ZIBELINE INTERNATIONAL™ PUBLISHING

Malaysian Applied Geography (MAGG)

DOI: http://doi.org/10.26480/magg.02.2023.75.80

ISSN: 2616-5155
CODEN: MECJBU

CrossMark

RESEARCH ARTICLE

THE IMPACT OF RAINFALL AND TEMPERATURE VARIABILITY ON MALARIA INCIDENCE: EMPERICAL EVIDENCE FROM YAMALTU/DEBE LOCAL GOVERNMENT AREA OF GOMBE STATE NIGERIA

Ahmed Abubakar Jajere[a*], Muhammed Bukar Ngamdu[b], Usman Ibrahim[a] and Nafiu Ahmed[a]

[a]Department of Geography Federal University of Kashere, Gombe State, Nigeria
[b]Department of Geography Yobe State University Damaturu, Nigeria
**Corresponding Author Email: ahmedabubakarjajere@yahoo.com*

ARTICLE DETAILS

Article History:

Received 18 November 2023
Revised 20 December 2023
Accepted 09 January 2024
Available online 11 January 2024

ABSTRACT

Despite significant advancements achieved in the last two decades in reducing the worldwide impact of malaria, the disease still poses a substantial public health challenge. Moreover, there exists a growing apprehension that climate change could potentially broaden the regions conducive to disease transmission. This research focuses on investigating the impact of climate variability on malaria incidence in the Yamaltu/Deba Local Government Area (LGA) of Gombe State, Nigeria, from 2013 to 2022. Precipitation and temperature records were sourced from the Upper Benue River Basin Development Authority's Dadin-Kowa Meteorological station, while confirmed uncomplicated malaria cases were obtained from the Gombe State Primary Healthcare Development Agency.The study entails an examination of the relationship between climate variability and malaria incidence in the study area. Pearson's product-moment correlation coefficient was employed for this purpose. Furthermore, time series analysis was conducted to assess trends in rainfall, temperature, and malaria cases. The findings revealed an increasing trend in both rainfall and malaria cases, while maximum and minimum temperatures displayed negligible decreases over the specified period. Notably, correlation analysis unveiled a positive relationship between rainfall and malaria, with an r value of 0.319. Conversely, maximum and minimum temperatures exhibited a strong negative correlation, with r values of -0.152 and -0.534, respectively. Seasonal analysis highlighted a greater prevalence of malaria cases during the late rainy season, specifically in the months of July and October. October emerged as the month with the highest recorded malaria cases, totaling 44,351 cases, while May exhibited the lowest number of cases at 15,488. Given these findings, it is recommended to prioritize vector control initiatives and raise public awareness regarding the effective implementation of intervention measures, such as indoor residual sprays. These efforts are especially crucial during peak periods characterized by favorable weather conditions to mitigate malaria outbreaks effectively.

KEYWORDS

Rainfall, Temperature, Variability and Malaria incidence

1. INTRODUCTION

Malaria is a bilateral infectious disease transmitted through the bites of female mosquitoes (Anopheles), transferring the infection from already infected individuals to non-infected ones. The mode of malaria's spread remains a subject of inquiry, with studies identifying consistent transmission patterns in Sub-Saharan Africa linked to alterations in weather conditions, while others point to non-weather-related factors (Mohammadkhan, 2016). The temporal variability of weather parameters also contributes to creating favorable conditions for mosquitoes. Therefore, understanding the impact of climate variability on malaria's outbreak, resurgence, and transmission holds paramount significance.

In 2017, there were approximately 219 million reported malaria cases globally, resulting in 435,000 deaths. A significant portion—around 90%—of these deaths occurred in Sub-Saharan Africa, with Nigeria bearing a substantial burden. The most vulnerable groups to malaria include children under five, pregnant women, travelers from non-endemic regions, refugees, and displaced individuals (Nyarko, 2014). Worrisomely, resistance to malaria treatment has surged in sub-Saharan Africa, partly attributed to weather fluctuations, with West Africa facing levels of 20%-35%. Additionally, mosquitoes can develop resistance to insecticides, whether applied indoors or outdoors, due to changes in climate variables like rainfall and temperature (World Health Organization, 2015).

