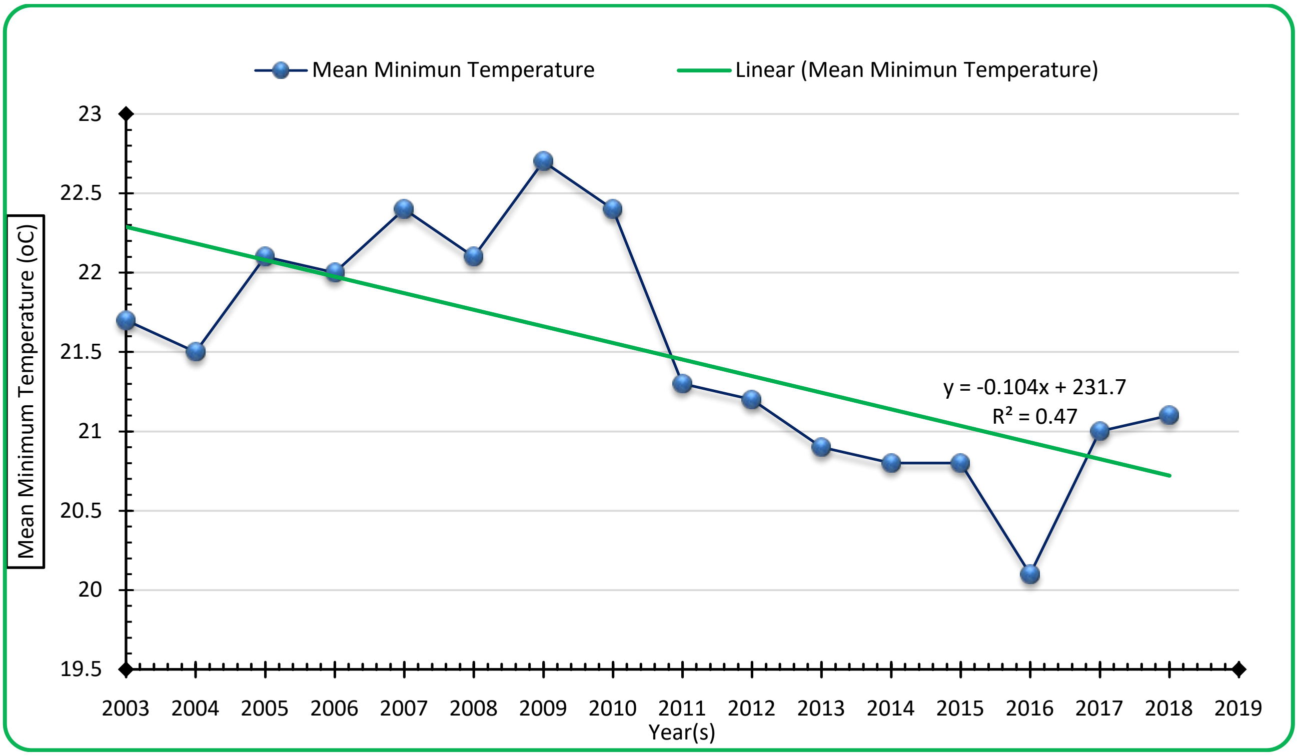
Fig. 2: Trend Chart of mean maximum temperature (°C) in the study area

All the annual temperature was reading high with just little variations from 2003.-2018 respectively (fig. 1). This probably could be because of the fact that, it's a natural phenomenon with natural occurrences (Ayoade, 2004). And the increased temperature could further be traced to agricultural practices as well which resulted to the upsurge of temperature this high in the area. i.e logging down of trees, setting of bushes on fire in search for games could probably be a cause or factors to this high range of temperature witnessed within this period in the study area (J.O Ayoade, 2004).

ii. *Minimum Temperature*

Figure2 depicts the nature of the trend of mean minimum temperature in the study area across the time frame under consideration by the researcher. The step downward sloping nature of the trend line indicates a sharp decreasing trend in the mean minimum temperature in the study area. It is however important to note take prior to the decreasing nature of the trend plot, there was a gradual increasing trend in the average (mean) minimum temperature in the study area. This increasing trend was recorded between 2003 and 2010. Explicitly, the year 2003 recorded a mean minimum temperature of 21.7°C, while the year 2004 recorded a slight decrease, with a mean minimum temperature of 21.5°C recorded. Compared to the year 2003 and 2004, the year 2005 recorded an increase in the mean minimum temperature in the study area at 22.1°C, while the year 2006 recorded a slight decline in the mean minimum temperature in the study area. This decline can be regarded as rather less significant and stood at 22°C. The year 2007 however recorded a slight increase in the average (mean) temperature in the study area. Temperature (mean minimum) recorded this year (2007) was 22.4°C, while the year 2008 experienced a slight decline (22.1°C). The fluctuating nature of increase and decline in the mean minimum temperature in the study area was also experienced in the year 2009 and 2010. During these periods, the mean minimum temperature recorded in the study area in 2009 was 22.7°C, while the year 2010 recorded a decline at 22.4°C.

What is most notable in the trend plot depicted in Figure 4.2 is the rapid and continuous decline in the mean minimum temperature in the study area. This decline began in the year 2011 to 2016. During these periods the mean minimum temperature recorded in the study area were; 21.3°C in 2011, 21.2°C in 2012, 20.9°C in 2013, 20.8°C in 2014 and 2015, and 20.1°C in the year 2016. Unlike previous years (2011-2016), the year 2017 and 2018 recorded gradual increase in the mean minimum temperature in the study area. Minimum temperature recorded during these periods were 21.0°C and 21.1°C respectively. It is important to state here that the year 2009 recorded the highest mean minimum temperature in the study area (22.7°C), while the year 2016 recorded the lowest mean minimum temperature in the study area (20.1°C). The trend equation indicates suggest a goodness of fit of the trend plot, while the value of r^2 (0.47) indicates a 47% variability in the mean minimum temperature in the study area. This results conform with the findings of Okoroha, (2018).



Source: Author's computation, 2021.

