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ORIGINAL RESEARCH ARTICLE

Public Perceptions of Climate Variability and its Impact on Measles Outbreak in Kano State, Nigeria

Ahmad Hamza Abdullahi[1]*, Abdulrazak Ahmed[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

Climate variation affects the rate of measles occurrence. High temperatures in a congested environment, for instance, positively influence the outbreak of the disease. This consequently resulted in a high rate of disease occurrence and the livelihood of the community at large. The current research assessed public perception of the impact of climate variability on the occurrence of measles in Kano State. Data on people's perceptions was obtained using a questionnaire and key informant interviews. In addition, raw data for the variables was also obtained for regression analysis. Seven hundred and eighty-four (784) structured copies of the questionnaire were administered, and five (5) key informants' members were selected for qualitative data. The obtained data were analysed using descriptive, inferential statistics, and thematic framework, and the results were presented using charts and tables. Results showed that the majority (75.7%) and 49.3 of the respondents were of the view that temperature and rainfall, respectively, are increasing in the area, while the majority (43.6%) were of the view that humidity has been on the decrease. The results show that 63.2% considered temperature to be positively related to measles, while 46.9% being of the view that an increase in rainfall does not lead to higher cases of measles. Results from regression analysis revealed R^2 values during hot/dry (0.075), this was followed by cold/dry with 0.03. However, it was just around 0.013 during warm/wet, which indicated that temperature and rainfall affect the outbreak of measles at lower degrees. Based on these, it is concluded that, not everywhere and at all times climate variability influences the occurrence of measles in Kano State. It was recommended that several strategies, such as planting of vegetation and public campaigns, should be increased in the area.

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INTRODUCTION

Among the most important meteorological variables influencing disease outbreaks are variations in temperature and precipitation levels (Abdullahi et al., 2023a). Researchers and scientists from all over the universe were presently rather concerned about how climatic factors were shifting and fluctuating and how this was affecting people's ability to make a living. According to Maini et al. (2017), public health and other climate-sensitive events are now significantly more affected by variations in climatic elements. Watts et al. (2018) state that the direct effects of climate variability on the occurrence of disease include floods, extreme temperatures, and so on. Indeed, researchers around the world have observed that one of the primary causes of disease outbreaks is climate variability, which is mostly influenced by variations in temperature and precipitation (Abdullahi et al., 2023b).

Measles became one of the most contagious illnesses that threaten humanity on the planet with its advent. Despite the availability of a safe and effective vaccination for the past 40 years, the disease continues to be a major cause of death for young infants (Okonko et al., 2009). Numerous reasons, including poverty, overcrowding, unfavorable environmental conditions, and other environmental factors, including climate fluctuation, are linked to the ongoing spread of measles. This is due to the possibility that climatic variability may directly affect pathogen survival and dissemination outside of the host, as well as indirectly affect other factors that influence the likelihood of transmission, like alterations in social behavior (Morand et al., 2013). Studies conducted by Waitsa et al. (2018) indicated that temperature and precipitation appear to be the most influential climatic factors in infectious disease

Correspondence: Abdullahi, Ahmad Hamza. Department of Geography and Environmental Management, Ahmadu Bello University, Zaria, Nigeria. ✉ ahmadhamzaabdul@gmail.com. Phone Number: +234 805 313 4439

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transmission including measles occurrence. In tropical climates, such as Nigeria, for instance, as reported by Moss and Griffin (2012), the disease occurs irregularly but is associated with seasons.

According to Yang et al. (2014), the 75th percentile of mean temperature (27.9°C) for lags 0–10 days and the 25th percentile of relative humidity (64%) for lags 0–30 days are related to the relative risks for measles occurrence in China. In general, the research showed that cold spells had a considerable negative impact on the incidence of measles in the study area. According to Orsoo et al. (2019), the measles outbreak in Mongolia has been linked to temperature rises that produce more heat, which has increased the rate of measles transmission. According to Omonijo et al. (2012), variation of temperature in Ondo State, Nigeria, was found to be among the factors responsible for over 40% of the fluctuation in measles transmission, with the peak incidence occurring from January to May during the dry season.