When individuals move from non-malarial to malaria-prone areas, or vice versa, where the conditions are conducive to malaria transmission, the likelihood of contracting or transmitting the disease is elevated (Craig et al., 2004).

Climate is conventionally defined in terms of the mean and variability of atmospheric variables like temperature, precipitation, and wind. It can be regarded as a summation or amalgamation of weather conditions. A warmer, more volatile climate intensifies certain air pollutants and escalates extreme weather events. This heightened climate variability amplifies the rates and ranges of transmission for infectious diseases like malaria carried by vector organisms such as mosquitoes. Increased temperatures and shifts in rainfall patterns pose health risks, especially in tropical and sub-tropical regions (Lunde and Lindtjorn, 2013). This concern is exacerbated by the vulnerability of a majority of the people in these areas due to their limited adaptive capacity to cope with and adapt to environmental challenges (Ayanlade et al., 2010).

Quick Response Code	Access this article online	
	Website: www.magg.com.my	**DOI:** 10.26480/magg.02.2023.75.80

Cite The Article: Ahmed Abubakar Jajere, Muhammed Bukar Ngamdu, Usman Ibrahim and Nafiu Ahmed (2023). Analysis of Impact of Rainfall and Temperature Variability on Malaria Incidence in Yamaltu/Deba Local Government of Gombe State, Nigeria. *Malaysian Applied Geography, 1(2): 75-80.*

The anticipated variations in temperature, rainfall, and relative humidity due to climate change are poised to directly impact the dynamics of malaria transmission. This influence arises from modifying the behavior and geographical spread of malaria vectors, as well as shortening the parasite's developmental cycle within the vector. The outcomes of these changes will manifest diversely in different eco-epidemiological contexts. The recent severe malaria epidemics in Yamaltu/Deba, stemming from climate fluctuations that affect various aspects of population demographics, have raised concerns about the expanding threat of malaria, underscoring the necessity for research.

Given the inconsistent weather variables and persistent shifts in weather parameters, regular monitoring of these interconnected variables in relation to vector-borne diseases becomes imperative. This practice enhances malaria early-warning systems and provides insights into the evolving malaria scenario. Although extensively explored in literature, uncertainties regarding the disease's future trends persist, resulting in numerous research endeavors. For instance, examined climate variability's impact on malaria in western Kenya (Bryan et al., 2023). Their study employed Bayesian models, revealing fluctuating malaria rates despite bed net usage, with temperature and rainfall changes playing a pivotal role.

Similarly, introduced a machine learning model that classifies malaria cases based on climate variability across Sub-Saharan African countries (Nkiruka et al., 2021). This predictive tool contributes to early warnings and supports public health authorities in addressing climate-related health impacts. Likewise, evaluated climate change's influence on malaria dynamics, observing significant effects in western Kenya despite intervention efforts (Beloconi et al., 2023).

According, in there study examined how climate variability impacted malaria rates following the implementation of interventions in western (Kenya Bryan et al., 2023). To do this, Bayesian negative binomial models were applied to monthly malaria data, which was collected from patients with febrile illnesses visiting Lwak Mission Hospital between 2008 and 2019. Data regarding bed net usage and socio-economic status (SES) were gathered from household surveys. Additionally, climatic proxy variables from remote sensing were used as factors in the models. Bayesian variable selection was utilized to establish the time lag between climate suitability and malaria incidence. The results indicated a 50% rise in malaria cases from 2008 to 2010, followed by a 73% decline until 2015. However, cases resurged after 2016, despite widespread bed net usage. An increase in daytime land surface temperature correlated with reduced malaria incidents (incidence rate ratio [IRR] = 0.70, 95% Bayesian credible interval [BCI]: 0.59–0.82), while higher rainfall linked to increased incidence (IRR = 1.27, 95% BCI: 1.10–1.44). Bed net usage was tied to lowered malaria rates in children aged 6–59 months (IRR = 0.78, 95% BCI: 0.70–0.87).

