UMYU Scientifica, Vol. 3 NO. 4, December 2024, Pp 311 – 320
https://doi.org/10.56919/usci.2434.025
ISSN: 2955 – 1145 (print); 2955 – 1153 (online)
A periodical of the Faculty of Natural and Applied Sciences, UMYU, Katsina

ORIGINAL RESEARCH ARTICLE

Public Perceptions of Climate Variability and its Impact on Meningitis Outbreaks in Kano State, Nigeria

Abdulrazak Ahmed[1], Ahmad Hamza Abdullahi[1]*, AbdulHakim Wagini Hassan[1], Jibril Haruna Umar[2], Rabi'u Abdullahi[3] and Benshima Isaac Ityonum[4]
[1]Department of Geography and Environmental Management, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Environmental Management, Kaduna State University, Kaduna, Nigeria
[3]Environmental Science Laboratory, Bauchi State Environmental Protection Agency (BASEPA), Bauchi, Nigeria
[4]Department of Social and Environmental Forestry, Joseph Sarwuan Tarka University Makurdi, Benue, Nigeria

ABSTRACT
Weather patterns and their variations pose one of the biggest threats to public health worldwide, particularly in third-world nations like Nigeria. Higher temperature and dust conditions, for instance, increase the rate at which meningitis occurs. This study evaluated the effect of meteorological factors on the meningitis outbreak in Kano State. A questionnaire was used to collect data on respondents' perceptions. Archival data for temperature, rainfall and Cerebrospinal meningitis (CSM) data was also obtained for quantitative analysis. A total of seven hundred and eighty-four (784) questionnaires were distributed. The questionnaires were analysed using descriptive statistics, and charts were used to display the findings. Ordinary Least Square (OLS) and spatial autocorrelation were performed on the raw data in ArcGIS 10.8. Findings from OLS revealed that an increase in temperature by 1 unit resulted in to increase in CSM by 8.68, 0.12, and 3.7 during hot/dry, warm/wet, and cold/dry seasons, respectively. It also shows a negative relationship between rainfall and CSM, whereby an increase in rainfall by 1 unit may lead to a decrease in the outbreak of the disease by 0.12 and 0.001 during hot/dry and warm/wet seasons, respectively. The study's meningitis outbreak is known to 86.4% of the respondents. Further research revealed that, respectively, 38.3% and 34.6% strongly agreed and agreed with the assertion that a rise in temperature raises the local risk of contracting meningitis. Just 8.9% strongly agreed that there is a definite correlation between increased rainfall and the high incidence of meningitis in Kano State. Based on these, the study concluded that increasing temperature without proper adaptation and mitigation processes will result in a higher occurrence of CSM in Kano State. There is a direct association between temperature and meningitis outbreaks in Kano State. Hence, strategies such as reducing congestion and planting of trees should be increased.

ARTICLE HISTORY
Received August 08, 2024
Accepted November 15, 2024
Published November 19, 2024

KEYWORDS
Assessment, Weather, Parameters, Outbreak and Meningitis

INTRODUCTION

Meningitis is a highly contagious disease that can cause serious illness and even death to people living in different parts of the world. According to the Global Burden of Disease (GBD (2019), the disease's global burden in 2017 was estimated to be 5 million new cases and 290,000 deaths. In the West African belt, Ayanlade et al. (2020) reported that approximately 400 million people are exposed to meningitis, resulting in 25,000 to 250,000 victims annually. The first major epidemic of the disease in the African belt was about 100 years ago, but since then, according to Greenwood (2006), the reasons for the epidemiology in the belt are still poorly understood. This is because communities outside the belt, such as Uganda (Santaniello-Newton and Hunter, 2000) and Kenya (Gituro et al., 2017), are constantly reporting disease cases annually to the WHO since 1937 (Cunin et al., 2003). This indicated that numerous factors affect the occurrence of meningitis. Among these, variability in the weather parameters, such as temperature and rainfall, play a vital role in the distribution pattern of the disease. Henne et al. (2018) showed that the ability of disease-causing vectors to spread depends largely on appropriate settings, with climatic factors being one of them. Maini et al. (2017) were of the view that changes in today's climate factors, such as temperature, rainfall, and wind blowing, are having a significant impact on public health and other climate-sensitive events. Numerous researchers have examined the impact of meteorological components and their

Correspondence: Ahmad Hamza Abdullahi. Department of Geography and Environmental Management, Ahmadu Bello University, Zaria, Nigeria. ahmadhamzaabdul@gmail.com. Phone Number: +234 805 313 4439
How to cite: Ahmed, A., Abdullahi, A. H., Hassan, A. W., Umar, J. H., Abdullahi, R., & Ityonum, B. I. (2024). Public Perceptions of Climate Variability and its Impact on Meningitis Outbreaks in Kano State, Nigeria. *UMYU Scientifica*, 3(4), 311 – 320. https://doi.org/10.56919/usci.2434.025

fluctuations on the incidence and spread of meningococcal meningitis. Notable examples of these studies include Greenwood (2013) in the African meningitis belt, who reported the peak of meningitis incidence to have been correlated significantly with the highest mean temperatures and inversely with absolute humidity and rainfall. Dukić et al. (2012) employed a generalized additive modeling approach to assess the association between the number of reported meningitis cases and a set of weather variables in Navrongo, Ghana. The results revealed that higher levels of current month temperature, sunshine, percentage of dusty days, as well as previous months of CO emissions and wind tended to co-occur with the higher meningitis incidence. Additionally, it was noted that a reduced incidence of meningitis was linked to greater minimum temperatures, relative humidity, and rainfall the previous month. Also, the 4-degree model used in their analysis predicted that the log of the mean number of meningitis cases increased by 0.181, or roughly 20%, for every degree Celsius increase in the monthly average maximum temperature, holding other variables constant.

Codjoe and Nabie (2014) conducted a similar study in the Ghanaian Meningitis Belt, examining the connection between climate fluctuation and cerebrospinal meningitis. The data utilized by the researchers came from ten key informant interviews with medical superintendents of War Memorial Hospital, as well as health officials, disease control officers, and assembly members, as well as Focus Group Discussions (FGDs) held in Vunania and Nayagnia. A set of procedures were followed in order to analyze the data using a thematic framework: familiarization and identification of thematic frameworks, indexing, and charting, development of a coding frame, and production and interpretation of the outcome.