Akinbobola and Hamisu (2018) conducted a study in the Kano metropolis, Nigeria, elucidating the mechanism that links meteorological variables to measles. Monthly measles cases from Muhammad Abdullahi Wase Specialist Hospital in Kano were acquired between 1997 and 2012. Data on rainfall minimum and maximum temperatures were sourced from NiMets within the same time frame. The Spearman's rank correlation test was used for analysis to look at the association between disease cases and weather factors. The findings indicated that there is a relative risk of the disease incidence with high temperatures, often between 38°C and 40°C. The researchers also observed measles incidence to have been correlated with the rainfall season.

In fact, the linkages between measles occurrence and climate variability in different parts of the world have been reported by various researchers. However, most of these studies relied upon the use of archival data. On the other hand, some researchers, such as Jonathan et al., 2018; and Tomson et al., 2018 were of the view that to understand the linkage between climate and the occurrence of disease, the views of the community are also paramount. This call for assessing public perceptions of climate variability and its impact on the occurrence of measles in Kano State, Nigeria. In relation to these, the current study shows community belief linking temperature increases to measles outbreaks. People also indicated that an increase in rainfall does not lead to a rise in the cases of measles in the research area. The use of archival data also shows how temperature is directly related to the measles outbreak in the research area. This research findings indicate the need for targeted public health interventions during variations in climatic elements.

MATERIAL AND METHODS

Ethical Statement

This research is committed to upholding the highest ethical standards. Participation in this study was entirely voluntary, and informed consent was obtained from all participants prior to data collection. Participants were provided with clear information about the purpose of the research, the nature of their involvement, and their rights, including the right to withdraw from the study at any time without consequence.

Data collected was treated with strict confidentiality and used solely for research purposes. Personal identifiers were removed to ensure anonymity. The study adhered to ethical guidelines established by relevant institutional review boards and regulatory bodies. Additionally, the research outcomes aimed to contribute positively to public health awareness and policy development in relation to climate change and disease prevention in Kano State. Participants were also informed of the potential implications of the study findings on local health initiatives and climate resilience strategies.

Study Area

Kano State is located between Latitude 10°3' N and 12°3' North of the Equator and Longitude 7°35' E and 9°20' East of the Prime meridian with a total land area of about 20,760sq km Research and Documentation Directorate (RDD, 2009) (Figure 1).

There are forty-four Local Government Areas (LGAs) in the State, eight of which are located inside major cities. Jigawa State forms its northern and northeastern borders, followed by Katsina State to the northwest, Bauchi State to the southeast, and Kaduna State to the southwest. The State receives roughly 800 mm of total annual precipitation in the north and 1100 mm in the south (Nabegu, 2014). According to Weather Atlas (2020), the hottest month in the State is April, with average high and low temperatures of 38.2°C and 23.6°C, respectively, while the coolest month is December, with average high and low temperatures of 31.1°C and 13°C, respectively.

Reconnaissance survey

A reconnaissance survey was conducted by the researchers in order to be acquainted with the area of study. During the survey, the characteristics of elements of climate (temperature and rainfall) were observed and discussion with respondents was conducted. Based on the researcher's observation and interview with people in the Infectious Disease Hospital Kano, there are linkages between climate and the outbreak of measles disease.

Types of data used in the study

The types of data used in this study include the socio-demographic characteristics of the respondents, their knowledge of the incidence of temperature, rainfall, and humidity in the area, and the linkages between rainfall and temperature variability in the measles outbreak in Kano State. Measles cases surveillance data, which contain the number of people treated for ten years (2013 to 2023) and mean annual values of temperature and rainfall data for the same period, were used to compare with the findings from public perception.