In the study titled "Predicting Malaria Incidence using Climate Variability and Machine Learning," researchers introduce a machine learning model designed to classify instances of malaria based on climate variability in six Sub-Saharan African countries spanning twenty-eight years (Nkiruka et al., 2021). The research commences with a process of feature engineering that identifies the climate elements influencing malaria incidence. This is followed by employing the k-means clustering technique to detect outliers and subsequently employing the XGBoost algorithm for classification purposes. The findings reveal that while the specific connection between malaria incidence and climate variability varies by geographical region, consistent changes in three climatic factors precipitation, temperature, and surface radiation play a significant role in malaria outbreaks. The proposed model was benchmarked against other classification models, demonstrating superior performance. This classification model for malaria incidence serves as an early warning system, aiding in the monitoring of malaria spread. It represents an innovative data-driven approach to uncover insights, supporting public health authorities in understanding climate's impact on health. Furthermore, it aids in formulating appropriate preventive and adaptive strategies, thereby ensuring more timely healthcare interventions and potentially saving lives.

The study focused on evaluating the varying influence of climate change on malaria patterns, which proves to be a intricate challenge. To address this, researchers employed a stochastic transmission model rooted in processes. The outcomes unveiled that within the lowlands of western Kenya, an area with high malaria prevalence, fluctuations in climatic variables significantly influenced malaria cases from 2008 to 2019. This influence persisted despite the widespread usage of bed nets among the population. The model effectively captured the key interplays among humans, parasites, and vectors, thereby offering a prospect to predict malaria occurrences in regions prone to the disease. Importantly, this predictive capability considers the interplay between forthcoming climatic conditions and potential intervention strategies. However, limited research has explored the correlation between climate variability and malaria incidence. Therefore, this study's objectives include determining trends in rainfall and temperature variability, analyzing malaria incidence, and investigating the link between climate and malaria in Yamaltu/Deba LGA. The findings can help policymakers design an appropriate intervention programme on vector control and proper case management. so that appropriate coping strategies could be designed and integrated within the health related sector

2. Materials and Methods

2.1 The Study Area

The study location for this study is Yamaltu Deba is a local government area of Gombe state, Nigeria. The LGA lies at about latitude 10^0'0'0N and 10^{0}35'0"N between longitude 11^{0}15'0"E and 11^{0}50'0"E with the headquarters situated at the town of Deba (Deba Habe) to the southeast of the Local Government's capital Gombe. It has a landmass of approximately 1,981km^2 (7655 mi) and the official population was 255,248 people at the 2006 population and housing census (NPC, 2006).

The LGA shares borders with Borno Local Governments and Yobe Local Governments. The southern part of lake Dadin-kowa lies within the area.

Gombe state has two distinct climates which was not different with that of the study area, the dry season between November and March and the warm, humid rainy season between April and October with an average rainfall of about 850mm (Malik 2004). The highest daily temperature is about 38^{0}C which corresponds to the hottest period usually experienced in the months of March to April and the months of December to January are usually very cold with temperature as low as 25^{0}C (Obiefuna and Sheriff, 2011).

2.2 Methods of Data collection

The type of data to be use in objective one is temperature and rainfall data were source from Upper Benue River Basin Development Authority Dadin-Kowa Metrological station while the data were collected in softcopy using flash drive. Also in objective two Malaria incidence data of the study area were source from the Gombe State Primary Healthcare Development Agency. All data collected were use correlate coefficient to measure the strength of the relationship between selected climate element temperature/rainfall and malaria incidence.

2.3 Methods of Data analysis

The data to be obtain for this study will be subjected to both descriptive and inferential statistics. Descriptive statistics comprises of means such as the mean monthly rainfall; mean monthly temperature (^{o}C). The descriptive statistical results were presented in graphs and tables. Regressions will use to determine the various trends, while Pearson's product - moment correlation coefficient was used to measure the strength of the relationship between malaria incidence and the selected climatic elements (temperature and rainfall) using the SPSS Version16.