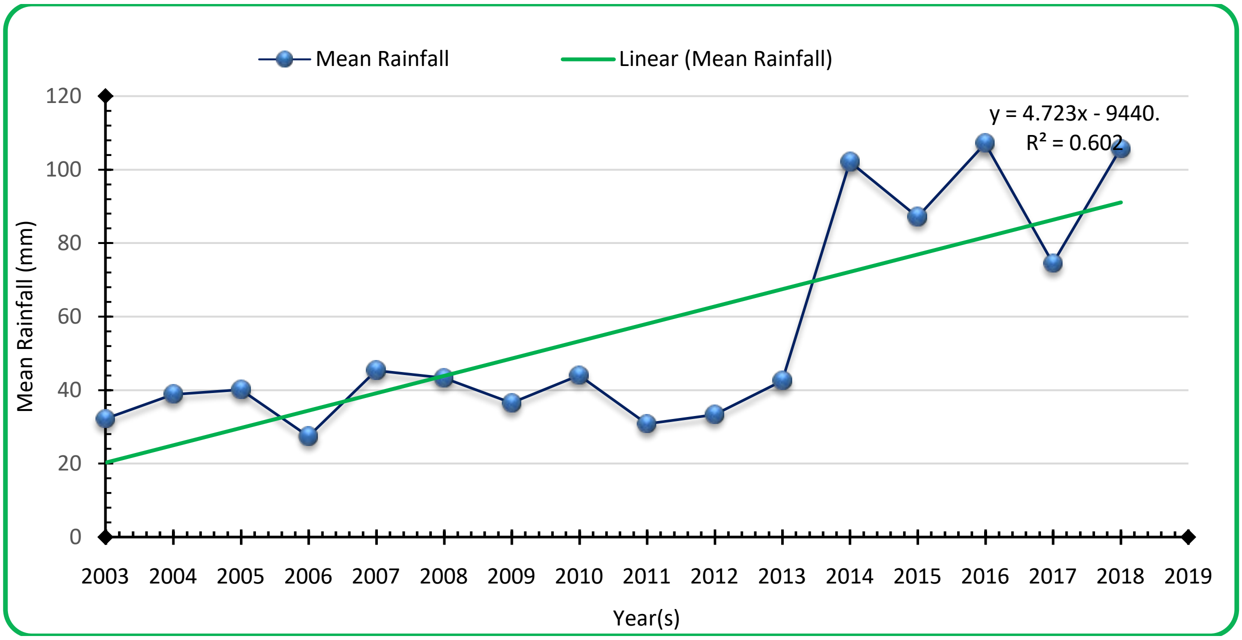
Fig. 2: Trend chart mean minimum temperature (°C) in the study area

All the annual temperature was reading high with just little variations from 2003.-2018 respectively (Fig. 1). This probably could be because of the fact that, it's a natural phenomenon with natural occurrences (Ayoade, 2004). And the increased temperature could further be traced to agricultural practices as well which resulted to the upsurge of temperature this in the area. i.e logging down of trees, setting of bushes on fire in search for games could be probably be a cause or factors to this high range of temperature witnessed within this period in the study area (Ayoade, 2004).

iii. *Rainfall*

The trend of rainfall was also taken into consideration in assessing the variability trend of climatic variables in the study area. The trend chart depicted in Figure 4.3 shows the nature of the trend of mean rainfall in the study area between 2003 and 2018. From the trend chart, it can be observed that the trend line is upward in nature, signifying an increasing trend in the average (mean) rate of rainfall in the study area. Although some years like 2006, 2009, 2011, 2015, and 2017 recorded slight decline in rainfall, this decline was not significant to warrant step fall in the trend plot. During these periods mean rainfall data recorded were 27.4mm, 36.5mm, 30.8mm, 87.1mm, and 74.5mm respectively. More so, the significant increase in rainfall (average) in the study area was experienced in the year 2014. During this period, the mean rainfall recorded was 102.1mm.

The highest mean rainfall recorded in the study area was in the year 2016. Mean rainfall during this period was recorded at 107.1mm, while the lowest rainfall experienced, and was in the year 2006, which was recorded at 27.4mm. The trend equation suggests a goodness of fit of the trend plot, while the value of r^2 (0.629) indicates a 63% variation in the mean rainfall recorded in the study area between 2003 and 2018. This result conforms with the studies of Bulus (2018).



Source: Author's computation, 2021.

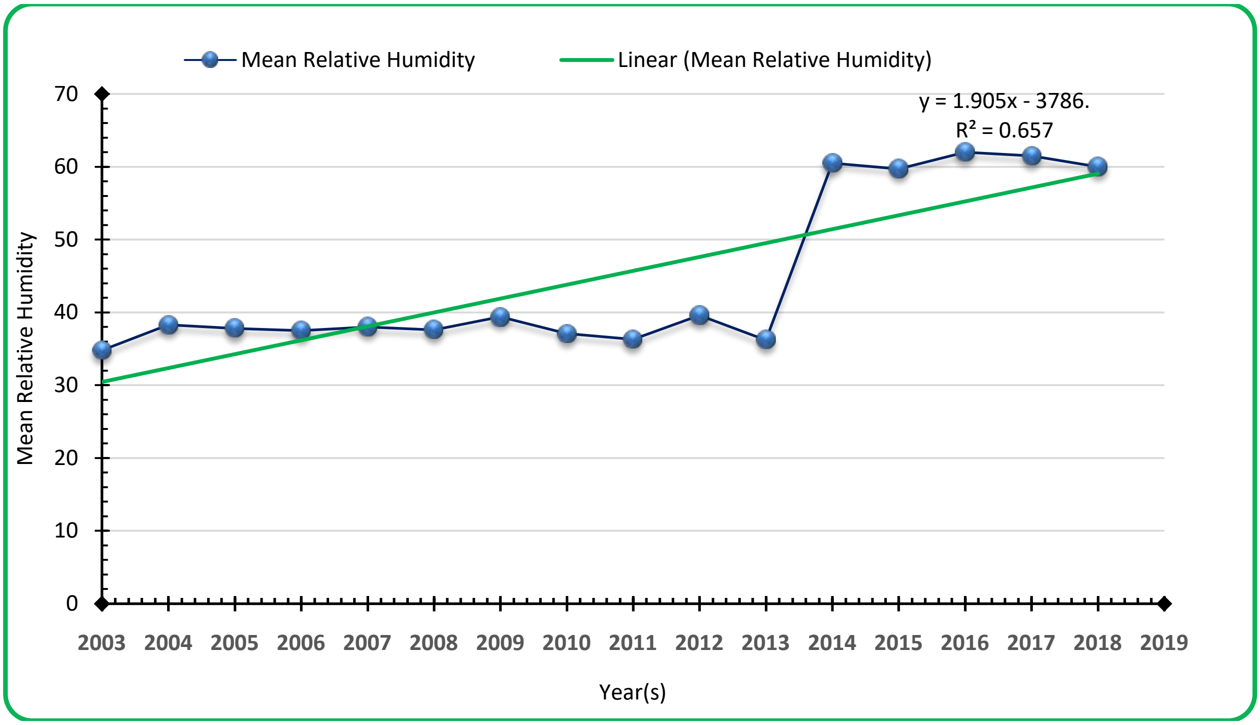
Fig. 3: Trend chart of mean rainfall in the study area

