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Analysis of the Effect of Temperature on Age and Sex Incidence of Cerebro-Spinal Meningitis in Funtua Local Government Area, Katsina State, Nigeria

*Alemaka, J., Sawa, B.A., Yusuf, R.O., Balarabe, A., Aliyu, B.

Department of Geography and Environmental Management, Faculty of Physical Sciences, Ahmadu Bello University, Zaria, Nigeria

Corresponding Author's Email & Phone No.: alemakajohn@yahoo.com, +234-8025424603, +234-8071454224

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ABSTRACT

This study analysed the effect of temperature on the incidence of cerebro-spinal meningitis between males and females and among age groups in Funtua Local Government Area (LGA) of Katsina State, Nigeria. Funtua LGA falls within the meningitis belt where the climate is favorable for the incidence of the disease. All cases of meningitis reported to Funtua General Hospital from 1986-2015 were abstracted from patients files. For each year, sex and age specific incidences were estimated. Monthly and annual incidence of CSM occurrence in the study area for the 30 years period was subjected to time series analysis. Linear trend line equation was fitted in order to determine the direction of change in the incidence of CSM. The relationship between temperature and the incidence of meningitis was analysed using simple correlation. Null hypotheses were tested to see if there was significant difference in the incidence of CSM among age groups and between males and females. The tests were conducted at 95% confidence level and 0.05 margin of error. The monthly distribution of CSM cases (1986-2015) indicated April and March had the highest incidence cases (1606 and 1128 respectively) while the lowest cases were recorded in September and October with (1 case) each. The seasonal variation also showed that the highest incidence cases fell within the hot-dry season which mark the period with the highest average temperatures while the lowest incidence cases fell within the cold-wet season when humidity is high in the area. Annual trend of CSM indicated an increasing trend (approximately 60 persons) over the 30year period in the study area. There is a significant and positive relationship between mean monthly temperature and incidence of meningitis with an observed value of ($p < 0.05$ and $r = 0.592$). The observed correlation ($r = -0.141$, $p > 0.05$) indicated that there was negative and insignificant relationship between annual temperature and the incidence of meningitis in the study area. In conclusion, meningitis in the study area over the 30years under review has been a recurrent epidemic however; the rate of occurrence differs from year to year.

Keywords: Temperature, Cerebro spinal Meningitis, Sex and Age

There is an increasing need to assess the potential impact of climatic elements on meningitis. Therefore, many studies have been conducted on the influence of different meteorological variables on the transmission of air borne diseases like meningitis (Xue et al, 2017). Auwal et al (2014) inferred that future temperature increases due to climate change have the potential to significantly increase meningitis cases in both the early 2025-2035 and late 2060-2075. According to Hensen (2009), meningitis outbreak killed more than 156 people throughout Nigeria. Jigawa, Kano, Bauchi, Yobe, and Katsina states were among the worst hit. In many countries discrepancies have been observed to exist in age and sex specific incidences.

1.0 INTRODUCTION

A graver report from UNICEF (2017) stated that the death toll was about 562 with 99,085 cases. The World Health Organization reported that, Niger experienced no fewer than 573 deaths owing to the outbreak of meningitis between the months of January to June 2015. The Nigerien ministry of Public Health notified the World Health Organization that the infections were increasing rapidly with about 8,500 suspected cases of meningococcal meningitis in 2015. This is a rapidly growing outbreak with some unprecedented features (WHO 2015).

For instance, a study carried out in Tehran on the incidence of meningitis showed a sharp difference

in incidence ratios between the sexes according to age. The three to four fold increases in male cases aged 15 to 35 years presents a challenging issue in the epidemiology of meningitis in Iran (Alireza, 2009). Incidence of neonatal bacterial meningitis was reported as 1.3% in a district hospital in Kenya (Mwangwi et al 2002). In Nigeria it was reported to range from 1.6% in Ilesha (Ogunlesi et al 2005) western Nigeria to 6% in Kano northern Nigeria (Nuadioha et al, 2011).

In a study conducted by Nuadioha, Onwuezobe, Egesie, Kashibu, Nwokedi (2011) on pediatric patients aged 0-15 years between 2006 and 2009 in Aminu Kano Teaching

Hospital Kano, Nigeria, it deduced that Neonates are most at risk of acute bacterial meningitis. Most of the studies affirm that climatic variables such as temperature play a significant role in the incidence of meningitis and people of all ages are at risk of meningitis. However, most studies narrowed their studies on a specific age group with more emphasis on neonates and not its effect across all age groups. Exploring the age and sex incidence of meningitis across all age groups and sexes can help better explain the epidemiology of meningitis in the population.