According to the results, most participants believed that CSM only affects people during the dry season. Some participants, such as the District Disease Control Officer, also believed that the disease only occurs during hot weather. Lastly, some participants stated that CSM occurs in epidemic proportions during droughts that coincide with extreme heat and dust.

Abdussalam (2014) modeled the impact of climatic change on the incidence of cholera and cerebrospinal meningitis (CSM) in Northwest Nigeria. The study made use of CMIP5 climate projection data, ERA-Interim grid point data, and climatic data from the Nigerian Meteorological Agency's Kano and Kaduna stations. The researcher also collects data from the National Center for Disease Control (NCDC) as well as from Barau Dikko Hospital in Kaduna, General Hospital Gusau, Specialist Hospitals in Kano and Sokoto, and other locations between 2000 and 2011. To assess the future impact of changes to disease epidemiology, statistical models created for studies on climate change were used for analysis. The generated models' results demonstrated the impact of meteorological conditions on illness incidences. The results of the projections also indicated that, in all scenarios and time scales, future temperature increases may considerably raise the rate of disease cases.

These clearly indicated that meningitis, poses a significant public health threat, particularly in sub-Saharan Africa, this is more especially with the variation in weather parameters. Therefore, understanding how weather variations, specifically temperature and rainfall, influence its outbreaks is crucial for effective prevention strategies. However, despite the importance of communities who experience the incidence in assessing factors associated with the disease outbreak, researchers put less interest in that. Moreso, considering the finding of Abdussalam (2014), who used 2000 to 2011 data and reported future linkages between temperature and CSM outbreaks in Northwestern Nigeria. It becomes paramount to further assess the effects of temperature and rainfall on CSM outbreaks. This also calls for assessing the community's perception on the linkages. Based on these, the present study assesses the effect of temperature and rainfall on the outbreak of CSM in Kano State. The specific objectives are: i. examine the relationship between temperature and rainfall variability with CSM outbreak in the area. ii. assessing public perceptions on the effect of temperature and rainfall on CSM outbreaks in the research area.

MATERIAL AND METHODS

Ethical Statement

This research is committed to upholding the highest ethical standards. The study involves collecting qualitative and quantitative data from participants regarding their perceptions and experiences related to climate variability and meningitis outbreaks. In doing so, we ensured that all participants were fully informed about the purpose, procedures, risks, and benefits of the study.

Participation was entirely voluntary, with the option to withdraw at any time without consequence. Informed consent was obtained from all participants, and confidentiality was strictly maintained; personal identifiers were removed, and data was reported in aggregate form to preserve anonymity.

The research also respected the cultural values and norms of the communities involved, and we prioritized sensitivity and awareness of local beliefs regarding health and climate issues. We were committed to disseminating findings compassionately and responsibly, aiming to contribute positively to public health discourse and interventions in Kano State. The study has been reviewed and approved by an institutional ethical review board to ensure adherence to ethical guidelines.

Study Area

The research region lies between the prime meridian's Longitudes of 7°41'9.1572" E and 9°21' 54.7056" E and Latitudes 10°37'6.4467" N and 12°40'55.7634" N of the equator. Katsina State borders the area to the northwest, Jigawa State northern and northeastern, Kaduna State to the southwest, and Bauchi State to the southeast (Figure

1). The study area occupied a total land mass of 20,760 square kilometers. Its total annual rainfall, as reported by (Nabegu, 2014) in the northern and southern parts, is approximately 800 mm and 1100 mm, respectively. Temperature is high throughout the year with April as the hottest. According to Weather Atlas (2020), the area recorded an average high and low temperature of 38.2°C and 23.6°C respectively, in April and 31.1°C and 13°C in December as the coolest month.

Reconnaissance survey

The researchers conducted a reconnaissance survey from 12th to 16th July 2023. This enables us to be familiar with the area. During the survey, the researchers were able to understand the characteristics of some weather elements, this is more especially temperature and rainfall; a discussion with some residents was also conducted. Finally, it was understood that some people in the area were of the view that weather elements influence the occurrence of meningitis in the area.

Types of Data Used

The study collected and used a variety of data, such as respondents' knowledge of the local meningitis outbreak, their perception of the danger of contracting the illness, and their thoughts on potential connections between the disease and local weather conditions (such as temperature and rainfall). This study was restricted to only two (mean monthly temperature and monthly rainfall) weather parameters and CSM cases surveillance data from 2013 to 2023.

Source and techniques of data collection

Data for perception analysis was obtained through structured questionnaires administered to the people residing within the sample area. On the other hand, raw temperature and rainfall data for regression analysis were downloaded from the Climatic Research Unit of the University of East Anglia (CRUv3.4, 0.5° resolution) archive. However, that of CSM cases was obtained from the Kano State Ministry of Health, and this follows a written application for ethical approval.

Sample size and sampling technique

The study sample population was gotten from the population of Kano State as at 1991, which stood at 5,810,470 people according to NPC (1991), this population data was projected to 2023 population using Newman's (2001) population projection as given in equation 1:

$$P_n = P_0 + \left(\frac{1+R}{100} \times P_0\right)n \quad \text{.......................... Equation 1}$$

Where: Pn = Population in the recent year;
P_0 = Population in the base year (5,810,470)
R = annual growth rate (2.6%)
n = number of intermediary years (32 years)

Based on the above calculation, the sample population as of 2023 has been 12,713,308. Krejcie and Morgan's (1970) sample size technique was adopted for sampling size. According to the techniques, the sample size of 784 people should be used for population ranges from 10, 000, 000 to 100, 000, 000. To arrive at the sampling location, the researchers adopted clustering sampling methods. 20% of the 44 Local Government Areas (LGAs) were first selected, given 9 LGAs as sampling LGAs. The 9 LGAs were identified based on the total number of LGAs per senatorial zone. Similarly, to arrive at the required wards, 20% (18) of the total number of wards within the sampled LGAs was used. In order to get the sampled wards, the wards in each sampled LGA were arranged on the basis of population size, and then the ones with the highest and lowest populations were selected (Table 1).