The town always experience this trend of downpour following probably its location at the tropics. Where is usually relatively unstable and high. Influenced by its tropical temperature (Akwa *et' al* 2007). And lastly, its unstableness and variations could be traced to the phenomenon of climate change experienced over the years (Ayoade, 2004). Logging of trees increases the effect of drought thereby, impacting patterns of precipitation.

iv. *Relative Humidity*

Figure 4 depicts the trend of relative humidity in the study area. From the trend plot it can be observed that the trend line is upward sloping in nature, indicating an increasing trend in the mean value of relative humidity in the study area between 2003 and 2018. From the trend chart, it can be observed that there is a steady and gradual increasing trend between 2003 and 2009. During these periods the relative humidity recorded in the study area were 34.8% in 2003, 38.3% in 2004, 37.8% in 2005, 37.5% in 2006, 38% in 2007, 37.6% in 2008, and 39.4% in 2009. In the year 2010 and 2011, a slight decline of mean relative humidity was recorded in the study area. During these periods, relative humidity recorded were 37.1% and 36.3% respectively; while a slight increase was recorded in the 2012, which was 39.6%. A noticeable decline in relative humidity in the study area was recorded in the year 2013 as depicted by the downward movement of the trend plot. During this period, the mean relative humidity recorded in the study area was 36.2%.

Most vivid from the trend chart as depicted in Figure 4.4 is the sharp upward movement of the trend line. This movement signifies a significant increase in the relative humidity in the study area. This increase was recorded in the year 2014. In this year (2014) relative humidity recorded in the study area was 60.5%. However, a slight decline in relative humidity was recorded in the year 2015, which was 59.7%. Besides the decline recorded in the year 2015, the year 2016 to 2018 recorded a much higher percentage in relative humidity in the study area. During these periods (2016 to 2018) relative humidity recorded were; 62% in 2016, 61.5% in 2017, and 60% in 2018. The trend equation indicates a goodness of fit in the trend plot, while the value of r^2 (0.6573) suggest a 66% variation in relative humidity in the study area between 2003 and 2018. This work conform with the studies of Ahmad (2020).



Source: Author's computation, 2021.

Fig. 4: Trend chart of mean relative humidity in the study area

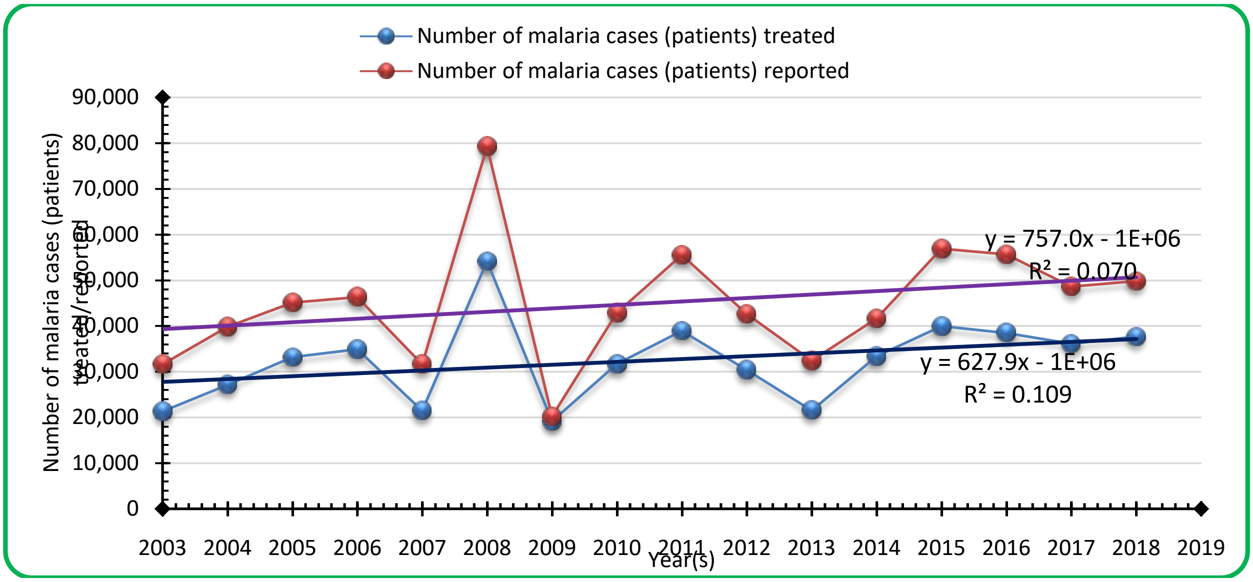
The variations and increased relative humidity over the years could reflect the climate change phenomenon (Cooney C.M, 2011). Hence, it's a natural phenomenon itself. Also, declination of rainfall reduces moisture content in the air aggravating asthmatic condition.

b) Incidence of Malaria and Asthma

i. *Malaria Treated and Reported Cases*

The trend chart depicted in Figure 5 revealed the trend of reported cases of malaria in the study area, as well as treated cases between the year 2003 and 2018 vis-à-vis the variation between reported cases and treated cases. From the trend chart, it can be observed that there is an upward movement in the trend plot between the year 2003 and 2006, implying and increasing trend in malaria cases reported and treated. Specifically, the cases of malaria reported were; 31,605 in 2003, 39,802 in 2004, 45,101 in 2005, and 46,307 in 2006. Similarly, the cases of malaria treated during this period were; 21,034 cases in 2003, 27,103 cases in 2004, 33,171 cases in 2005, and 34,908 cases in the year 2006. The year 2007 recorded a decline the cases of malaria reported as well as treated cases of malaria in the study area. In this year malaria cases reported was 31,604, while patients (cases) treated of malaria was 21,444.