2.0 THE STUDY AREA

The study area is Funtua,, Katsina State, Nigeria. It lies between latitude 11°19' 59" N and 11°42' 59" N, and longitudes 7°14' 59" E and 7°29' 59" E. Funtua is located in the extreme southern part of the state at about 197km from Katsina city (the state capital) and 72km from Zaria, Kaduna State. It is bordered to the south by Giwa LGA of Kaduna State, to the west by Dandume L.G.A, to the north by Faskari LGA, and to the east by Bakori and Danja LGAs of Katsina State. Funtua Local Government Area covers an area of about 448km². The study area is characterized by tropical continental climate (the Koppen's Aw climate, with two well pronounced seasons (wet and dry). However, the two seasons could be further subdivided (based on pronounced temperature variations) into: Warm-dry (*Rani* in Hausa language) from late February to early April; Warm-wet (*Bazare* in Hausa) from late April/ early May to late June; Cold-wet (*Damina* in Hausa) from July to late September/ early October; and Cold-dry (*Kaka/ Hunturu* in Hausa) lasting from mid November of one calendar year, mid-February of the next calendar year. The Vegetation of the

area is the Sudan Savanna type, which combines the characteristics of both Guinea and Sahel Savanna (Abaje, 2007) as cited in Abaje, Abdullahi and Jeje (2016).

The population of Funtua according to the 2006 Population and Housing Census (PHC) constituted 117,789 males and 107,367 female giving a total of 225,156. However according to the 2012 estimated census the population of Funtua was 420,110 (PHC, 2010).The inhabitants of the area are predominantly Hausa and Fulani, especially in the rural areas. However, the Urban Funtua is socially heterogeneous with the coming of various ethnic groups such as Yorubas, Igbos, Igalas, Nupe, and Kanuri etc as migrant traders, industrial and public employees. The Hausa and Fulani's are majorly Muslims. Culturally, the male is considered the house hold head that makes most of the decisions influencing the family. Thus decisions on disease management practices are taken by the male. Funtua town is the only urban settlement in the area, while several villages and Hamlets also exist in all directions (Lawal, 2009).