Validity of the Research Questionnaire

In order to test the validity of the research instrument, sample questions were designed and sent to 3 experts each in the field of environmental health, climatology, and public health officers called Disease Surveillance and Notification Officers (DSNO). The validity of the essential questions was then determined using Lawshe's (1975) method (equation 1).

$$CVR = \frac{ne - (N/2)}{N/2} \quad \dots\dots\dots\dots\dots\dots\dots \quad \dots.\text{equation 2}$$

Where:

CVR = content validity ratio
n_e = number of questions indicating essential
N = total number of experts

Henceforth, the CVR values of 0.84 (84%) were determined, this shows that the research instrument has been valid to be used for the research.

Questionnaire administration

The research and other co-researchers were involved during questionnaire administration this helps to access qualitative data by the researchers. Random sampling was first used to determine the starting point for questionnaire administration, and this was then followed by systematic sampling techniques whereby at regular intervals of twenty houses, another house was selected until the numbers of households required were selected. In a situation where more than households were found within a compound, the eldest household was selected. The researchers interpreted the questions to the respondents using their local language in case respondents were unable to read the questions. The heads of the villages helped the researchers to get the consent of the respondents; in doing so, the husband or his elder wife was allowed to respond to the questions.

Data Analysis

The temperature, rainfall, and CSM archival data were grouped into three seasons: hot/dry, warm/wet, and cold/dry (Table 2). The average values were generated for each season.

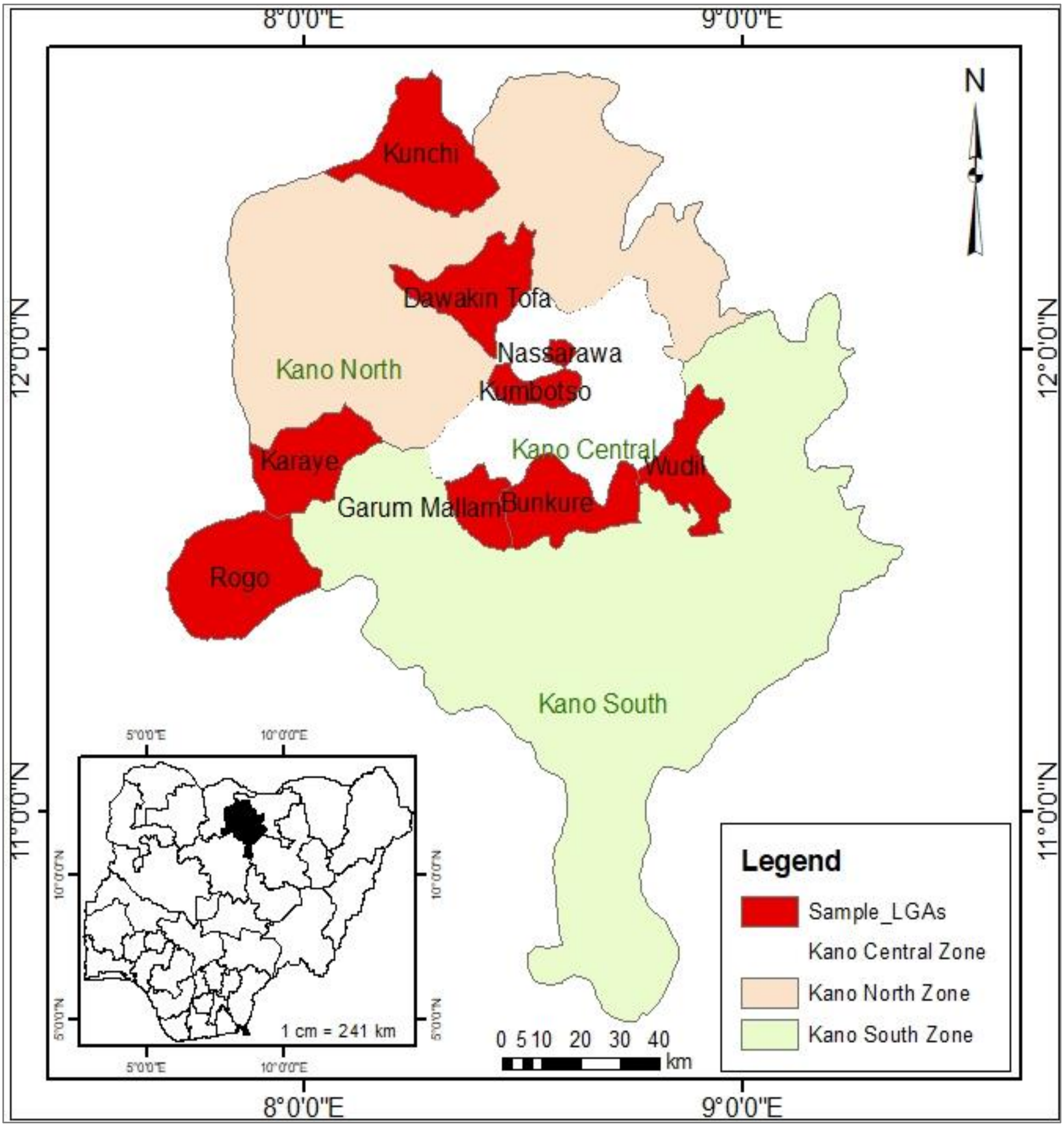

Figure 1: Study Area Map
Source: Adopted from Kano State Ministry of Land and Physical Planning

The Ordinary Least Squares (OLS) regression and spatial autocorrelation in ArcGIS environment was performed with the data, to examine the effects of temperature and rainfall on the occurrence of the disease. Before running the model, researchers assumed that residuals are homoscedastic, independently, and identically distributed normally around a mean of zero. The result was presented in tables, while interpretations and discussions were done based on the following statistical parameters:

* An asterisk next to a number in a table indicates a statistically significant p-value ($p < 0.05$). When the Jarque-Bera Statistic test is statistically significant model predictions are biased. However, when the Koenker (BP) Statistic test is statistically significant, the relationships modeled are not consistent. In other words, there is variation in the influence of explanatory variables on the occurrence of dependent variables. In addition, the strength and type of relationship between each explanatory variable and the dependent variable are explained by the coefficient of intercept.