The sharp movement of the trend plot of malaria cases reported in the year 2008 indicates a significant increase in the cases of malaria in the year. Reported cases consisted of 79,240 patients. Similarly, the sharp upward movement of the trend plot for treated cases of malaria in the study area signifies a significant increase in treated cases of malaria in the study area during the same year (2008). Treated cases of malaria during this year consisted of 54,147 patients. Though the trend plot of treated cases of malaria in the study area was upward significantly, it important to not that the movement no way near that of the upward movement of the trend plot of reported cases, thus implying a significant difference (25,093 cases) between reported cases of malaria and actual treated cases in the study area during the said year. More so, it is important to state that this period recorded the highest cases of malaria reported as well as treated cases of malaria in the study area.



Source: Author's computation, 2021.

Fig. 5: Trend chart of the number of treated and reported cases of malaria in the study area

The year 2009 recorded a significant decline in the cases of malarial reported and treated in the study area as depicted by the sharp downward slope of the trend plot. During this period reported cases of malaria consisted of 20,209 patients, while treated cases consisted of 19,157 patients. What is most peculiar is that there was no significant difference between the number of treated cases of malaria and reported cases of malaria in the study area. The difference between treated and reported cases was 1,052 cases (patients). More so, this year recorded lowest cases of reported and treated cases of malaria across the entire timeframe (2003 to 2018) under consideration in the study.

From the trend chart in Figure 5, it can be observed that is an upward movement in the trend plot between the year 2010 and 2011, signifying and increasing trend in reported cases of malaria, as well as treated cases of malaria in the study area. During this period, reported cases of malaria were 42,890 cases in 2010 and 55,505 cases in 2011, while treated cases consisted 31,700 cases (patients) in 2010 and 38,922 cases in 2011. From this data, it can be observed that there is a significant variation between reported cases of malaria and treated cases of malaria in the study area. Explicitly, 11,190 cases in the year 2010 were not treated, while 16,583 cases were not treated in the year 2011. Contrast to the year 2010 and 2011, the 2012 and 2013 carried downward sloping trend plot; signifying a decreasing trend in reported and treated cases of malaria. During this period reported cases of malaria were 42,619 cases in 2012 and 32,406 cases in 2013, while treated cases were 30,362 cases in 2012, and 21,505 cases in 2013. During these periods a cumulative case of 23,158 were left untreated.

Looking at the trend chart (Figure.5), it can be observed that there is steady upward movement in the trend plot between 2014 and 2018, signifying and increasing trend in the reported and treated cases of malaria in the study area. During this period, a cumulative 252,595 cases of malaria was reported, while a cumulative 185,444 cases of malaria were treated. More so, a cumulative malaria cases of 67,151 were not treated. Overall, the upward nature of the trend lines in Figure.5 indicates an increasing trend in both reported and treated cases of malaria in the study area between 2003 and 2018. More so, the trend equation signifies a goodness of fit of the trend plot. The value of r^2 (0.0707) signifies a 71% variation in reported cases of malaria in the study area between 2003 and 2018. Similarly, the r^2 value of 0.1091, signifies an 11% variation in the number of treated cases of malaria in the study area between 2003 and 2018. In the discussion carried out between the researcher and the authorities of PHC unit, LGC, it was revealed that some of the factors attributed to the variation between reported cases of malaria and treated cases were; cost of treatment/drugs, inability to finance treatment by patients after diagnose, delay/shortage of supply malaria drug by WHO, especially in the year 2008. This work conform with the studies of Nyasa (2021).

The cases of malaria witnessed in the area could be attributed to both physical and human induced factors (Sarah Moore, 2021), i e, precipitation creates mosquito breeding grounds, which promotes mosquito operations leading to high incidence of malaria in the study area (US. CDC, 2017).

It could further be probably due to increased temperature experienced in the region (Fig. 1), i.e hence, high temperature leads to heat-upsurge, compelling people to keep outdoor (US. CDC, 2017). This becomes an added advantage to mosquitoes operation given rise to such high cases of treated malaria incidence in the area over the years. Whereas, those human induced factors are; lack of adequate hygiene in the environment, also open up rooms for mosquitoes breading.

And also, we witnessed high range of temperature (Temperature maximum. and Temperature minimum.) in 2003, 2007 and 2013 respectively (Fig. 1) (which poses a great impact on malaria). But yet, low treated malaria cases in those years was recorded. This probably could be connected to economic factors, i.e lack of money to go for treatment resulted to low treated cases or records in those years.

And lack of sensitization and awareness to go for the treatment may also be a factor why treated cases are low.

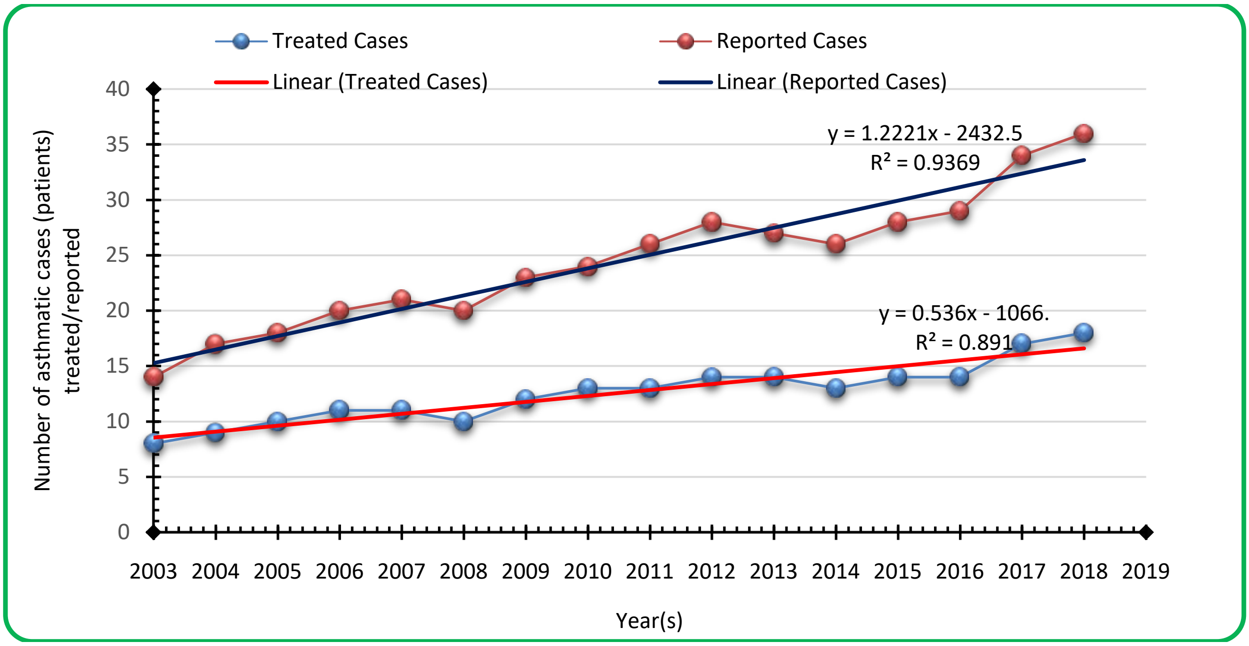
c) Evidence of Climatic Sensitive Diseases in Keffi Local Government Area of Nasarawa State