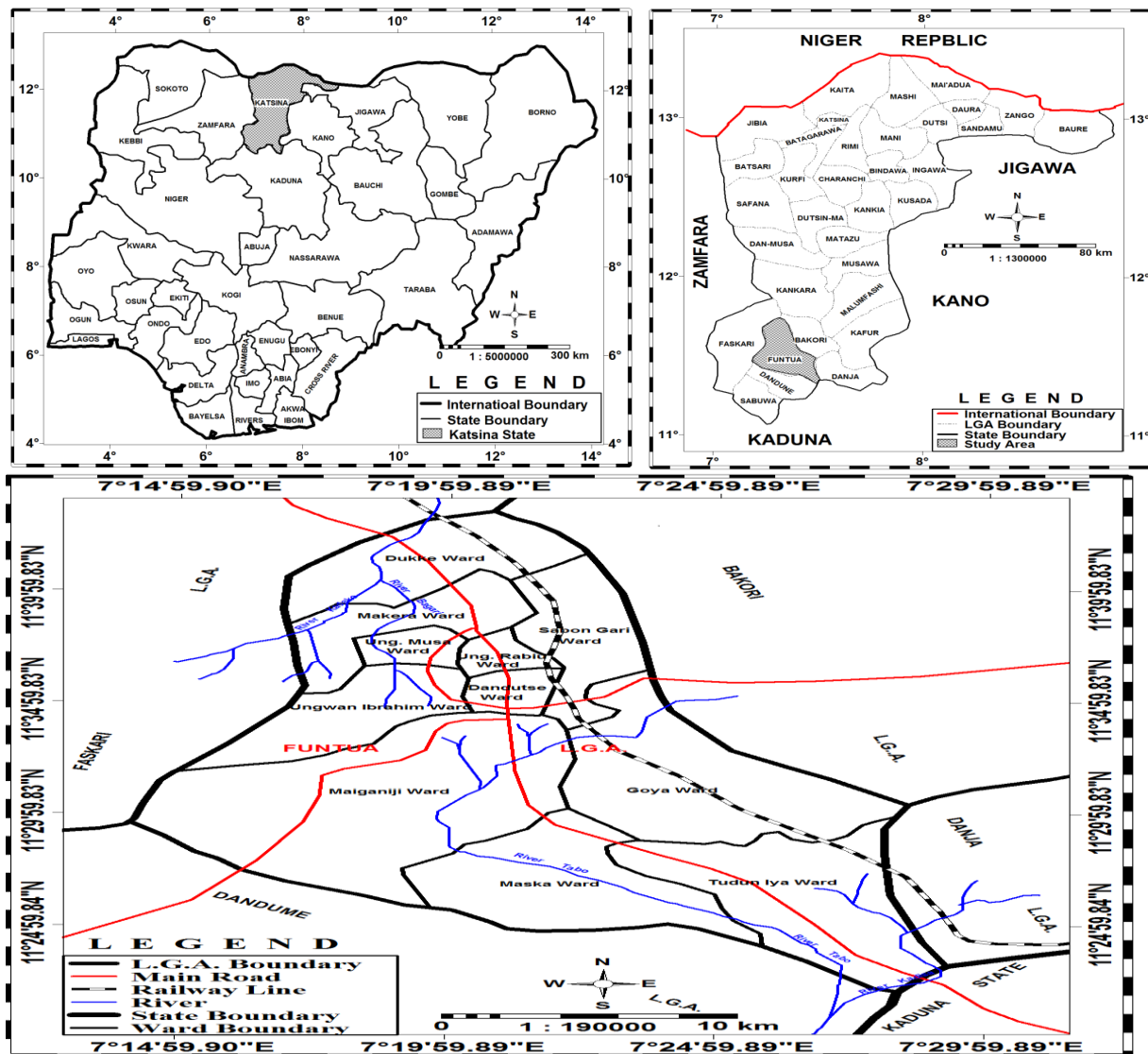


Fig. 1: The Study Area

Source: Modified from Administrative Map of Katsina State

3.0 MATERIALS AND METHODS

3.1 Primary Data

A set of structured questionnaire was used as the main instrument for data collection in this study. The questionnaire consisted of two sections (A and B). Each section had several questions designed to collect relevant information from the sampled respondents.

3.2 Secondary Data

Thirty years (1986-2015) hospital records containing the number of cases, age and sex of meningitis patients were sourced from the archive

of Funtua General Hospital (Sarkin Maska Shehu Hospital). The choice of this source is based on the fact that it is the largest and only hospital with records on meningitis. The hospital could only make available to the researcher records spanning from 1986 to 2015. Records beyond 2015 had not been filtered from the confidential files of patients and that is what informed the period under review. Thirty years (1986-2015) temperature records (maximum and minimum temperatures) for the study area, was sourced from the archive of Katsina state Agricultural and Rural Development Agency, meteorological unit (KATARDA Headquarters).

3.3. Sampling design

Funtua Local Government Area is made up of eleven (11) political wards. These are Makera, Dukke, Maska, Goya, Dandutse, Sabon-Gari, Unguar Ibrahim, Unguar Musa, Maigamji, Ungwar Rabiu/Nasarawa and Tudun Iya. Population census figures (1991) at both LGA and ward levels were obtained from the archive of Funtua LGA demographic unit. Based on the census figure, Funtua has a total population of 91,423 persons with an annual growth rate of 6.2%. The basis for using 1991 census figures instead of 2006 census is due to the fact that 2006 population census document has no population at ward level. The population figure was projected to 2015 using Newman's (2001) method of population projection given as:

$$P_n = P_o + (1 + R/100 \times P_o) \times n$$

Where: P_n = population in the recent year;

P_o = population in the base year;

R = annual growth rate and

n = number of intermediary years.

Therefore, using the above, the projected population of Funtua LGA in 2015, was 249,402 people

In order to determine the sample size for this study, Krejcie and Morgans (1970) calculated table was used for determining sample size.

3.4 Sampling technique in selecting the respondents.

A multi-stage sampling technique was used in the selection of respondents for this research. The first stage involved identifying the eleven wards. The wards were outlined in alphabetical order and every second (2nd) ward was systematically selected.

The second stage involved selection of settlements from each of the wards. This was also done by arranging all the settlements under each of the wards selected in an alphabetical order and every fourth settlement was selected which yielded a total of 12 settlements.

4.0 RESULT AND DISCUSSION

4.1 Temporal Incidence of Meningitis

The monthly distribution, seasonal variation and annual incidences of meningitis in the study area under the years being reviewed were analysed.