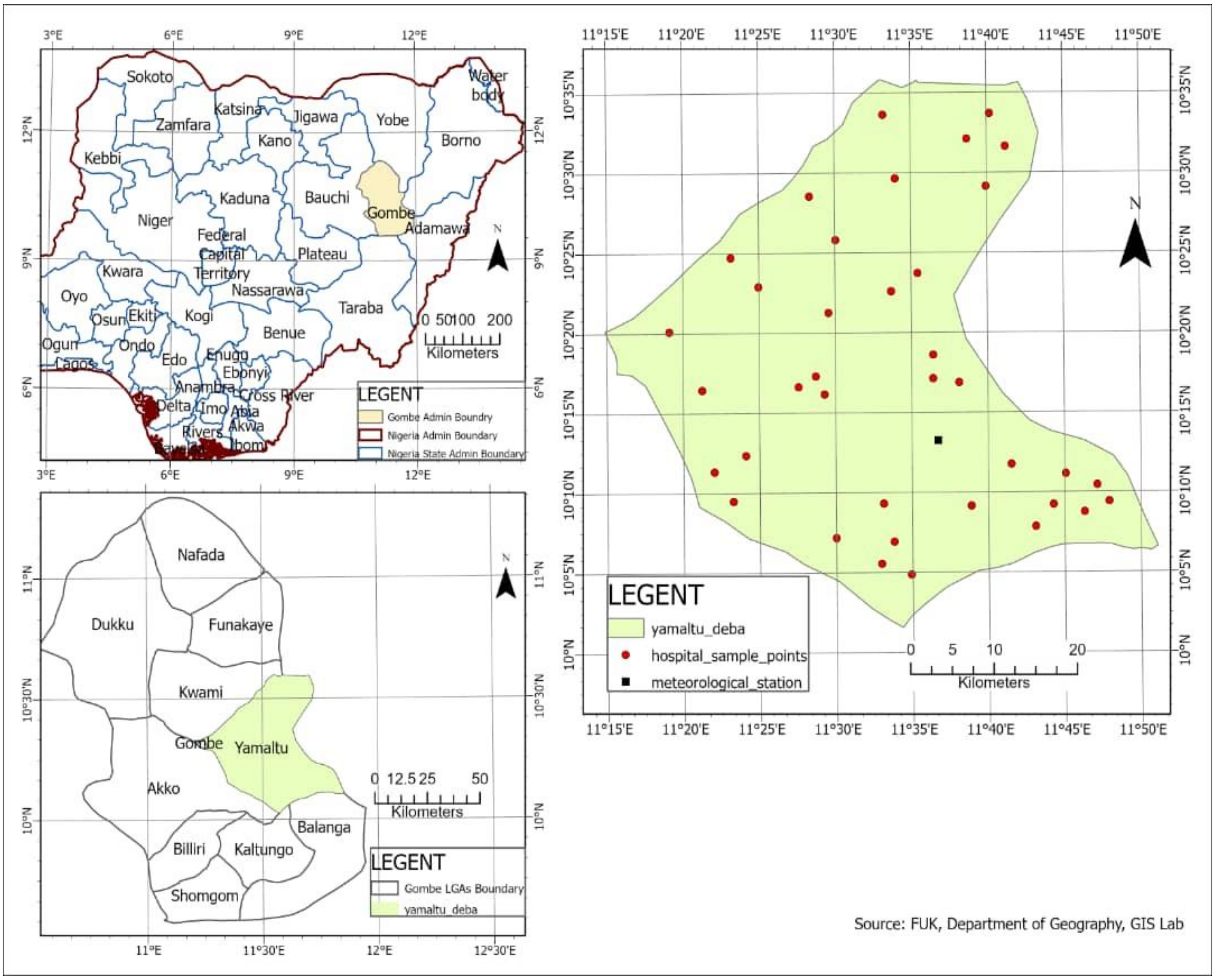

Figure 3: Yamaltu/Deba Local Government Area of Gombe State

Source: FUK, Department of Geography, GIS Lab (2023)

3. RESULTS AND DISCUSSION

3.1 Trend and Pattern in the Occurrence of Malaria (2013-2022)

Malaria cases were relatively high in July to October in study area as revealed by Table 1, this could be due to low down pours where most of the mosquito lavas were laid, thereby increasing the population of the potential reproductive mosquitoes within the four months of the rainfall.