Responses obtained from the respondents using the questionnaire were imputed into Microsoft excel in the appropriate rows and columns of tables. The Likert scale on the questionnaire, which ranged from 1 to 5, was explained as follows: 5 for strongly agree, 4 for agree, 3 for undecided, 2 for disagree, and 1 for strongly disagree were used for the analysis. These were conducted using percentages, while the result was presented using charts. This was done to provide a clear understanding of the public perceptions of the effect of weather parameters on CSM outbreaks in the research area.

Table 1: Sampled Size in the Study Area

Senatorial Zones	Selected LGAs	Sampled Wards	1991 Population	2023 Pop. Projection	Sampled Respondents
Kano North	Dawakin Tofa	Dawaki west	16, 235	35,522	62
		Marke	4,521	9,892	17
	Kunchi	Kunchi	7,427	16,250	28
		Shuwaki	2707	5,923	10
Kano Central	Garun malam	Garun malam	10,142	22,191	39
		Yalwan yada	3,217	7,039	12
	Kumbotso	Chiranchi	19,614	42,915	75
		Challawa	4,261	9,323	16
	Nassarawa	Gama	40,147	87,842	153
		Kaura Goje	15,317	33,514	58
Kano South	Bunkure	Bunkure	13,285	29,068	51
		Gafan	2,847	6,229	11
	Karaye	Karaye	9,617	21,042	37
		Turawa	2,728	5,969	10
	Rogo	Sabon Gari	16,085	35,194	61
		Gwangwan	4,162	9,106	16
	Wudil	Wudil	29, 969	65,572	114
		Kausani	3,518	7,697	14
Total			**205,799**	**419,956**	**784**

Table 2: Classification of Season in the Study Area

Seasons	Month
Hot/dry (*Bazara*)	March to May
Warm/wet (*Damina*)	June to October
Cold/dry (*Kaka*)	November to February

Source: Adopted from Olofin (2008)

RESULTS AND DISCUSSION

This section presents the results of the analysis and discussion in two ways

Effect of Temperature and Rainfall Variability on the Occurrences of CSM

Results of the effect of temperature and rainfall variability on the occurrence of CSM in the study area are presented in Table 3. The result from Koenkered statistics with p-values greater than 0.05 shows statistically no significant effects for the three seasons. However, the coefficient of intercept showed that temperature influences the occurrence of the disease positively throughout the study period in such a way that an increase in temperature by 1 unit resulted in to rise in the cases of CSM by 8.68, 0.12, and 3.7 during hot/dry, warm/wet and cold/dry seasons respectively. On the other hand, the result indicated a negative relationship between rainfall and CSM in the study area, whereby an increase in rainfall by 1 unit may lead to a decrease in the outbreak of the disease by 0.12 and 0.001 during hot/dry and warm/wet seasons, respectively.

The result of the Jarque–Bera statistic with the p-values of 0.15 during the hot/dry season showed no bias in the distribution of residuals; hence, the residuals are normally distributed across the study area. But, during warm/wet and cold/dry seasons, Jarque–Bera statistic returned significant p values of 0.000000 and 0.000061, respectively which implied that the residuals are not normally distributed during these seasons. Spatial autocorrelation was then used to examine the pattern of the residuals, and the result in Table 3 revealed that the residual has a positive Moran's I index during hot/dry, which implied clustering in the pattern of the disease due to temperature and rainfall variability, this, therefore, means that similar values tend to occur across the study area. While during warm/wet and cold/dry, it is negative, which implies a tendency toward dispersion.

As a whole finding from regression analysis shows that the higher the temperature, the higher the rate at which CSM occurred in the research area, while the higher the rainfall, the lower the level of the disease cases in the area. This result may be associated with the fact that CSM was popularly known to have been affecting people during the dry season, especially when there is a substantial amount of dust. High temperatures and dust mainly characterize the dry season in Kano State, while the absence of dust characterizes the wet season. This might lead to a higher occurrence during the hot/dry season. This result supports Dukić et al. (2012) in the Navrongo district of Ghana, who revealed that climatic variability such as temperature and relative humidity influenced spatial and temporal variability of CSM; according to their results increase in hot conditions is dangerous to public health. The finding is also in line with that of Abdussalam (2014) that temperature and rainfall affected the occurrence and transmission of CSM in the North-Western part of Nigeria. The researcher stated that people residing in cities are at higher risk than those in rural areas. This result also agreed with that of Ayanlade et al. (2020), who reported a weak positive relationship between temperature and meningitis outbreaks in all tropical ecological zones.

Table 3: Effects of Temperature and Rainfall on the Occurrence of CSM

Parameters	Hot/dry	Warm/wet	Cold/dry
Koenker r statistic (P values)	0.218015	0.533606	0.142750
Jarque–Bera statistic (P values)	0.148453	0.000000*	0.000061*
Rainfall coefficient of intercept	-0.127347	-0.001345	
Temperature coefficient of intercept	8.689337	0.129179	3.738125
Spatial autocorrelation (Moran's I)	0.4	-0.02	-0.06

* Significant at 0.05

Public Perception on the Effect of Temperature and Rainfall on CSM Outbreak

Respondents' awareness of meningitis outbreak

Figure 2 displays the respondents' awareness of the meningitis outbreak in the research area based on the results. The majority (86.4%) of respondents were found to be aware of the incidence and spread of meningitis in the research area. This degree of awareness among respondents may be related to the high occurrence of disease outbreaks and the state's attempts to inform the public about the risks connected with disease outbreaks through Disease Surveillance and Notification Officers (DSNO). The outcome is consistent with Nguyen's (2010) study conducted in Ho Chi Minh City, which found that the majority (65%) of respondents strongly agreed that they are aware of the prevalence of illness infections and the effects they have on health. It also aligns with the findings of Hayden et al. (2013) in Northern Ghana, where over 68.9% of the participants were informed about the meningitis outbreak and its symptoms. This result is also consistent with a prior study on community-based research carried out in Lafia by Reuben and Gyar (2016), who found that a high level of public awareness of the Lassa fever outbreak was one of the diseases that were most likely to cause epidemics in that area. This research suggests that people living in the study area may become more interested in learning more about the causes, symptoms, and methods of the disease breakout and transmission.