Figure 2 illustrates the monthly distribution of CSM cases within the years under review.

The third stage involves determining the number of respondents. To determine the proportion of respondents from each of the units of observation (ward), Yamane's (1967) method was used. This is given as:

$$Pr = \frac{n \times Q}{N}$$

Where: Pr = proportion of respondents;

n = population of each of the selected area;

Q = sample size = 383; and

N = total population of all the selected areas.

The last stage involves the selection of house hold heads from each of the selected settlements. This was done with the help of community heads (mai-unguwa), and other community volunteers who understand the people in their community that can provide credible and valid responses.

3.5 Methods of Data Analysis and Presentation

To determine the trend of occurrence of meningitis in the study area, the monthly and annual incidence of CSM in the study area for the 30years period was subjected to time series analysis. Linear trend line equation was fitted in order to determine the direction of change in incidence of CSM. The data were analyzed with the aid of Microsoft Excel 2013 tool and presented graphically. To determine the relationship between temperature and incidence of meningitis, simple correlation was applied to assess the relationship between the two variables. To test the hypothesis which states that there is no significant difference in the incidence of CSM among age groups; Kruskal-Wallis test in SPSS 23 tool at 95% confidence level and 0.05 margin of error was used. Also to test the hypothesis which states that there is no significant difference in the incidence of CSM between males and females, Mann-Whitney U test was used in the SPSS 23 tool. The test was conducted at 95% confidence level and 0.05 margin of error

The result shows that April has the highest recorded cases of CSM with (1606 cases). This coincides with the time of the year when temperatures are at the peak. The next, being the month of March with (1128 cases).

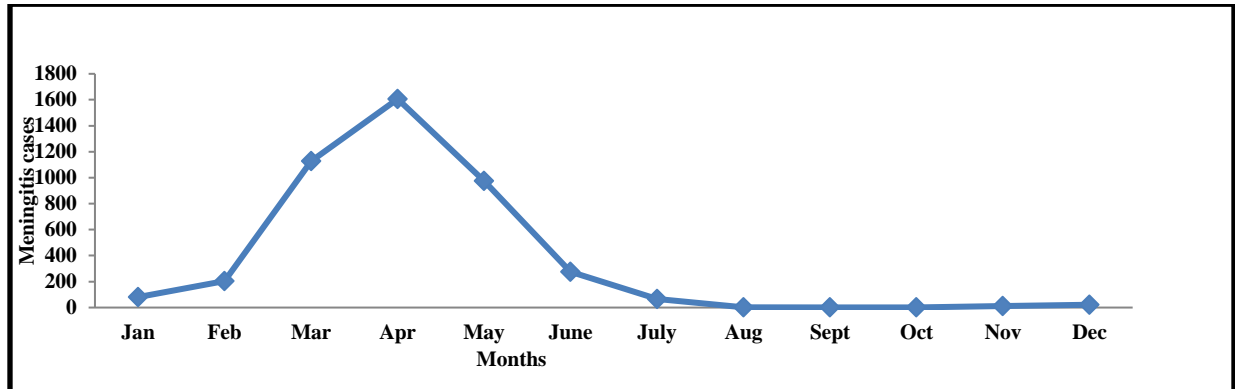


Figure 2: Monthly distribution of Meningitis Incidence

These months (April and March) are characterized by dryness, hotness, fatigue, and dehydration that increase susceptibility to CSM in the study area. The lowest cases were recorded in the months of September and October with (1 case) each. By November the cases begin to rise again.

4.2 Seasonal Variation of Meningitis

The result on Figure 2 shows the seasonal variation of CSM within the period under review in the study area. The study area is characterized by tropical continental climate (Koppens Aw climate), with two well pronounced seasons (wet and dry). The result reveals that most of the cases start rising from the Cold-Dry season (Nov-Jan) when the dry harmattan winds cause damage to the mucous membrane of the respiratory system, inhibits muscular immune system thereby facilitating

transfer of the bacterium to the meninges and thus create conditions that trigger the CSM epidemic (WHO, 2012), and attain their peaks in the Hot-dry season (March/ April) when temperatures are on the rise. There is however a sharp decline in incidence cases during the rainy season from 1606 in April to 975 in May down to just one case in the Cold-wet season (August- October) due to increase in humidity and lower temperatures. When the numbers of cases for each month in the thirty (30) years period were added, highest occurrence (1606) was recorded during the hot-dry season in the month of April which actually marks the month with the highest average temperature in the study area; while the lowest incidence cases were recorded during the Cold-wet season in the months of September and October when humidity is high in the study area.