Table 1: Monthly Data for Persons with Confirmed Uncomplicated Malaria (2013-2022)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Jan	122	2070	1653	713	858	980	3036	4177	4670	3788
Feb	144	1629	3144	694	459	770	2616	4093	4043	3524
Mar	142	1434	155	542	465	1278	3072	4575	4425	3431
Apr	179	1342	1016	385	396	1328	2287	3985	3161	3624
May	137	1515	1322	340	179	286	1989	2752	3116	3852
Jun	167	1544	611	524	388	978	2574	3021	4121	2965
Jul	58	1451	867	674	825	4203	5409	4683	6279	6899
Aug	1657	2936	1455	835	900	4433	7621	5213	7110	7473
Sep	1298	1331	1772	960	1116	6268	8141	4831	7459	5333
Oct	872	658	3359	708	1055	6710	9623	7852	6427	7087
Nov	959	931	951	310	707	3913	7085	7015	5237	6853
Dec	953	890	1022	316	1007	4969	6535	5340	5365	6047

Source: Gombe State Primary Healthcare Development Agency (2023).

From Figure 1 and 2 it can be observed that malaria cases were on increase throughout the years in the study area but with fluctuating characteristics. The trend as indicated by the trend line and linear trend line equation y=2078.x +14241 is that the occurrence of malaria within a time frame of this study was on the increase.

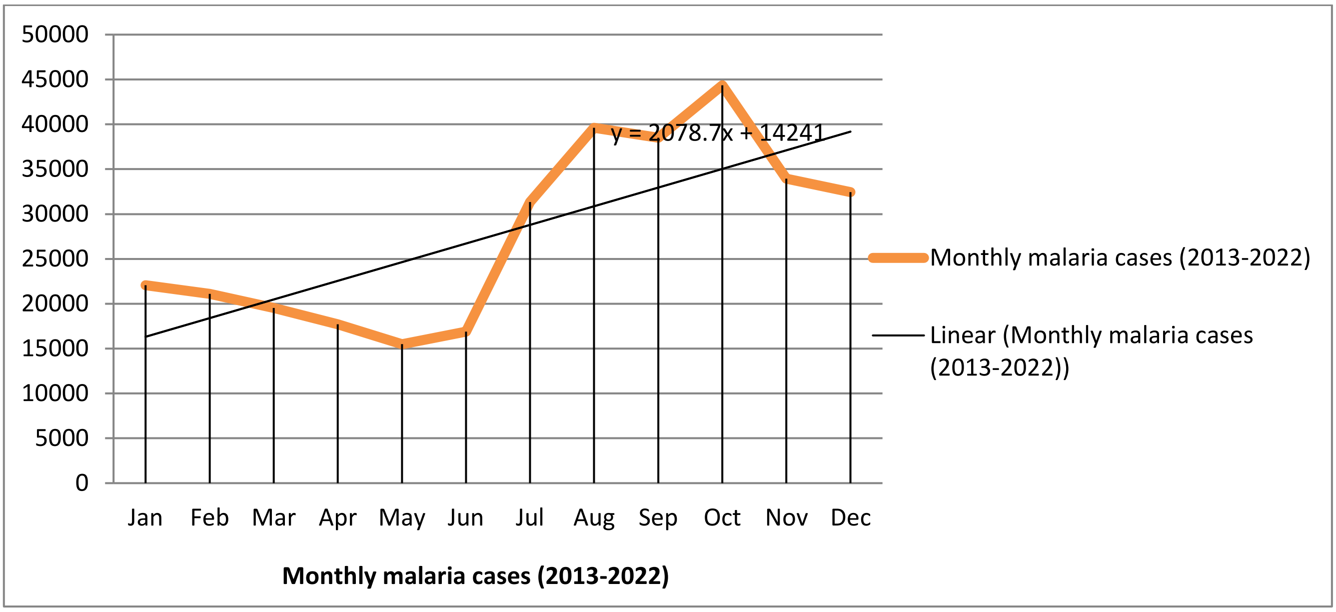

Figure 1: Monthly malaria cases (2013-2022)