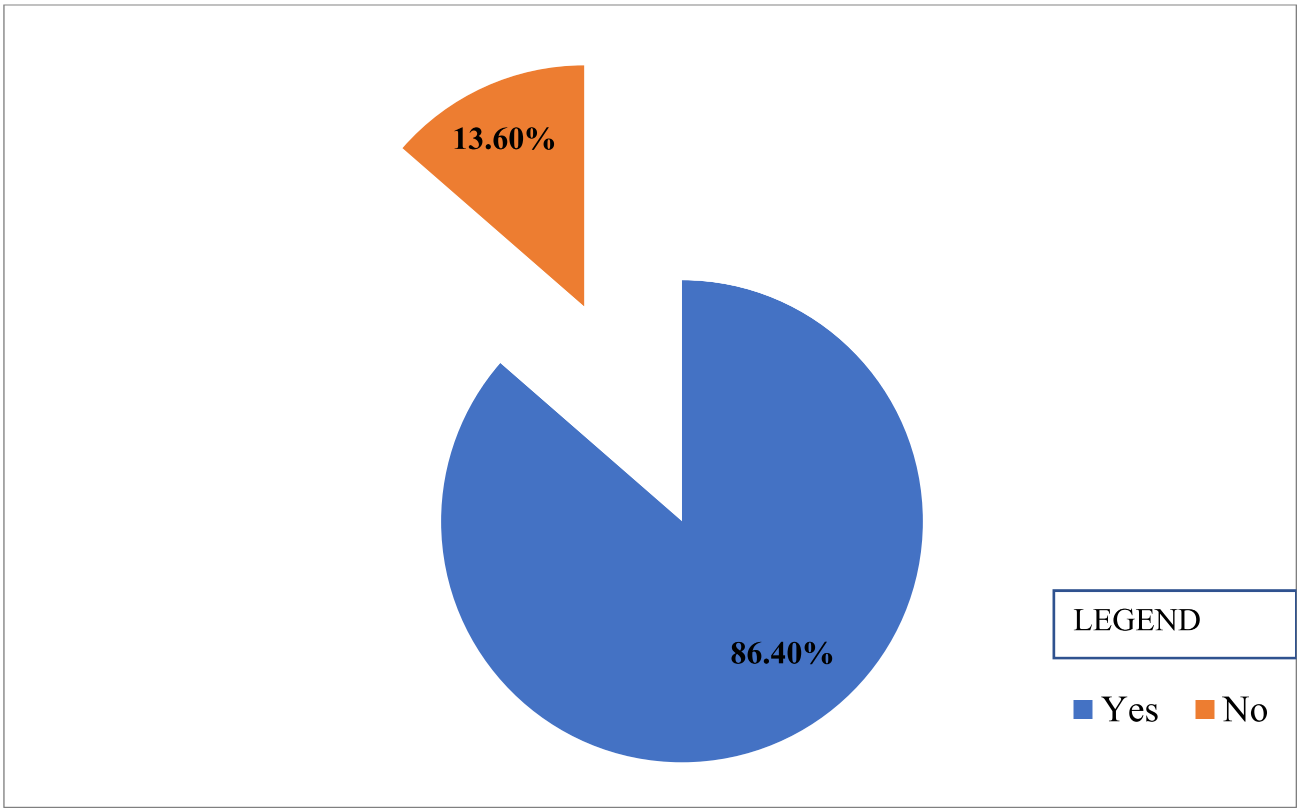

Figure 2: Respondents' Awareness of Diseases Occurrence in the Study Area
Source: Author's Fieldwork, 2023

Respondents' perception of the risks of the disease infection

In Sub-Saharan Africa, which includes the northern portion of Nigeria, meningitis is becoming one of the main diseases that is prone to epidemics. There is a high chance that it will infect many people. The community's opinion of the risk of infection by the diseases is shown in Figure 3. The majority (35.5%) of respondents think they have a moderate risk of infection, followed by those who think they have a high risk (26.6%). 9.4% of people, however, think there was no chance they could get sick. Of the responders, 14.6% were unsure, and 13.8% were unaware of their risk of contracting the disease. The efforts of DSNO and the Kano State Ministry of Environment to inform the public through the media and meetings about the risk of contracting epidemic-prone diseases like meningitis, cholera, and measles may be linked to respondents' perceived higher risk of the disease. For example, it is commonly recognized that meningitis is linked to high temperatures. Kano State has a generally high temperature, and there is a high population concentration in Kano City (Abdullahi et al., 2023).

The benefit of the respondents' awareness of the risk of contracting a disease is that some of them, particularly the younger and more educated ones, may be more concerned with adaption and control measures. This result is in line with that of Aerts et al. (2020), who reported that a large number of people are aware of their risk of contracting an illness, but to what extent depends on their environment, economic status, and educational attainment. This result is also in line with that of Chan et al. (2018) who reported that higher knowledge of disease risk among people is likely to be associated with increasing awareness of risk perception.