Source: Author field survey (2021)

Plate 1: Malaria patient receiving treatment at the Federal Medical Centre Keffi, Nasarawa State

d) Asthmatic Treated and Reported Cases

Figure 6 depict the trend of treated and reported cases of asthma in the study area between the year 2003 and 2018. From the upward nature of the trend line, it can be deduced that there is a steady increasing trend of treated and reported cases of asthma in the study area across the timeframe considered in the study. The most significant movement in the trend plot was in the year 2018. During this period, a total of 18 cases of asthma was treated, while 36 cases were reported. The value of r^2 (0.9369) signifies a 94% variation in reported cases of asthma in the study area between 2003 and 2018, and an 89% (r^2 = 0.891) variation in treated cases of asthma in the study area, across the time series under study. This was conform with the work of Asher (2020).

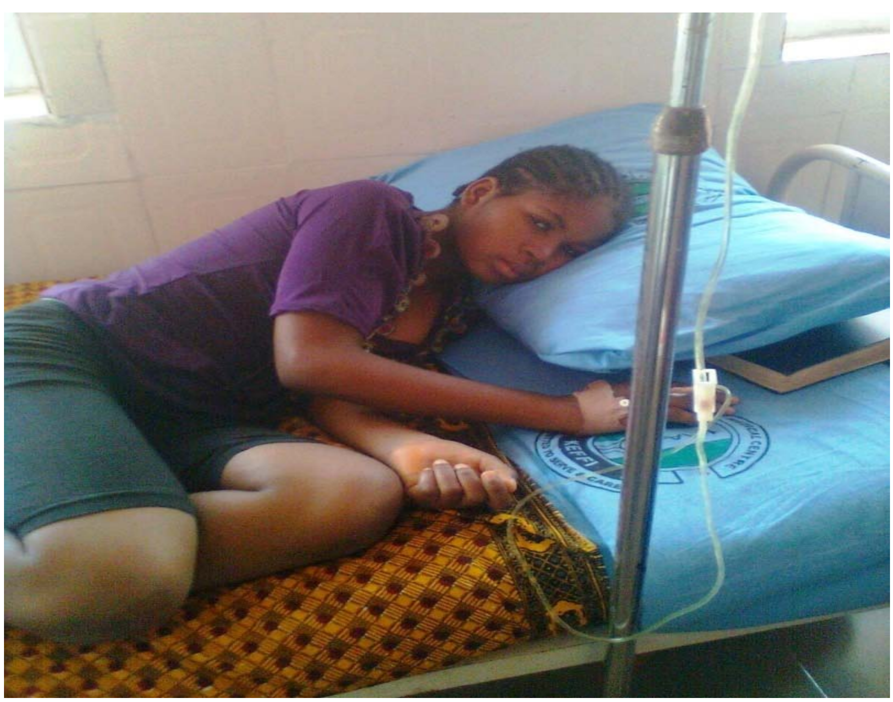


Source: Author's computation, 2021.

Fig. 6: Trend chart of the number of treated and reported cases of Asthma in the study area

Generally, the plotted graph depicts a consistence increase of asthmatic treated and reported cases throughout the period up to the last year. This could probably be attributed to an increased relative humidity in the area (fig. 3) and the high temperature (fig .1 & 2) as well. Hence, relative humidity and temperature has a vast impact on Asthmatic condition (Cooney C.M, 2011). While, other factors that could be responsible to this increasing cases of asthma in the area could be; lack of efficient awareness of the disease to the people to reduce its effect or increasing cases shown on the graph, (fig..3)

e) Evidence of Climatic Sensitive Diseases in Keffi Local Government Area of Nasarawa State



Source: Author field survey

Plate 2: Asthmatic patient receiving treatment at the Federal Medical Centre Keffi, Nasarawa State

f) Relationship between Climatic Variables and Incidence of Malaria/Asthma

The relation between climatic variables and incidence of malaria/asthma in the study area was examined through the Pearson Product Moment Correlation and a one-tail test employed.

g) Relationship between Maximum Temperature and Malaria

The result extract presented in Table 1 depicts the relationship between mean maximum temperature and reported cases of malaria in the study area. For the result extract, the Pearson Product Moment correlation coefficient was arrived at 0.500. The value of the correlation coefficient by interpretation implies that there is a moderate positive relationship between mean maximum temperature and reported cases of malaria in the study area. More so, this moderate positive relationship was statistically significant, as indicated by the *p*-value (significant value) 0.024 < 0.05. This positive significant relation conforms with the study of Minoo *et al.* (2019).

Table 1: Correlation between Max. Temperature and Reported Cases of Malaria

Variables		Mean Max. Temperature	Reported Cases of Malaria
Mean Max. Temperature (T°C)	Pearson Correlation	1	0.500*
	Sig. (1-tailed)		0.024
	N	16	16
Reported Cases of Malaria	Pearson Correlation	0.500*	1
	Sig. (1-tailed)	0.024	
	N	16	16

*. Correlation is significant at the 0.05 level (1-tailed).

Source: Author's computation, 2021.

This result shows that maximum temperature affect malaria. Though, study showed that, high temperature disturb mosquitoes life cycle. The inconsistency can be related to mosquito habits and their adaptations to the region's climate (Nkurunziza *et' al*, 2011).

h) Relationship between Minimum Temperature and Malaria

Table 2 depicts the relationship between mean minimum temperature and reported cases of malaria in the study area. For the result extract, the Pearson Product Moment correlation coefficient was arrived at -0.295. The value of the correlation coefficient by interpretation implies that there is a weak negative relationship between mean minimum temperature and reported cases of malaria in the study area. More so, this weak negative relationship was not statistically significant, as indicated by the *p*-value (significant value) 0.134 > 0.05.