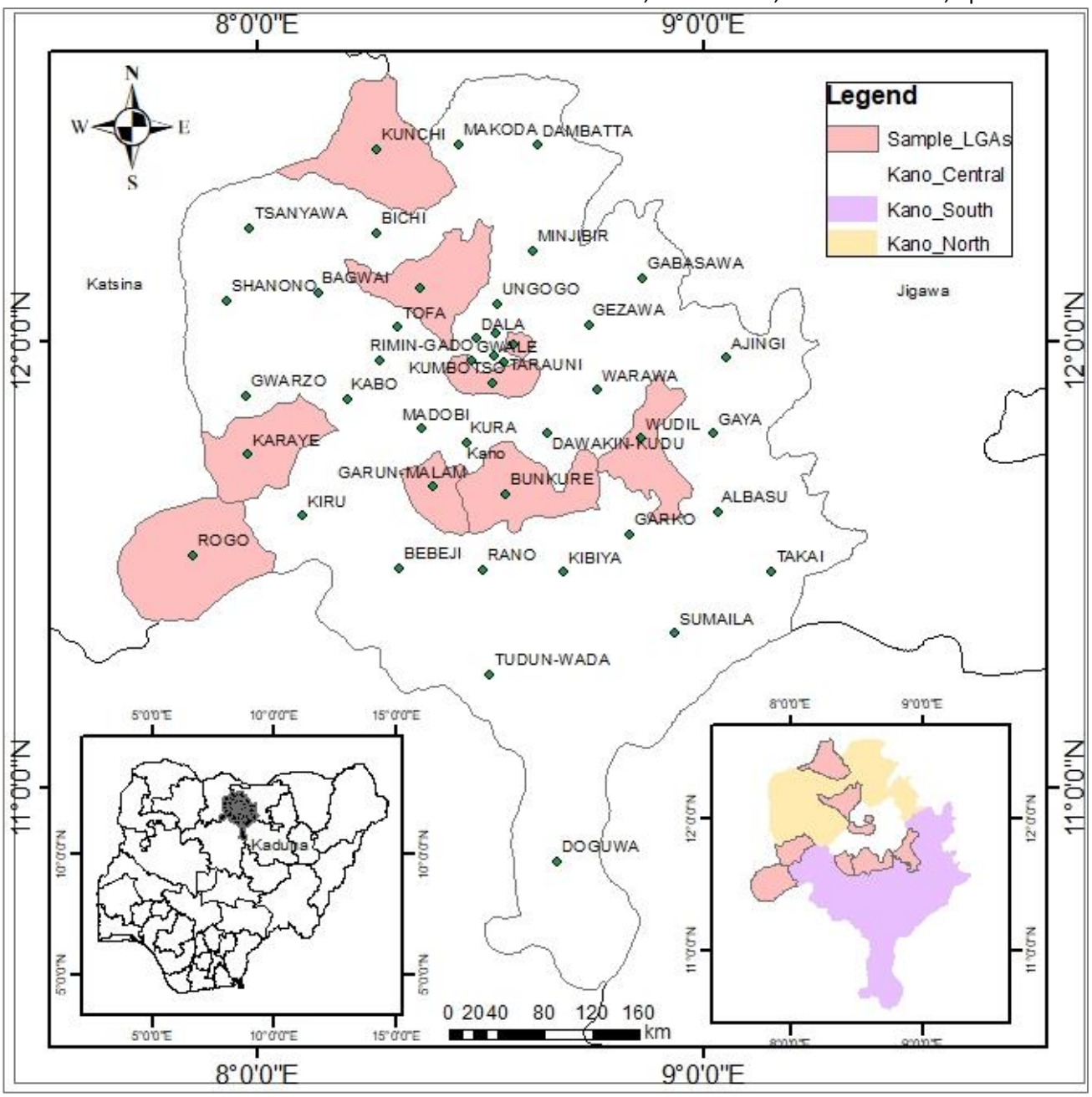

Figure 1: Study Area Map
Source: Kano State Ministry of Land and Physical Planning

Source and Techniques of Data Collection

Data from respondents was sourced using a structured questionnaire and interview. Measles case surveillance data was obtained from the Kano State Ministry of Health after a written application together with a proposal of the study for ethical approval. While mean annual values of temperature and rainfall data were downloaded from the Climatic Research Unit of the University of East Anglia (CRUv3.4, 0.5° resolution) archive.

Questionnaire: The questionnaire had both open and closed-ended questions. Some of the questions were answered on a Likert scale in a range of 1 to 5, such as 5 - strongly agree, 4 - agree, 3 – uncertain, 2 – disagree, and 1 – strongly disagree. The questions generally allowed respondents to indicate the extent to which climate variability could lead to a heavy burden of measles.

Validity of the Questionnaire Instrument

The study employed content validity to assess the validity of the design questionnaire. The design questions were sent to 9 experts (3 each in the field of climatology, environmental health, and Disease Surveillance and Notification Officers (DSNO). After returning from the experts' assessment, the validity of the essential questions was then calculated using Lawshe's (1975) method as presented in Equation 1

$$CVR = \frac{ne - (N/2)}{N/2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 1}$$

Where:

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

Finally, CVR values 0.84 (84%) indicate that the research instrument has been valid to be used for the research.