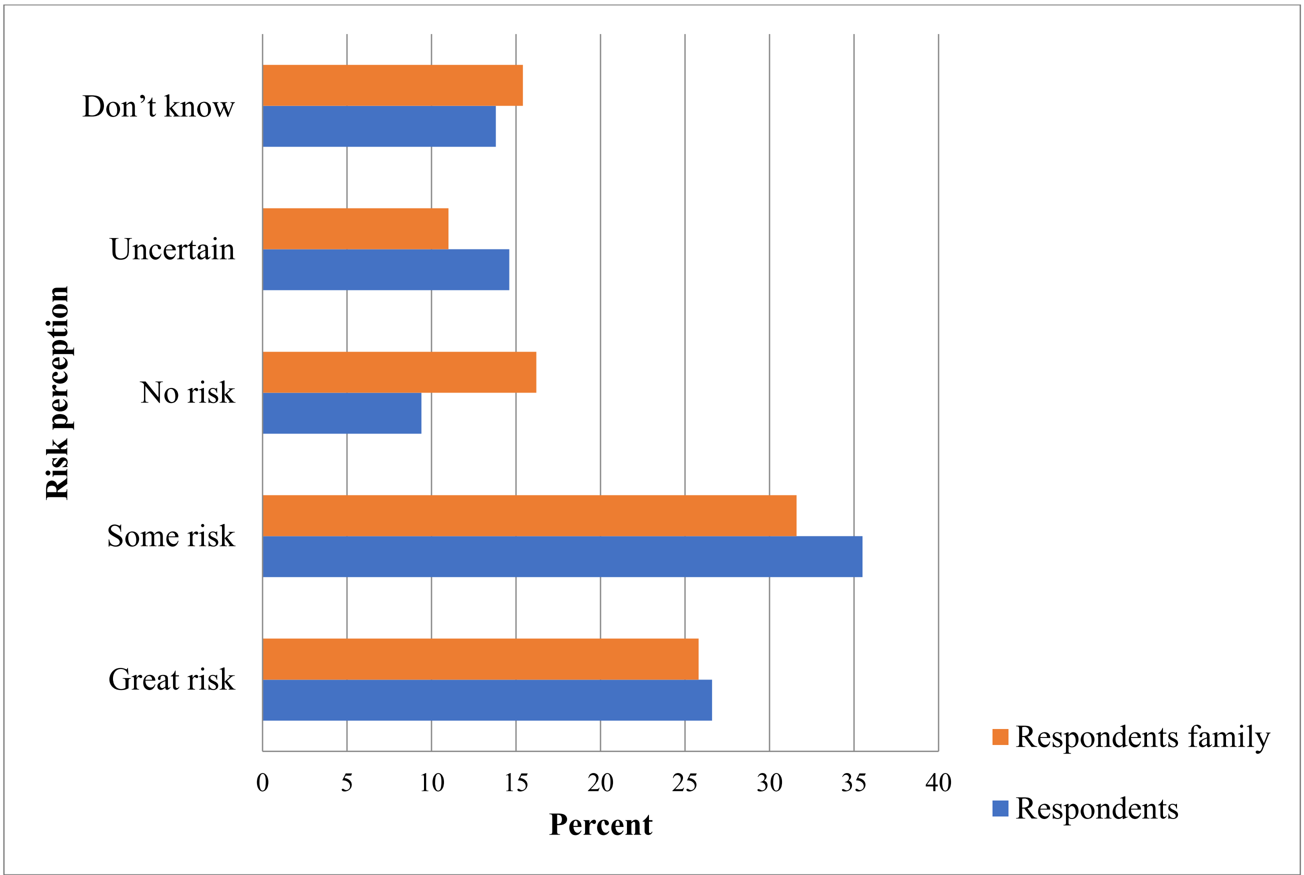

Figure 3: Respondents' Perception of the Risks of Getting Meningitis
Source: Author's Fieldwork, 2023

However, Figure 3 also showed that 31.6% of respondents believed that a family member may be in danger of infection. 25.8% of respondents then said that their family was in high danger. Though 15.4% of respondents were unsure if their family members were at risk of infection, 16.2% of respondents believed that their family members had no danger of infection, and 11% of respondents were unsure if their family members were infected in the research area. This suggested that the majority of respondents believed that there was a chance that their family members would contract the illnesses. The results suggested that respondents were determined to be at higher risk than their family members based on a comparison of the respondent's perceptions of their dangers and those of their relatives. Whatever the situation, it may be related to the respondents' perception that their family members were safe because they were raised in the home and were not exposed to harsh environments, or it may have been because they neglected to accurately assess their families' circumstances when filling out the questionnaire. Nonetheless, the education and income levels of the head of the home have the greatest impact on the health of children and other dependents; therefore the former point should be given careful thought. The findings from this study agree with that of Kumaran et al. (2018) that awareness and knowledge of disease risk have been coming high, especially among educated and wealthy people from increased access to information through multiple channels.

Perception of the effect of temperature and rainfall variability on meningitis outbreak in the study area

Figure 4 presents the result of the respondents' perception that rising temperature leads to a higher occurrence of meningitis.