Unlike the study of Minoo *et al.* (2019) which established a positive significant relationship between mean minimum temperature and malaria, the current study was of an opposite result.

Table 2: Correlation between Minimum Temperature and Reported Cases of Malaria

Variables		Mean Minimum Temperature	Reported Cases of Malaria
Mean Minimum Temperature (T °C)	Pearson Correlation	1	-0.295
	Sig. (1-tailed)		0.134
	N	16	16
Reported Cases of Malaria	Pearson Correlation	-0.295	1
	Sig. (1-tailed)	0.134	
	N	16	16

Source: Author's computation, 2021.

The relation between minimum temperature and incidence of malaria may be due to low temperature at night. Though, some studies reveal that, minimum temperature has been known as an effective factor in the incidence of malaria. These differences may be further attributed to mosquitoes response to habitats and climatic condition of a certain location.

i) Relationship between Relative Humidity and Malaria

The result extract presented in Table 4.3 depicts the relationship between mean relative humidity and reported cases of malaria in the study area. For the result extract, the Pearson Product Moment correlation coefficient was arrived at 0.274. This by interpretation, implies a weak positive relationship between the mean relative humidity, and reported cases of malaria in the study area. More so, this weak positive relationship was statistically not significant, as indicated by the *p*-value (significant value) 0.152 > 0.05. This positive relationship agrees with the study of Minoo *et al.* (2019). However, while the current study established a non-statistically significant positive relationship, the study of Minoo *et al.* (2019) established a statistically significant positive relationship.

Table 3: Correlation between Relative Humidity and Reported Cases of Malaria

Variables		Mean Relative Humidity	Reported Cases of Malaria
Mean Relative Humidity	Pearson Correlation	1	0.274
	Sig. (1-tailed)		0.152
	N	16	16
Reported Cases of Malaria	Pearson Correlation	0.274	1
	Sig. (1-tailed)	0.152	
	N	16	16

Source: Author's computation, 2021.

Increase in relative humidity is related to increase in malaria. The result is probably the fact that, humidity in this area is high enough to influence malaria all year round. Because, high humidity will increase the mosquito's life-span and help the parasite complete its life cycle and transmit the infection. (Akinbobola & Omotosho, 2013).

j) Relationship between Rainfall and Malaria

Table 4 depicts the relationship between mean rainfall and reported cases of malaria in the study area. For the result extract, the Pearson Product Moment correlation coefficient was arrived at 0.274. The value of the correlation coefficient by interpretation implies that there is a weak positive relationship between mean rainfall and reported cases of malaria in the study area. More so, this weak positive relationship was not statistically significant, as indicated by the *p*-value (significant value) 0.153 > 0.05.

This positive relationship agrees with the study of Minoo *et al.* (2019). However, while the current study established a non-statistically significant positive relationship, the study of Minoo *et al.* (2019) established a statistically significant positive relationship.

Table 4: Correlation between rainfall Temperature and Reported Cases of Malaria

Variables		Mean Relative Humidity	Reported Cases of Malaria
Mean Rainfall	Pearson Correlation	1	0.274
	Sig. (1-tailed)		0.153
	N	16	16
Reported Cases of Malaria	Pearson Correlation	0.274	1
	Sig. (1-tailed)	0.153	
	N	16	16

Source: Author's computation, 2021.

This study showed an unexpected and complex relation between rainfall and malaria incidence, probably connected to understated reason; studies revealed that, the time and location of precipitation plays an important role in disease (malaria) transmission. Such that, if precipitation occurs before the anopheles' reproductive season, rivers and water streams can become places for mosquito breeding, but if rainfall occurs during the reproductive season of mosquito, it will wash the breeding sites and reduce malaria transmission (Juri, Zaidenberg, Claps, Santana, & Almiron, 2009). Probably resulted to this outcome.

k) Relationship between Maximum Temperature and Asthma

Table 5 depicts the relationship between mean maximum temperature and reported cases of asthma in the study area.

For the result extract, the Pearson Product Moment correlation coefficient was arrived at -0.403. The value of the correlation coefficient by interpretation implies that there is a weak negative relationship between mean maximum temperature and reported cases of asthma in the study area. More so, this weak positive relationship was not statistically significant, as indicated by the *p*-value (significant value) 0.061 > 0.05.

Table 5: Correlation between Max. Temperature and Reported Cases of Asthma

Variables		Mean Max. Temperature	Reported Cases of Asthma
Mean Max. Temperature (T°C)	Pearson Correlation	1	-0.403
	Sig. (1-tailed)		0.061
	N	16	16
Reported Cases of Asthma	Pearson Correlation	-0.403	1
	Sig. (1-tailed)	0.061	
	N	16	16

Source: Author's computation, 2021.

This study indicates a weak negative relation between maximum temperature and asthma. Whereas, some study showed positive relation. This complex result could be traced to the fact that it's a natural phenomenon with natural occurrence. And latitudinal response to temperature and the disease.

l) Relationship between Minimum Temperature and Asthma

The results depicted in Table 4.6 depicts the relationship between mean minimum temperature and reported cases of asthma in the study area. For the result extract, the Pearson Product Moment correlation coefficient was arrived at -0.586. The value of the correlation coefficient by interpretation implies that there is a moderate negative relationship between minimum temperature and reported cases of asthma in the study area. More so, this moderate negative relationship was statistically significant, as indicated by the *p*-value (significant value) 0.009 < 0.05. This result agrees with the study of Campbell (2016).

Table 6: Correlation between minimum Temperature and Reported Cases of Asthma

Variables		Mean Minimum Temperature	Reported Cases of Asthma
Mean Minimum Temperature (T°C)	Pearson Correlation	1	-0.586**
	Sig. (1-tailed)		0.009
	N	16	16
Reported Cases of Asthma	Pearson Correlation	-0.586**	1
	Sig. (1-tailed)	0.009	
	N	16	16

**. Correlation is significant at the 0.05 level (1-tailed).*

Source: Author's computation, 2021.

This also indicates a weak negative relation between minimum temperature and asthma. Whereas, some study showed positive relation. These inconsistence result could be traced to the fact that it's a natural phenomenon with natural occurrence. And also latitudinal response to temperature and the disease.

m) Relationship between Relative Humidity and Asthma

Table 7 depicts the relationship between mean relative humidity and asthma in the study area. For the result extract, the Pearson Product Moment correlation coefficient was arrived at 0.728. The value of the correlation coefficient by interpretation implies that there is a strong positive relationship between relative humidity and asthma in the study area. This strong positive relationship was statistically significant, as indicated by the *p*-value (significant value) 0.001< 0.05.