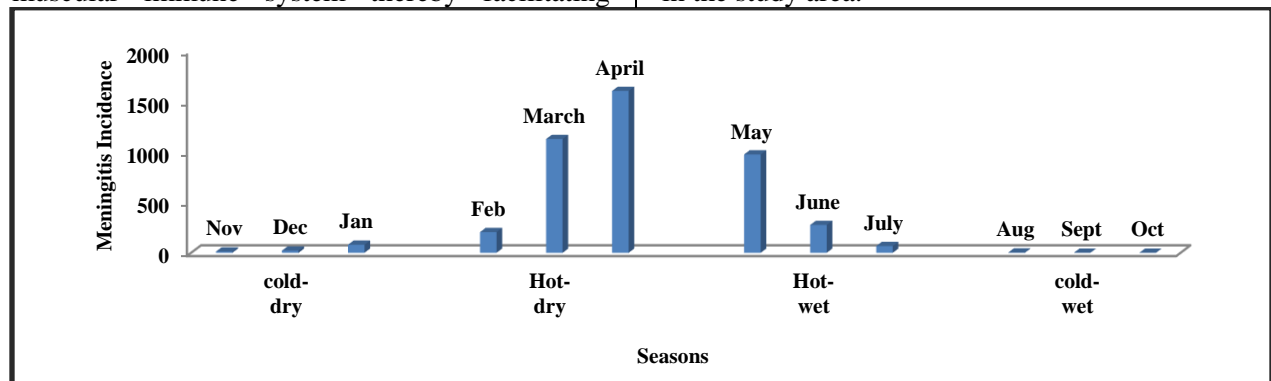


Figure 3: Seasonal variation of Meningitis incidence

4.3 Annual Trend of CSM Occurrence

The result in Figure 3 shows that the trend of CSM in the study area over the 30 years period under review has been a recurrent epidemic over the years

in Funtua. However, the rate of occurrence differs from year to year.

The result shows that there was no year in the 30 years under study that the disease was not

experienced either in its mild, moderate or severe form. In each of the years, the months from July to December were mild periods of meningitis incidence; January, February, May and June were moderate periods while April and March were periods of severe incidences of the disease.

Looking at the linear trend line in figure 3, it shows an increasing trend in the incidence of meningitis at the rate of approximately two (2) persons per annum over the 30-year period of study.

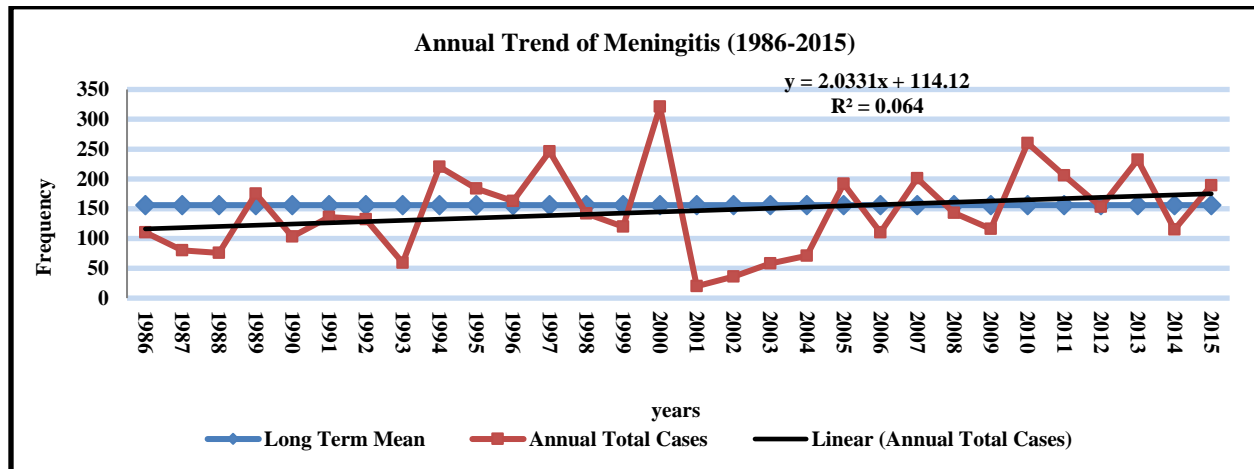


Figure 4: Annual Trend of CSM Incidence in Funtua LGA.