Sample size and Sampling technique

Kano State, according to NPC (1991), has a total population of 5,810,470 people. This data was projected to the 2023 population figure using Newman's (2001) method of population projection as given in equation 2:

$Pn = P_0 + (\frac{1+R}{100} X P_0)n$ ..... Equation 2

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 (31 years)

Hence, as of 2023, the population of the study area stood at 12,504,131 Krejcie and Morgan's (1970) technique stated that, where a population ranges between 10 000, 000 and 100, 000, 000, the sample size to use is 784 at 95% confidence level and 3.5% Margin of error was adopted. Therefore, the sample size of 784 was used.

For the investigation, a multi-stage sampling technique was modified. This sampling method involves grouping the population into smaller groups or clusters and is a sophisticated variation of cluster sampling. Next, a cluster or clusters are selected at random, and a sample of each selected cluster can be taken. Senatorial zones were used to group Local Government Areas (LGAs) in this study. In order to determine the sample distribution, nine LGAs, making 20% of the State's 44 LGAs, were chosen as samples in the first phase. In the second phase, eighteen (20%) out of the total number of wards in the sampled LGAs were chosen. 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 population in each ward were selected as used by Yalwa (2014). The number of respondents per award is presented in Table 1.

Questionnaire Administration

The researchers applied random and systematic sampling techniques to administer questionnaires to the sample of individual households. In this method the first house was picked randomly to determine the starting point, and others were then picked at regular intervals of twenty houses until the numbers of households required were exhausted. This gave every relevant household the probability of being picked. In order to ensure the quality of data collection. The major researcher and other co-researchers were involved during questionnaire administration. In a situation where the respondent does not understand the language of the question, the researcher translates the questions into appropriate language during administration. In every household, the consent of the husband or wife was demanded by the help of the village head to answer the questions.

Interview: An interview was also conducted to solicit information from 2 experts in the field of climatology (a lecturer from Bayero Universities, Kano and Sa'adatu Rimi College of Education), 1 environmental health officer from Kano State Ministry of Environment, and 2 DSNO from Kano State Ministry of Health. The interviews were conducted at their various places of work.

Table 1: Sampled Wards and Number of Respondents in the Study Area

Senatorial Zones	Selected LGAs	Sampled Wards	1991 Population	2020 Pop. Projection	Number of Respondents
Kano North	Dawakin Tofa	Dawaki west	16, 235	33,184	62
		Marke	4,521	9,249	17
	Kunchi	Kunchi	7,427	15,181	28
		Shuwaki	2707	5,533	10
Kano Central	Garun malam	Garun malam	10,142	20,730	39
		Yalwan yada	3,217	6,576	12
	Kumbotso	Chiranchi	19,614	39,385	74
		Challawa	4,261	8,709	16
	Nassarawa	Gama	40,147	82,061	153
		Kaura goje	15,317	31,308	59
Kano South	Bunkure	Bunkure	13,285	27,155	51
		Gafan	2,847	5,819	11
	Karaye	Karaye	9,617	19,657	37
		Turawa	2,728	5,576	10
	Rogo	Sabon Gari	16,085	32,878	61
		Gwangwan	4,162	8,507	16
	Wudil	Wudil	29, 969	61,257	114
		Kausani	3,518	7,191	14
Total			**205,799**	**419,956**	**784**

Data Analysis

Microsoft Excel was used for the analysis. The questionnaire responses were imported into the proper table rows and columns. Descriptive statistics (percentage) were used for the analysis, and results were displayed using charts as used by the WHO Regional Office for Europe (WHO, 2018). Conversely, following coding and interpretation, interview responses were analyzed using a theme framework.

The values of the measles, temperature, and rainfall were group into three seasons based on the classification made in Olofin (2008) as presented in Table 2. For each season, total and mean values were generated. Regression analysis was finally performed on the categorical data to test the null hypothesis, and results were presented using tables.

Table 2: Classification of Season in Kano State

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

Source: Adopted from Olofin (2008)

H_o: There is no significant relationship between temperature and rainfall variability with measles occurrence in Kano State.