Table 7: Correlation between Relative Humidity and Reported Cases of Asthma

Variables		Mean Relative Humidity	Reported Cases of Asthma
Mean Relative Humidity	Pearson Correlation	1	0.728**
	Sig. (1-tailed)		0.001
	N	16	16
Reported Cases of Asthma	Pearson Correlation	0.728**	1
	Sig. (1-tailed)	0.001	
	N	16	16

*. Correlation is significant at the 0.05 level (1-tailed).

Source: Author's computation, 2021.

Probably, damped and warm air reduces inhalation oxygen quality, causing respiration deficiency and influencing the complication.

n) Relationship between Rainfall and Asthma

The results depicted in Table 8 reveals the relationship between mean rainfall and asthma in the study area. For the result extract, the Pearson Product Moment correlation coefficient was arrived at 0.668. The value of the correlation coefficient by interpretation implies that there is a strong positive relationship between rainfall and asthma in the study area. This strong positive relationship was statistically significant, as indicated by the *p*-value (significant value) $0.002 < 0.05$.

Table 8: Correlation between Rainfall and Reported Cases of Asthma

Variables		Mean Rainfall	Reported Cases of Asthma
Mean Rainfall (mm)	Pearson Correlation	1	0.668**
	Sig. (1-tailed)		0.002
	N	16	16
Reported Cases of Asthma	Pearson Correlation	0.668**	1
	Sig. (1-tailed)	0.002	
	N	16	16

**. Correlation is significant at the 0.05 level (1-tailed).*

Source: Author's computation, 2021.

This relation may be probably because of the heats emitted from the surface (ground) after some hours of down pour associates in impacting the disease condition via respiration.

o) The Ranking Effect of Climatic Variables on Malaria/Asthma

i. *The Ranking Effect of Climatic Variables on Malaria*

Juxtaposing the result extract (see appendix iV) of the coefficients of the explanatory variables into the linear regression model postulated in chapter three of the study, we have;

$IM = \beta_0 + \beta_1 Mmax\ Temp + \beta_2 Mmin\ Temp + \beta_3 R\ Humidiy + \beta_4 Mrainfall + \mu$

$IM = \beta_0 = (-359776.1)\ \beta_1 = (17644.23)\ \beta_2 = (-8862.783)\ \beta_3 = (244.3905) + \beta_4 = (-40.19738)$

T-Statistic $= \beta_0 = (-1.810367)\ \beta_1 = (3.157584)\ \beta_2 = (-1.561924)\ \beta_3 = (0.299275)\ \beta_4 = (-0.130316)$

Prob. $= \beta_0 = (0.0976)\ \beta_1 = (0.0091)\ \beta_2 = (0.1466)\ \beta_3 = (0.7703)\ \beta_4 = (0.8987)$

R-squared (r^2) = 0.526362

Adjusted R-squared ($\bar{R}^2$) = 0.354130

F-statistic = 3.056118

Durbin-Watson stat. = 1.595989

Prob(F-statistic) = 0.063895

The theoretical aprior expectation of the parameters coefficients is: $\beta_1, \beta_2, \beta_3, \beta_4 > 0$

The result summary depicts the ranking effect of climatic variables on malaria across the time frame under study with value of the coefficient of determination (also known as the R-squared [r^2]) as well as the coefficient of the adjusted coefficient of determination (also known as the Adjusted r-square [$\bar{R}^2$]). The coefficient of determination (r-square: r^2) which by definition, is the proportion of the variance in the dependent variable (incidence of malaria in this case), that is predictable from the independent variable(s) (mean maximum temperature, mean minimum temperature, mean relative humidity, and mean rainfall), was arrived at 0.526362. This thus implies that 53% of the variation in incidence of malaria in the study area, is explained by the variation in mean maximum temperature, mean minimum temperature, mean relative humidity, and mean rainfall in the study area across 2003 and 2018.

From the summary of the results, the adjusted $\bar{R}^2$ was arrived at 0.354130. This by implication implies that over 35 percent of the total variation in the incidence of malaria is explained by the variation in the explanatory variable (mean maximum temperature, mean minimum temperature, mean relative humidity, and mean rainfall) after taking into consideration the degree of freedom (12) which is indeed strong.

The F-statistic value of 3.056118 was low and shows the overall estimated regression model was not at the conventional significance level of 0.05 level of significance, and thus not statistically significant. This was as a result of the F-statistics (3.056118) found to be greater than the critical F-statistics probability (0.063895 > 0.05).

The Durbin-Watson statistic of 1.595989, indicate the presence of positive autocorrelation in the regression.

The regression results also reveals the coefficient of the constant parameter, as well as the coefficients of the explanatory variables of the regression model of the study. From the regression result, it can be observed that the constant parameter (β_0) is negatively related to the incidence of malaria in the study area over the period under study with a coefficient of β_0 = -1.810367. The value of t-statistic of the constant parameter shows the statistical significance of the relationship between the constant parameter and the dependent variable of the regression model. Given that the t-statistic was arrived at -1.810367, with a probability value of 0.0976, the negative relationship between incidence of malaria and β_0 was not statistically significant, since the p-value = 0.0976 > 0.05.

The results revealed a positive relationship between mean maximum temperature and the incidence of malaria in the study area, with a coefficient value of *MmaxTemp* = 17644.23. The t-statistic value of *MmaxTemp* shows the statistical significance of the relationship between *MmaxTemp* and the dependent variable of the regression model (incidence of malaria [*IM*]). The t-statistic of *MmaxTemp* was arrived at 3.157584, with a probability value of 0.0091. At 0.05% level of significance, p-value = 0.0091< 0.05. It thus implies that the positive relationship between *IM* and *MmaxTemp* is statistically significant. This result conforms to the aprior expectation of a positive relationship between *IM* and *MmaxTemp* ($\beta_1 > 0$). The implication here is that a unit increase in *MmaxTemp* resulted in a unit increase in *IM* in the study area between 2003 and 2018.