Figure 2 below shows that, malaria was generally high in the study area; the trend line indicated a significant increase in the disease occurrence within the stipulated period of this study. The lowest malaria cases were recorded in 2013 (557.3) and the highest were recorded in the year 2021 (5117.75). The increase in the malaria incidence may be due to a significant increase in rainfall amount in the study area during the study period since malaria is associated with stagnant water, which usually occurred when there is high rainfall coupled with other factors like dirty environment, poor water drainage systems among others.

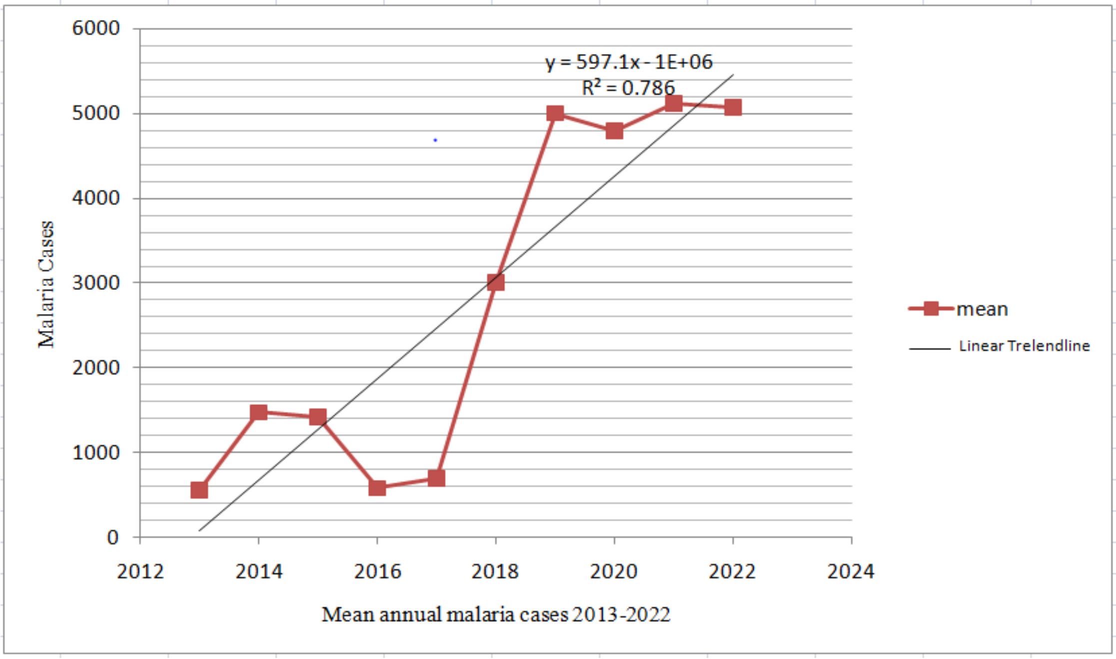

Figure 2: Mean Annual Malaria Cases Variability and Trend in Yamaltu/Deba (2013-2022)

3.2 Relationship between Rainfall and the Malaria Incidence

From Table 2 the correlation between rainfall and malaria was 0.319, which was significant at 0.05 level of significance. This means that there was a strong positive relationship between rainfall and the occurrence of malaria in the study area. An increase in rainfall could lead to an increase in the occurrence of malaria, which implies that malaria was highly dependent on the amount of rainfall received in the study area.