RESULTS AND DISCUSSION

Respondents' perception on the incidence of climatic elements in the study area

Temperature and other climatic parameters that lead to climate variability are some of the factors that define an individual's susceptibility to disease and the overall State of public health. It is crucial to comprehend how people view the frequency of various climatic factors, particularly temperature and rainfall, in their local places. The percentage of respondents who felt that temperature, humidity, and rainfall varied frequently in the research area is shown in Figure 2. The results showed that the vast majority (75.7%) of respondents thought that the temperature had increased from previous years, followed by 13.1% who didn't know about temperature variability, and a very small (11.2%) percentage thought that the study area's temperature had been declining. This demonstrated unequivocally that Kano State residents were aware of the temperature's rising temporal pattern. The results of this study corroborated those of Addisu et al. (2015), who studied the mean, maximum, and lowest temperatures in the study region and found that there was a general increasing tendency; on the other hand, yearly rainfall showed a general decreasing trend. The research was conducted in the Ethiopian Lake Tana Sub-basin.

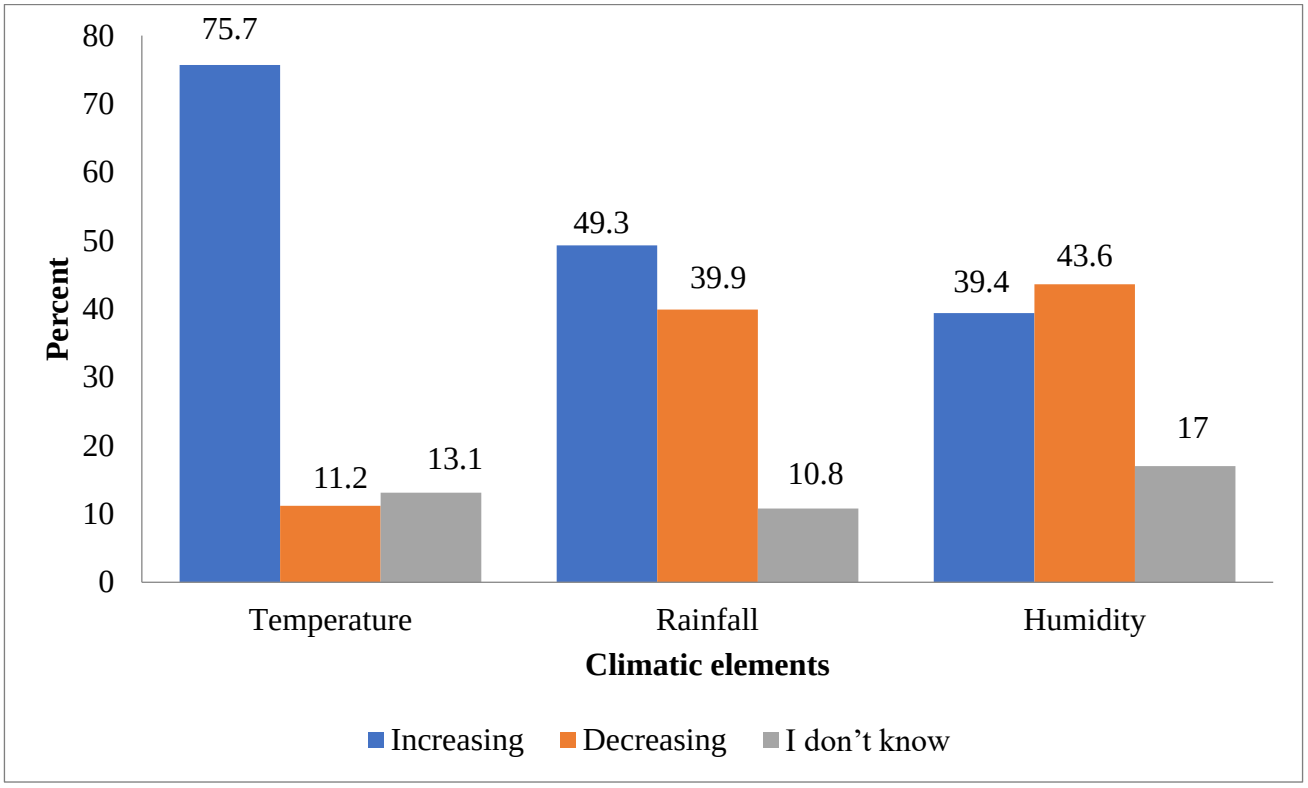

Figure 2: Respondents' Perception of the Incidence of Climatic Variables
Source: Author's Fieldwork, 2023