It also indicates that year 2000 has the highest incidence of 321 cases (7%); followed by year 2010 with 260 cases (6%) and 1997 with an incidence rate of 246 cases (5.2%). However, the year 2001 has the lowest incidence of the epidemic (20 cases). A closer examination of the trend shows that, a total positive change of approximately 60 persons were observed over the 30-year period under review. The linear trend indicates an increase in the incidence of meningitis in the study area.

4.4 Sex and Age specific Incidence of Meningitis

Incidence of meningitis among males and females Tables 1 and 2 present the descriptive statistics of CSM incidence among males and females and the significant difference between sex and incidence of meningitis.

Table 1 shows that females with 2,374 incidence rate have a slightly higher case of meningitis than males with 2,295 incidences, having a difference of 79 cases between them.

Table 1: CSM Incidence among Males and Females (1986-2015)

	M in	Max	Ran ge	Sum	Mean	S.D
Males	10	153	143	2295	76.50	35.399
Females	10	177	167	2374	79.13	37.311

miscarriage, premature delivery, and still birth. Females as care givers for meningitis victims are also more susceptible to contracting meningitis. These factors may serve as a reason for higher incidence cases among females in the study area.

This may be attributed to the fact that females are care givers both to babies and the sick. For instance the stool of babies can harbor a virus that can cause meningitis hence females who more often than not change the diapers have a higher risk of contracting the disease. Though it's rare, pregnant women can be at risk of developing meningitis associated with an infection called listeriosis in the last trimester. This puts the mother and child at risk of

The observed significant level of (0.888) in Table 2 is more than 0.05. This indicates that there is no statistical significant difference in the incidence of meningitis between males and female in Funtua LGA over the 30 year period (1986-2015). Thus the null hypothesis is accepted. This corresponds with the work of Walling *et al.* (1991) which also revealed there was no significant difference in the incidence of meningitis between males and females in the United States of America.

4.5 Incidence of Meningitis Among Age Group

The analysis on Table 3 is presented to show the minimum, maximum, range, mean and standard deviation. The result shows that the age group 10-14 years has the highest incidence of meningitis with a total number of 1,247 (26.8%) cases, a minimum number of 5 cases, maximum number of 104 cases, a mean value of 41.57 and a standard deviation of 25.738 for the 30 year period.

Table 3: Age Specific Incidence of CSM (1986-2015).

Age group	Mi n	Ma x	Rang e	Su m	Mea n	S.D
0-4	3	64	61	710	23.67	13.226
5-9	7	66	59	1038	34.60	15.406
10-14	5	104	99	1247	41.57	25.738
15-19	2	68	66	963	32.10	17.424

20& above 2 52 50 683 22.7 13.9997

Source: Authors Analysis

This is followed by the age group 5-9 years with a total number of 1,038 (22.3%) cases, a minimum number of 7 cases, maximum number of 66 cases, a mean value of 34.60 and a standard deviation of 15.406. These age groups (5-14years) appear to be the most vulnerable groups to the incidence of meningitis in the study area. This can be attributed to increased social interaction in the place of play and school in this age group. The meningococcal bacteria are passed from person to person by coughing, sneezing and intimate kissing. This means the bacteria can be passed more easily within this age group. This corresponds with the findings of Rabasa, Mohammed and Omotara (2003) in Borno state where children within the age group of 1 week to 14 years were admitted in the hospital due to an outbreak of meningitis with the highest incidence occurring between the ages 4-9 years. Table 4 presents the Kruskal Wallis test result indicating the significant difference in the incidence of meningitis among age groups.

Table 4. Significant Difference of CSM Incidence Among Age Groups

	Incidence of Meningitis
Chi-Square (Kruskal-Wallis H—Test)	18.103
Df	4
Asymp. Sig.	.001

a. Kruskal Wallis Test

b. Grouping Variable: Age Group

The observed level of significance (0.001) in Table 4.4 is less than 0.05. This means that there is a significant difference in the incidence of meningitis between the age groups in the study area. Thus the null hypothesis which states that “there is no significant difference in the incidence of meningitis among age groups” is rejected.

Table 5 gives the summary of birth registration of the age and sex population distribution in Funtua LGA as retrieved from rapidsms.org (2015).

According to the summary birth registration of Funtua LGA in table 4.5, obtained from rapidsms.org (2015), the age groups 5-9 years and 10-17years have a population of about 38,291 and, from the analysis are highly vulnerable to the incidence of meningitis.