Table 2: Correlation between Rainfall and Malaria Cases

		Rainfall	Malaria
Rainfall	Pearson Correlation	1	.319
	Sig. (2-tailed)		.313
	N	12	12
Malaria	Pearson Correlation	.319	1
	Sig. (2-tailed)	.313	
	N	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

3.3 Relationship between Maximum Temperature and Malaria Incidence

Table 3 presents the relationship between maximum temperature and malaria occurrence in the study area. The correlation coefficient (r) between maximum temperature and the occurrence of malaria was – 152, which was significant at 0.05 level of significance. This implies that there was Perfect negative relationship between maximum temperature and occurrence of malaria in the study area. Hence, a change in maximum temperature negatively influences the malaria occurrence during the study period.

Table 3: Correlation between Maximum Temperature and Malaria Incidence

Correlations			
		Malaria	**Maximum Temperature**
Malaria	Pearson Correlation	1	-.152
	Sig. (2-tailed)		.637
	N	12	12
Maximum Temperature	Pearson Correlation	-.152	1
	Sig. (2-tailed)	.637	
	N	12	12

*. Correlation is significant at the 0.05 level (2- tailed).

3.4 Relationship between Minimum Temperature and Malaria Incidence

Table 4 shows the relationship between minimum temperature and the occurrence of malaria in the study area. The Pearson Product Moment Correlation Co-efficient (r) between minimum temperature and the occurrence of malaria was – 534 indicating a Perfect negative relationship. This implies that a change in minimum temperature weakly and negatively influences changes in the occurrence of malaria.

Table 4: Correlation between Minimum Temperature and Malaria Incidence

		Minimum Temperature	**Malaria**
Minimum Temperature	Pearson Correlation	1	-.534
	Sig. (2-tailed)		.074
	N	12	12
Malaria	Pearson Correlation	-.534	1
	Sig. (2-tailed)	.074	
	N	12	12

*. Correlation is significant at the 0.05 level (2- tailed).

3.5 Discussion of Results in Line With the Stated Objectives and Research Question

From Figure 3 and Table 1, it can be observed that malaria were recorded throughout the year, the frequency of the disease was higher during early rainy (July) and late rainy (October) season, this is in line with the preceding years which have their peaks during rainy season (July and October). The lowest malaria cases recorded from 2013-2022 is in the early dry season (January to May) due to low precipitation, which affects mosquito larvae. The values were lower in the drier month of November and December due to low temperature.

The study reveals that rainfall and temperature were all fluctuating during the study period and that temperature was not fluctuating as much as rainfall. Both the monthly and mean annual trend of rainfall showed an increment trend while that of maximum and minimum temperatures showed an insignificant decrease with r value of .319. Figure 1and 2, while with maximum and minimum temperature indicated negative relationship with r values of (-.152 and -.534) Figure 3 and 4 respectively. The increase in rainfall amount observed in the study area In line with the works of which found out that there was a general increase in rainfall amount in the study area from 1975-2014 (Yusuf et al., 2020). They also asserted that the increase in annual rainfall yield could be the predominant factor resulting into the significant increased of rainfall in September. The negative relationship between maximum temperature, minimum temperature and malaria does not mean that there is no any relationship between them; rather it implies that there was no linear relationship between them in the study area.

The study further indicated that the malaria occurrence in the study area within the time frame of this study was fluctuating, this might be as a result of fluctuations in weather elements especially rainfall. Like rainfall, malaria occurrence in the study area also indicated a significant increase. From Tables 2, 3 and 4 only rainfall data showed a positive relationship with the occurrence of malaria where by both maximum and minimum temperatures showed negative relationship with the disease.

These finding is in line with that of which found out that rainfall was the major determinant factor for the prevalence of malaria in Abuja FCT (Oguntade et al., 2020). Similarly, also found rainfall to be significant climatic variable in malaria transmission in Boricha district in (Sidama regional state of Ethiopia where temperature was not found significant Dabaro and Malar, 2021). However, the study is also in total contrast with that of (Klutse et al., 2014) which suggests maximum temperature as better predictor of malaria than minimum temperature or precipitation at Ejura and Winebba ecological zones in Ghana. Other studies that found both rainfall and temperature as significant factors in malaria transmission include: Yusuf U.A et al (2020), Dahiru A (2016), Efe and Ojoh (2012), Oluleye and Akinbobola (2010) and Weli and Efe (2015).