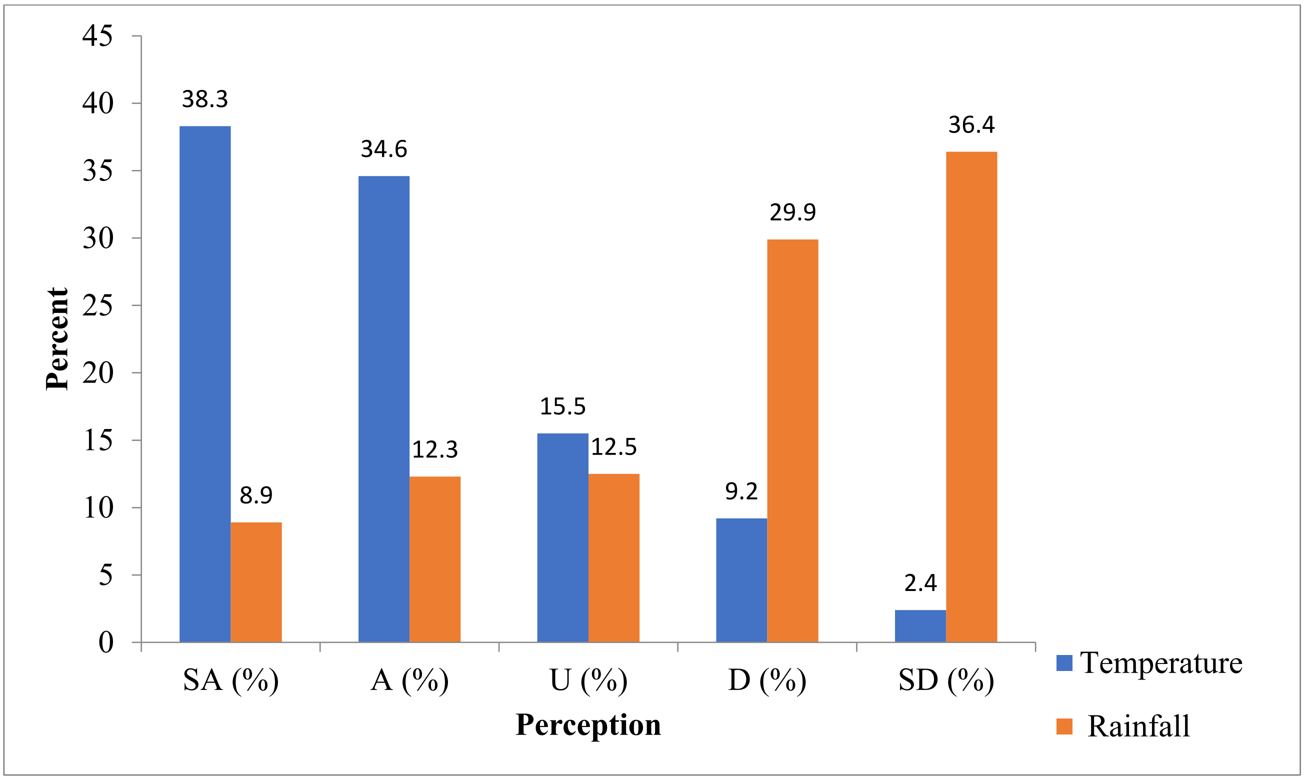

Figure 4: Effect of Temperature and Rainfall on Meningitis
SA = Strongly agreed, A = Agreed, U = Undecided, D = Disagreed and SD = Strongly disagreed
Source: Author's Fieldwork, 2023

The findings indicate that while 9.2% and 2.4% disagreed and strongly disagreed with the statement, respectively, and 15.5% were unsure, 38.3% and 34.6% strongly agreed and agreed with it. According to this result, the majority of respondents thought that the study area's higher temperatures led to an increase in meningitis cases. This is in line with the findings from the OLS analysis in section 3.1 of this study, which shows that there is a direct relationship between temperature and CSM outbreak in the study area. This agrees with the finding of Mazamay et al. (2020) in the Democratic Republic of the Congo who found that higher temperatures create ideal conditions for the emergence of CSM outbreaks in the nation. The results of this study are also consistent with those of Greenwood (2013), who demonstrated that the incidence of meningitis has a substantial positive correlation with the highest mean temperature and a negative correlation with absolute humidity and rainfall. Because of its robust economic activity, which draws in migrants from all over the world, Kano State, the most populous state in Northern Nigeria, has one of the densest populations in the nation in its capital city. Kano City's settlement layout is characterized by an unplanned, crowded population density of too many people living in small houses, particularly in the city (Ganuwa) and recently expanded districts inhabited by low-income earners. These are other circumstances that facilitate the growth and occurrence of meningitis-causing microorganisms. This agrees with Greenwood (2006), who observed that densely populated rooms with inadequate ventilation and overcrowding at public events, including worship centres and markets, favour transmission of the bacteria that trigger the spread of meningitis disease. This also conforms with the findings of the present study.

Figure 4 further showed that while 29.9% and 36.4% of respondents disagreed and strongly disagreed with the assertion that increased rainfall leads to a higher spread of meningitis, respectively, and 12.5% were indecisive, 8.9% and 12.3% of respondents highly agreed and agreed with the statement. This showed that the majority of respondents believed that the State's meningitis cases grow with decreasing rainfall and reduce with increasing rainfall. According to a disease monitoring official, meningitis outbreaks in Kano State often start during the dry season and spread until the rainy season arrives. This result supports that of Lindsay et al. (2002) in New Zealand, who reported that the incidence of meningitis increased with increasing humidity but declined with heavy rainfall. The finding also corresponds to that of Dukić et al. (2012), who studied the role of weather in meningitis outbreaks in Navrongo, Ghana, and reported that higher levels of minimum temperature, relative humidity, and rainwater were associated with lower levels of meningitis incidence in the area. The result is also in agreement with that of Codjoe and Nabie (2014), who revealed that the majority of the respondents generally held the view that meningitis is a disease that mostly affects people during the dry season and mostly occurs when the weather is hot. The result also agrees with Ayanlade et al. (2020), who reported that meningitis is a climate-related disease that usually occurs during the hot/dry season and decreases with an increase in the level of rainfall.

CONCLUSION

The study found that meningitis is one of the epidemic-prone diseases that people in Kano State experience outbreaks of; most study participants believed that they were at risk of contracting the disease; there is a direct correlation between temperature variability and the incidence of meningitis in the region and an inverse relationship with rainfall; and finally, the study recommended the implementation of more mitigation and adaptation strategies to diseases related to climate change in Kano State.

DECLARATION

The authors declared that there isn't a conflict of interest.

REFERENCES

Abdullahi, A. H., Sawa, B. A. and Saleh, M. (2023). An Assessment of the Influence of Climate Variability on the Occurrence of Meningitis in Kano State, Nigeria. Sahel Journal of Geography, Environment & Development 4(1): 1-8, June, 2756-536X saheljournalofgeography

Abdussalam, A.F. (2014). Climate Influences on Infectious Diseases in Nigeria, A thesis submitted to the School of Geography, Earth, and Environmental Science, College of Life and Environmental Science, University of Birmingham for the degree of Doctor of Philosophy.

Aerts, C., RevillaI, M., Duval, L., PaaijmansI, K., Chandrabose6, J., Cox6, H. and Sicuri, H. (2020). Knowledge, risk perception and behavior for selected vector-borne diseases in Guyana. PLoS Neglected Tropical Diseases 14(4): e0008149. Downloaded on 6 January, 2021. **[Crossref]**

Ayanlade, A., Sergi, C. and Ayanlade, O.S. (2020). Malaria and meningitis under climate change: initial assessment of climate information service in Nigeria, Meteorological Applications, 27: e1953, downloaded. **[Crossref]**.