Table 5 Summary of Birth Registration: Funtua LGA

Age group	Sex	Population	Sex	Population	Total
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economic surviva

Table 6 Relationship between Mean Monthly Temperature and Incidence of Meningitis

		30 years Meningitis Incidence	Temperature
Meningitis Incidence	Pearson Correlation	1	.592*
	Sig. (2-tailed)		.043
	N	12	12
Temperature	Pearson Correlation	.592*	1
	Sig. (2-tailed)	.043	
	N	12	12

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

< 1 year	Males	13,820	females	10,936	24,756
1-4 years	Males	15,621	Females	14,343	29,964
5-9 years	Males	11,016	Females	10,034	21,050
10-17 years	Males	9,606	Females	7,635	17,241

Source: rapidsms.org (2015)

These age groups are of great significance to households as they are the age groups that assist the family financially. The female children do so by engaging in hawking while the male children from ages 10-17 assist with farming activities particularly in the rural areas where farming is the major economic activity. If these vulnerable groups are not well protected from meningitis, it may have serious effect on house hold

4.6 Strength of Relationship Between Temperature and Incidence of Meningitis

4.6.1 Mean Monthly Temperature and Incidence of Meningitis (1986-2015)

The result of the test reveals that mean monthly temperature is a significant factor in the incidence of meningitis over the 30-year period. With $r = 0.593$ indicates that there is a positive and strong relationship between the two variables and with a p incidence of meningitis in the study area. This finding corroborates the work of Osuorah, et al (2015) in which it was observed that the mean monthly temperatures among other variables had more effect on CSM incidence in Navrongo, Ghana.

4.6.2 Mean Annual Temperature and Incidence of Meningitis

Table 7 shows the correlation between mean annual temperature and the incidence of meningitis. The

Table 6 give a clear picture of the strength of relationship between mean monthly temperature and incidence of meningitis in the study area.

(0.043) value which is < 0.05 it implies that the variables are significantly related. That means mean monthly temperature has a strong and strong relationship with the

observed correlation ($r = -0.141$) implies a negative and weak relationship between mean annual temperature and incidence of meningitis in the study area. With p (.456) value which is > 0.05 indicates that there is no significant relationship and relationship between annual temperature and the incidence of meningitis in the study area over the 30-year period. This is also further illustrated graphically in Figure 4.9, which shows that, as the temperature increases, the incidence of CSM decreases and vice versa over the study period.

Table 7: Relationship between Mean Annual Temperature and Meningitis

		Temperature	Incidence of meningitis
Temperature	Pearson Correlation	1	-.141
	Sig. (2-tailed)		.456
	N	30	30
Incidence of meningitis	Pearson Correlation	-.141	1
	Sig. (2-tailed)	.456	
	N	30	30

This implies that, mean annual temperature might not be the only controlling factor on the inter-annual incidence of CSM in the study area. Some other factors may include: immune receptivity of individuals, poor socio-economic levels, population density, social interactions such as pilgrimages, tribe migrations, housing design and construction. There is also the possibility of having some years with wetter, rainy season lasting longer than usual hence reducing the overall effect of three decades temperature on meningitis.

5.0 CONCLUSION

The annual trend analysis indicates that the incidence of meningitis is increasing in the study area in the year under review. The mean monthly temperatures play a significant role in the incidence of meningitis and there is marked seasonal variation with peak incidence cases occurring in the hot-dry months and sharp decline in incidence cases with the onset of the rainy season due to drop in temperature and increasing humidity. However, there was a weak relationship between mean annual temperature and the incidence of meningitis in the study area. This therefore implies that temperature cannot be taken as solely responsible for meningitis outbreak. Other factors may be working in association with temperature to enhance incidence cases in the study area. There is no significant difference in the incidence of meningitis between

males and females while there was significant difference in the incidence of meningitis between age groups. The result shows that the age group 10-14 years has the highest incidence of meningitis with a total number of 1,247 (26.8%) cases. This is followed by the age group 5-9 years with a total number of 1,038 (22.3%) cases.

6.0 RECOMENDATIONS

The following recommendations were made based on the findings of the research: Further research should be conducted to ascertain the effect of other climatic variables and environmental factors that influence meningitis incidence in the study area especially over a long period of time. The Katsina State Government and other stake holders such as the World Health Organization should focus on the vulnerable age group by taking precautionary measures to protect the vulnerable age groups that the research revealed have the highest incidence cases of meningitis in the study area. This is because the age bracket 5-14 years, play a significant role in contributing to the economic well being of the household. This will help to prevent an imbalance in the population structure of the state since meningitis is a killer disease and has the tendency of rendering its victims invalid if not arrested on time.