4. Conclusion

These research was investigated the influence of weather on malaria occurrence in Yamaltu/Deba LGA and it revealed that malaria prevailed throughout the years in the study area with an increasing trend and fluctuating characteristics within the period of this study. Rainfall also showed an increasing trend which consequently led to the corresponding increase in the prevalence of malaria in the study area. Thus, an increase in rainfall enhances mosquito development and improved breeding sites leading to incidence of malaria. On this basis, the study concluded that rainfall was the major climatic variable that influences malaria occurrence in the study area.

Recommendations

The following suggestions were given in light of the research findings:

- It is recommended that the Gombe State ministry of Health sand Ministry of Environment should collaborates with climatologists more closely so that they may share knowledge about malaria indices and meteorological data to support the development of effective monitoring and early warning systems that can stop widespread of malaria cases.
- Emphasis should be given to causing agent control activities and to create public health awareness on the proper usage of intervention measures such as indoor residual sprays to reduce the epidemic especially during peak periods with suitable weather conditions.
- The community should focus more on regular environmental (surroundings) cleanup and proper dumping of refuse, especially during the rainy season.

References

Ayanlade, A., Adeoye, N.O., and Babatimehin, O., 2010. Global climate change impacts on human health in sub-sahara Africa. Global Journal of Human Social Science (B) Geography, Geo-Sciences & Environmental. Vol. 14 online. ISSN 2249-460x.

Beloconi, A., Nyawanda, B., Bigogo, G., Khagayi, S., Obor, D., Danquah, I., Kariuki, S., Mu nga, S., and Vounatsou, P., 2023. Malaria, climate variability, and interventions:mo dell ing transmission dynamics. Scientific Reports. 13. 10.1038/s41598-023-33868-8.

Craig, M.H., Snow, R.W., le Sure, D., 2004. A Climate-based distribution model of malaria transmission in Sub- Saharan Africa, Durban 4013, South Africa.

Lunde, T.M., Lindtjorn, B., 2013. Cattle and climate in Africa: How climate variability has influenced national cattle holding from 1961-2008. Retrieved September 6, 2015 from https://dx.doi.org/10.7717/peerj.55.

Mohammadkhani, M., Khanjani, N., Bakhtiari, B., Sheikhzadeh, K., 2016. The relation between climatic factors and malaria incidence in Kerman, South East of Iran. Parasite Epidemiol. Control 2016, 1, Pp.

205–21.

National Population Commission, NPC. 2006. Nigerian population census report 2006.

Nyarko, S.H, Cobblah, A., 2014. Sociodemographic determinants of Malaria among under-five children in Ghana. Malar. Res. Treat. 2014, 2014, 304361.

Nyawanda, B., Beloconi, A., Khagayi, S., Bigogo, G., Obor, D., Otieno, N., Lange, S., Franke, J., Sauerborn, R., Utzinger, J., Kariuki, S., Munga, S. and Vounatsou, P., 2023. The rel ative effect of climate variability on malaria incidence after scale-up of interventions in western Kenya: A time-series analysis of monthly incidence data from 2008 to 2019. Parasite Epidemiology and Control. 21. e00297. 10.1016/j.parepi.2023.e00297.

Nkiruka, O., Prasad, D. and Onime, C., 2021. Prediction of Malaria Incidence using Climate Variability and Machine Learning. Informatics in Medicine Unlocked. 22.10.1016/j.im u.202 0.100508.

Obiefuna, G.I., and Sheriff, A., 2011. Assessment of Shallow Ground Water Quality of PindigaGombe Area, Yola area, NE, Nigeria for Irrigation and Domestic Purposes; Research Journal of Environmental and earth sciences 3 (2) Pp. 131-141.

World Health Organization, 2015. Regional Office for Africa, Geneva. http://www.afro.who .int/index.php?optio.=com_docman&g.d=479 Accessed 18 May 2018 World Malaria Repor.t