Chan, M.S., Winneg, K., Hawkins, L., Farhadloo, M., Jamieson, K.H. and Albarracı n, D. (2018). Legacy and social media respectively influence risk perceptions and protective behaviors during emerging health threats: A multi-wave analysis of communications on Zika virus cases. Social Science Medical, 212: 50-59, downloaded on 17th August 2021. **[Crossref]**

Codjoe, S.N.A. and Nable, V.A. (2014). Climate Change and Cerebrospinal Meningitis in the Ghanaian Meningitis Belt, International Journal of Environmental Research and Public Health, 11: 6923-6939. **[Crossref]**

Cunin, P., Fonkoua, M.C., Kollo, B., Bedifeh, B.A., Bayanak, P. and Martin, P.M.V. (2003). Serogroup a Neisseria meningitidis outside Meningitis Belt in Southwest Cameroon. Emergence Infectious Disease. 9(10):1351-1353. **[Crossref]**

Dukić, V., Hayden, M., Forgor, A. A., Hopson, T., Akweongo, P., Hodgson, A., Monaghan, A., Wiedinmyer, C., Yoksas, T., Thomson, M. C, Trzaska, S. and Pandya, R. (2012). The Role of Weather in Meningitis Outbreaks in Navrongo, Ghana: A Generalized Additive Modeling Approach; Journal of Agricultural, Biological, and Environmental Statistics, 17(3): 442-526. **[Crossref]**

Gituro, C.N., Nyerere, A., Ngayo, M.O., Maina, E., Githuku, J. and Boru, W. (2017). Etiology of bacterial meningitis: a cross-sectional study among patients admitted in a semi-urban hospital in Nairobi, Kenya. Pan African Medicine Journal, 1:28(Suppl1). **[Crossref]**

Global Burden of Disease (GBD) (2019). GBD Results Tool, downloaded from ghdx.healthdata.org

Greenwood, B. (2006). Editorial: 100 years of epidemic meningitis in West Africa has anything changed? Tropical Medicine International Health, 11: 773-780. **[Crossref]**

Greenwood, B. (2013). Priorities for research on meningococcal disease and the impact of serogroup A vaccination in the African Meningitis Belt. Vaccine, 31(11):1453- 1457. **[Crossref]**

Hayden, M.H., Dalaba, M., Awine, T., Akweongo, P., Nyaaba, G., Anaseba, D., Pelzman, J., Hodgson, A. and Pandya, R. (2013). Knowledge, Attitudes, and Practices Related to Meningitis in Northern Ghana, American Journal of the Tropical Medicine and Hyg., 89(2), 265-270. **[Crossref]**

Henne, P.D., Bigalke, M., Büntgen, U., Colombaroli, D., Conedera, M., Feller, U., Frank, D., Fuhrer, J., Grosjean, M., Heiri, O., Luterbacher, J., (2018). An empirical perspective for understanding climate change impacts in Switzerland, Reg Environ Change 18:205-221. **[Crossref]**

Krejcie, R.V. and Morgan's, D.W. (1970). Determining sample size for research activities, Educational and Psychological Measurement, 30: 607-610. [**Crossref**]

Kumaran, E., Doum, D., Keo, V., Sokha, L., Sam, B. and Chan, V. … (2018). Dengue knowledge, attitudes and prac-tices and their impact on community-based vector control in rural Cambodia. PLoS Neglected Tropical Diseases, 12(2):1-16. [**Crossref**]

Lindsay, A.P., Hope, V., Marshall, R.J. and Salinger, J. (2002). Meningococcal disease and meteorological conditions in Auckland, New Zealand. Australian N Z Journal of Public Health; 26: 21-28. [**Crossref**]

Maini, R., Clarke, L., Blanchard, K., and Murray, V. (2017). The Sendai Framework for Disaster Risk Reduction and its indicators-Where does health fit in? Int. J. Disaster Risk Science,8: 150-155. [**Crossref**]

Mazamay S, Broutin H, Bompangue D, Muyembe J-J, Gue gan J-F (2020) The environmental drivers of bacterial meningitis epidemics in the Democratic Republic of Congo, central Africa. PLoS Neglected Tropical Disease, 14(10): e0008634. [**Crossref**]

Nabegu, A.B. (2014). Analysis of Vulnerability to Food Disaster in Kano State, Nigeria. Greener Journal of Physical Sciences, 4: 22-29

National Population Commission (NPC) (1991). Census Report, Federal Republic of Nigeria. Analytical Result Report at the National Level. NPC Abuja-Nigeria.

Newman's, J. F. (2001). Population Projection for Research and Development. Retrieved from educationforallindia.com.

Nguyen, L. (2010). Health Implications of Infectious Diseases due to Climate Change: A Case Study of Ho Chi Minh City, M.Sc. Dissertation, School of Environmental Sciences, Faculty of Sciences, University of East Anglia.

Olofin, E.A. (2008). "The Physical Setting". In Olofin, E. A., Nabegu, A. B. and Dambazau, A.M. (edited). Wudil within Kano Region: a geographical synthesis. Published by Adamu Joji Publishers on behalf of The Department of Geography, Kano University of Science and Technology, Wudil, 5-34.

Reuben C. and Gyar S. (2016). Knowledge, attitudes and practices of Lassa fever in and around Lafia, Central Nigeria. International Journal of Public Heal Epidemiological Resources, 2(1):014-9.

Santaniello-Newton, A. and Hunter, P.R. (2000). Management of an outbreak of meningococcal meningitis in a Sudanese refugee camp in northern Uganda. Epidemiological Infection, 124(1):75-81. [**Crossref**]

Weather Atlas (2020). Monthly weather forecast and climate, Kano, Nigeria. Accessed from www.nga.com.

Yalwa, T.R. (2014). Assessment of Groundwater Potential for rural water supply in parts of Kano, State, Northern Nigeria, Unpublished Doctoral thesis, Department of Geography, Ahmadu bello University, Zaria.