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REFERENCES

- Abaje, I.B. (2007). Introduction to Soils and Vegetation Kafanchan. *Personal Touch Productions Limited*, Kafanchan Kaduna, Nigeria Pp 97-108.

- Abaje, I.B., Abdullahi, N. and Jeje, O. G. (2016). Climate Change and Infectious Diseases in Funtua Local Government Area of Katsina State, Nigeria. *African Journal Online*, 5 (1). Pp.47-50. <http://dx.doi.org/10.4314/stech/v5i1.5>.
- Alireza, M. (2009). Temporal analysis of the Incidence of meningitis in the Tehran Metropolitan, 1999-2005. Published 2009; license BioMed Central Ltd. <http://creativecommons.org/licenses>.
- Auwal, F et al (2014). The impact of climate change on meningitis in Northwest Nigeria: An Assessment Using CMID Climate model Simulations. *AMS Journal* volume 6. Retrieved from journals.ametsoc.org at 3:25pm 24/11/2015.
- Dogara, M.D et al(2017). "The Trend in Temperature and Solar Irradiance for Zaria, North-West Nigeria 1986-2015," *Science World Journal*, Vol. 12, Issue 3.
- Hensen, L.S. (2009). Cerebro spinal Meningitis spreads in Nigeria. www.healthmap.org. Retrieved 3:13pm, 18th January 2016.
- Inobeme, J., Iguisi, E.O., Murtala, M. and Ati, O.f. (2009) An Evaluation of Environmental Factors on the Outbreak of Cerebro-Spinal Meningitis in Zaria. *Zaria Geography journal*. Vol. 21. No.1. Pp. 107-118.
- Nuadioha, S.I., Onwuezobe, I., Egesie, J.O., Kashibu, E., Nwokedi, E.O.P., (2011). Bacterial Isolates from Cerebrospinal Fluid of suspected Acute Meningitis in Nigerian Children. *International Infectious Diseases*. Vol 8. Pp. 2231-6019.
- Sultan, B.A., Labadi, k., Guegan, J.F., Janicot, S. (2005) Climate Drives the Meningitis Epidemics onset in West Africa. Retrieved from Journals.plos.org at 2:15pm on 02/10/2015
- UNICEF (2017): West Africa on Alert for Meningitis Epidemic. www.unicef.org. 7th Nov 2017
- WHO (2015). Rapidly Growing Outbreaks of Meningococcal Disease in Niger. retrieved from www.int/medicentre on 12-01-2016 at 12:34pm.
- World Health Organization (2012): Meningococcal Meningitis. Retrieved from www.who.int/medicenter/factsheet.
- Jandarove, R., Haran, M., and Ferrari, M. (2012). A Compartmental Model for Meningitis Separating Transmission from Climate Effect on Disease Incidence. *J.Agric.Biol.Enviro.Stat.*, 17, 395-416
- Lawal, I.M. (2009). Funtua A History of Maska and Funtua Districts. Kano, Alfikra Publication Ventures. Nigeria Limited. Osuorah, D et al. (2015). Outbreak of serotype W135 Neisseria Meningitidis in Central River Region of the Gambia between February and June 2012. *A Hospital based review of Pediatric cases. Niger j Clin Pract*; 18: 41-70
- Population and Housing Census (2010). Priority table volume III. Retrieved from www.population.gov.ng.
- Krejcie, R.V. and Morgan, D.W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurements*. 30 Pp 607-610.
- Mwangi, I., Berkley J., Lowe, B., Peshu N., Marsh, K and Newton, C.R (2002). Acute Bacterial Meningitis in Children Admitted to a Rural Kenyan Hospital: Increasing Antibiotic Resistance and Outcome. *Pediatric Infectious Disease Journal*, 21. Pp. 1042-1048
- Newman, J.F. (2001). Population Projection for Research and Development. Retrieved from <http://www.educationforallindia.com/New%20population-projection.pdf>. On 04/02/2018.
- Xue.B. and Bingxue.H. (2017). Effects of Meteorological Factors on the Incidence of Meningococcal Meningitis. *African Health Sciences*. Vol 17 (3). Pp. 820-826.
- Yamane, T. (1967). "Statistics". An Introductory Analysis. 2nd Edition, New York: Harper and Row.