The results also lined up with those of Panda and Sahu (2019) in the Indian districts of Kalahandi, Bolangir, and Koraput in Odisha. They demonstrated that while rainfall showed a fairly good increasing trend during the Southwest monsoon, June, July, August, and September (JJAS) season, annual maximum and minimum temperatures showed an increasing trend and monsoon maximum and minimum temperatures showed a

decreasing trend. Similarly, the result is in line with the responses gathered from the key informant interview as captured and reported thus:

> *The Kano State metropolitan region has experienced an increase in temperature over the previous years, making it difficult to sleep even outside during the hot season. This is ascribed to the city's growing population, industrial activity, and an abundance of transit options* (DSNO, 1).

A similar response was also obtained from respondents from climatologists as:

> *Temperatures in Kano State have increased over the past few years, and urban heat island issues are growing more prevalent in the city while drought is occurring in the eastern part of the State* (C, 1).

Consequently, taking into account the conclusions of other experts, rainfall is a significant climatic component in addition to temperature. One of the main meteorological variables influencing public health is rainfall. Public health is typically impacted to some extent by rainfall levels. Flooding during periods of heavy rainfall causes buildings and bridges to collapse, which results in the loss of life as well as the spread of water-borne illnesses like cholera. Therefore, a study of this kind must find out how the subject area's residents see the frequency of rainfall. Thus, Figure 2 demonstrated that the majority of respondents (49.3%), of whom 35.2% were from Kano South and 14.1% from Kano Central, felt that the pattern of rainfall in the research region was rising. The bulk of those who felt that the amount of rainfall in the study area had decreased were from Kano North, accounting for 39.9% of the respondents. The remaining 10.8% said they were unaware of the rainfall pattern in the study area. This suggested that residents of the study area are aware of the trend of rainfall in the region and that most of them believe it has been steadily rising. This agrees with the study of Abaje et al. (2018) in Northern Nigeria, which showed that in recent years' rainfall patterns in the region have been on the increase.

The outcome also agrees with that of Addisu et al. (2015), who observed that yearly rainfall in Ethiopia's Lake Tana Sub-basin revealed a general declining tendency. The majority (79.4%) of key informants in the questionnaire analysis agreed with the questionnaire's results that Kano State's rainfall patterns had been rising recently. However, over 20.6% of respondents claimed that the pattern of rainfall fluctuates, meaning that, as compared to prior years, it occasionally exhibits a rising and decreasing pattern. Reports from some key informants interviewed showed thus:

> *In Kano State, the rainy season typically begins in late May or early June and ends in October, with August marking the heaviest month. It typically exhibits a cyclical pattern, with some years seeing very high rainfall and others seeing very low rainfall. Though geographically, certain places receive more rainfall than others, the State has recently seen a high pattern of rainfall overall* (C, 2).

According to one of the respondents from environmental health:

> *Rainfall in Kano State has been showing a decreasing pattern both in space and time"* (EHO, 1).

When asked about the temporal pattern of humidity in the study area, respondents again gave different answers. Of them, the majority (43.6%) thought it was decreasing, followed by 39.4% who thought it was increasing, and 17% said they were unsure. These results suggested that the research area's respondents thought the relative humidity had fluctuated. This outcome is consistent with key informant interviews, where most participants believed that Kano State's relative humidity varied by region. This result is in line with that of Agada et al. (2018), who stated that relative humidity in Kano State has been fluctuating since 1978, whereby in 2005 it was 60.1%, but it decreased in 2008 to about 43.5%. One of the key informants stated that:

> *The temperature and dew point of a certain location actually affect the relative humidity in Kano State, which is why the eastern portion of the State recorded higher humidity than the southern part* (C, 1).

Respondents' perception on the impact of temperature and rainfall variability on the outbreak of measles in the study area

Respondents' perception on the statement that increases in temperature result to higher outbreaks of measles in the study area is presented in Figure 3.