The coefficient of *MminTemp* shows a negative relationship between *MminTemp and IM* in the study area, with a coefficient value of -8862.783. The t-statistics of the coefficient of *MminTemp* was arrived at -1.561924, with a probability value of 0.1466 at 0.05% level of significance. This result is against our aprior expectation of a positive relationship between *MminTemp* and *IM* ($\beta_2 > 0$), and not statistically significant since p-value = 0.1466 > 0.05. The implication here is that an increase in *MminTemp* across the time series under consideration has disproportionally been met with *IM*, but not at a significant level.

The coefficient of *R Humidiy* from the results was arrived at 244.3905, indicating a positive relationship between the *IM* and *R Humidiy*. The t-statistics of this explanatory variable was arrived at 0.299275, with a probability value of 0.7703 at 0.05% level of significance. This result conforms with our aprior expectation of a positive relationship between *IM* and *RHumidiy* ($\beta_3 > 0$), but however, not statistically significant since p-value = 0.7703 > 0.05. The implication here is that an increase in *RHumidiy* across the time series under consideration resulted in an increase in *IM*, but not at a significant level.

More so, the coefficient of *Mrainfall* as depicted in the results above was -40.19738, implying an inverse (negative) relationship between *IM* and *Mrainfall* across the time series under study. The t-statistics of the coefficient of *Mrainfall* was arrived at -0.130316, with a probability value of 0.8987 at 0.05% level of significance. This result does not conform to our aprior expectation of a positive relationship between *IM* and *Mrainfall* ($\beta_4 > 0$), and was not statistically significant since p = 0.8987 > 0.05. The implication here is that and increase in the *Mrainfal* resulted into a decrease in the *IM* but not at a significant level.

p) The Ranking Effect of Climatic Variables on Asthma

Juxtaposing the result extract (see appendix V) of the coefficients of the explanatory variables into the linear regression model postulated in chapter three of the study, we have;

$IAsthm = \beta_0 + \beta_1 MmaxTemp + \beta_2 MminTemp + \beta_3 Mrainfall + \beta_4 RHumidiy + \mu$

$IAsthm = \beta_0 = (99.78362)\ \beta_1 = (-2.377939)\ \beta_2 = (-0.621961)\ \beta_3 = (0.431406) + \beta_4 = (-0.039827)$

t-Statistic $= \beta_0 = (1.212641)\ \beta_1 = (-1.027759)\ \beta_2 = (-0.264723)\ \beta_3 = (1.275884)\ \beta_4 = (-0.311828)$

Prob. $= \beta_0 = (0.2507)\ \beta_1 = (0.3261)\ \beta_2 = (0.7961)\ \beta_3 = (0.2283)\ \beta_4 = (0.7610)$

R-squared (r^2) = 0.586996

Adjusted R-squared ($\bar{R}^2$) = 0.436813

F-statistic = 3.908536

Durbin-Watson stat. = 0.579206

Prob(F-statistic) = 0.032654

The theoretical aprior expectation of the parameters coefficients is: $\beta_1, \beta_2, \beta_3, \beta_4 > 0$

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The result summary depicts the ranking effect of climatic variables on asthma across the time frame under study with value of the coefficient of determination as well as the coefficient of the adjusted coefficient of determination. The value of coefficient of r^2 was arrived at 0.586996. This thus implies that 59% of the variation in incidence of asthma in the study area, is explained by the variation in mean maximum temperature, mean minimum temperature, mean relative humidity, and mean rainfall in the study area across the time series under consideration.

From the summary of the results, the adjusted $\bar{R}^2$ was arrived at 0.436813. This by implication implies that over 44 percent of the total variation in the incidence of asthma is explained by the variation in the explanatory variable after taking into consideration the degree of freedom (12) which is indeed strong.

The F-statistic value of 3.908536 was low and shows the overall estimated regression model was at the conventional significance level of 0.05 level of significance, and thus statistically significant. This was as a result of the F-statistics (3.908536) found to be less than the critical F-statistics probability ($0.032654 < 0.05$).

The Durbin-Watson statistic of 0.579206, indicate the presence of positive autocorrelation in the regression.

The regression results also reveals the coefficient of the constant parameter, as well as the coefficients of the explanatory variables of the regression model of the study. From the regression result, it can be observed that the constant parameter (β_0) is positively related to *IAsthm* in the study area across the time series under study with a coefficient of $\beta_0 = 99.78362$. The t-statistic was arrived at -1.810367, with a probability value of 1.212641, the positive relationship between *IAsthm* and β_0 was not statistically significant, since the p-value $= 0.2507 > 0.05$.

The results revealed a negative relationship between *MmaxTemp* and *IAsthm* in the study area, with a coefficient value of -2.377939. The t-statistic of *MmaxTemp* was arrived at -1.027759, with a probability value of 0.3261. At 0.05% level of significance, p-value $= 0.3261 > 0.05$. It thus implies that the negative relationship between *MmaxTemp* and *IAsthm* was not statistically significant. This result does not conform to the aprior expectation of a positive relationship between *IAsthm* and *MmaxTemp* ($\beta_1 > 0$).

The coefficient of *MminTemp* shows a negative relationship between *MminTemp and IAsthm* in the study area, with a coefficient value of -0.621961. The t-statistics of the coefficient of *MminTemp* was arrived at -0.264723, with a probability value of 0.7961 at 0.05% level of significance. This result is against our aprior expectation of a positive relationship between *IAsthm* and *MminTemp* ($\beta_2 > 0$), and not statistically significant since p-value $= 0.7961 > 0.05$.

The coefficient of *RHumidiy* from the results was arrived at 0.431406, indicating a positive relationship between the *RHumidiy and IAsthm*. The t-statistics of this explanatory variable was arrived at 1.275884, with a probability value of 0.2283 at 0.05% level of significance. This result conforms with our aprior expectation of a positive relationship between *IAsthm* and *RHumidiy* ($\beta_3 > 0$), however, this positive relationship was not statistically significant since p-value $= 0.2283 > 0.05$. The implication here is that an increase in *RHumidiy* across the time series under consideration resulted in an increase in *IAsthm*, but not at a significant level.

The coefficient of *Mrainfall* was -0.039827, implying an inverse relationship between *IAsthm* and *Mrainfall* across the time series under study. The t-statistics of the coefficient of *Mrainfall* was arrived at -0.311828, with a probability value of 0.7610 at 0.05% level of significance. This result does not conform to our aprior expectation of a positive relationship between *IAsthm* and *Mrainfall* ($\beta_4 > 0$), and was not statistically significant since $p = 0.7610 > 0.05$. The implication here is that and increase in the *IAsthm* resulted into a decrease in the *IM* but not at a significant level.

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