According to Figure 3, 29.6% and 33.6% of the respondents agreed and strongly agreed with the statement, respectively, whereas 9.8% and 4.2% disagreed and strongly disagreed with it, and 22.8% were unsure. These findings demonstrated that most respondents believed that an increase in temperature causes an increase in measles cases in the study location. The fact that measles is a common illness among youngsters and that the majority of them spend more time indoors than outside could be the cause of this outcome. Therefore, when the temperature rises, particularly in the hot and dry season, indoor conditions can get so bad that kids who spend a lot of time indoors will be severely impacted. Those who disagreed and were unsure about the remark, however, might have been influenced by the knowledge that measles often strikes during two extremely hot and dry seasons. This result is consistent with the findings of Yang et al. (2014) in China, who reported that the incidence of measles is correlated with rising temperatures and is greatly impacted by cold climates. This finding is also consistent with that of Qiongying et al. (2014), who found that weather-related factors, such as temperature variations before and after a cold spell, can affect the measles outbreak.

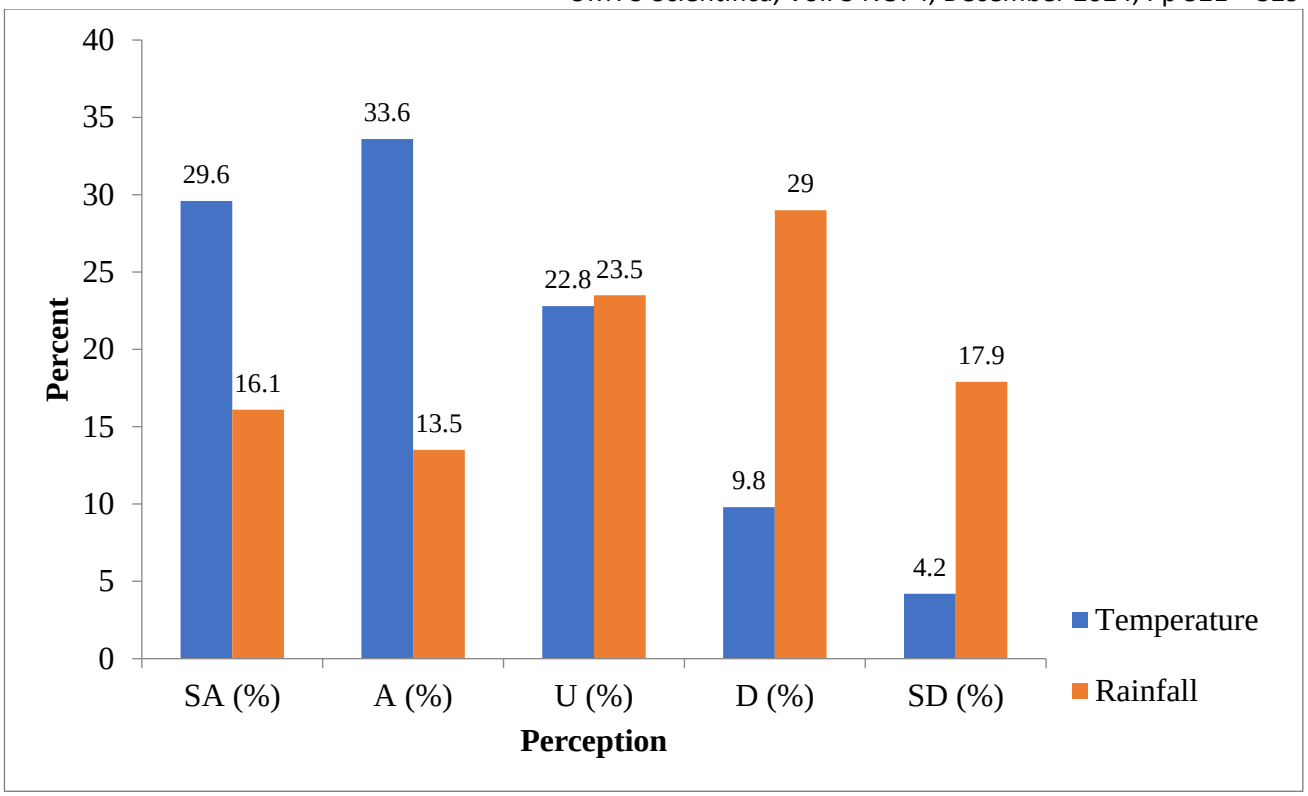

Figure 3: Linkages between Temperature and Rainfall with Outbreak of Measles
SA = Strongly agreed, A = Agreed, U = Undecided, D = Disagreed and SD = Strongly disagreed
Source: Author's Fieldwork, 2023

Additionally, Figure 3 demonstrated that 16.1% and 13.5% of respondents agreed, respectively, strongly agreeing with the statement that increased rainfall promotes the spread of the measles, while 29% and 17.9% disagreed, respectively, and 23.5% were unsure about the statement. This showed that the majority of respondents in the research area did not agree with the claim that the frequency of measles cases increases as precipitation intensity increases. The findings of this study are in line with the research conducted by Waitsa et al. (2018) that reported temperature and precipitation appear to be the most influential climatic factors in infectious disease transmission including measles. The finding is also in conformity with that of Kamruzzaman et al. (2015) in Bangladesh, who reported that the incidence of measles has been positively related to maximum temperature and negatively related to average minimum temperature and total annual rainfall. This result is also supported by the responses of some key informants who said:

> *We do see a spike in measles cases during the hot, dry season, so when this time of year draws near, we always take extra precautions and prepare to field complaints about measles outbreaks. However, there are extremely few documented cases of the disease during the rainy season* (DSNO, 2).

Another respondent stated thus:

> *Measles disease is season dependent it mainly occurred during hot/dry season among children under the age of five years* (DSNO, 1).

Respondent from environmental health reported that:

> *Measles is a deadly disease among children below the age of five years and mainly occurred during hot/dry season* (EHO, 1).

Climatology stated thus:

> *In relation to the temperature, individuals may contract the measles if, for example, the temperature rises and there is no other way to cool the area or if there is traffic* (C, 1).

The results of the regression analysis between climate parameters (temperature and rainfall) with the measles in presented in Table 3. The confidence level of the statistics has been 95%.

Table 3: Regression Analysis

Parameters	Hot/dry	Warm/wet	Cold/dry
Temperature			
Coefficient	-25.33	9.05	95.87
T-stat	0.41	0.56	0.97
P values	0.69	0.58	0.34
Rainfall			
Coefficient	0.95	0.12	15.09
T-stat	0.74	0.73	0.53
P values	0.46	0.47	0.53
	0.21	0.77	0.59
R^2	**0.075**	**0.013**	**0.03**

The results as a whole showed P – value is greater than 0.05 for all seasons, and the results of t-statistics recorded

higher values, these results, therefore, implied that there is no statistically significant deviation from the null hypothesis. This means that there is a difference between the occurrence of the diseases and the variability of the climatic parameters. In essence, the results indicated that the hypothesis cannot completely be rejected. This can further be explained by the R^2 values, which indicated that temperature and rainfall have an effect on the outbreak of measles at lower degrees. As can be seen in Table 3, the effect has been more during hot/dry (0.075) this was followed by cold/dry with 0.03. However, it was just around 0.013 during warm/wet. The results generally indicated that other factors may account for more than 90% influence on the occurrence of measles than temperature and rainfall variability in the study area. The results of this study on the linkage between rainfall and measles support that of Akinbobola and Hamisu (2018), who reported rainfall (P = 0.83) to have a lower effect on the outbreak of measles in the Kano metropolis. However, this is not in line with their findings in relation to temperature, which indicated a high correlation with p-values of 0.004 and 0.04 for maximum and minimum temperature, respectively. This variation might be linked to the fact that their findings covered only the Kano metropolis, where there is high concentration of people, while our study covered the entire State, including areas which are sparsely populated. Findings from regression analysis also support that of the public perception where both revealed that variation in climate parameters, especially rainfall, does not significantly increase the rate of measles in Kano State.

CONCLUSION

According to the survey's findings, the majority of respondents in the study area believed that while humidity had been declining, temperatures and rainfall had been rising. Results indicated that most respondents believed there was a relationship between the variables under investigation, including temperature, rainfall, and the measles outbreak. According to the study's findings, respondents believed that temperature had a positive correlation with measles outbreaks, whereas rainfall had a negative correlation. Findings from raw data also indicated a direct relationship between temperature and measles outbreaks in the research area. The general consensus was that there is a connection between the measles outbreak in the research area and the variability of climate characteristics.

DECLARATION

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

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