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Prevalence and Factors Influencing Cerebro-Spinal Meningitis, in Kano Metropolis, Nigeria

[*1] Mohammad Laraba Ahmed, [2] Umar, Nura Khalil, [3] Zakaria, Aliyu and [4] Yusuf, R.O.

[*1 and 3] Centre for Disaster Risk and Developmental Studies
Ahmadu Bello University Zaria

[2] Department of Geography,
University of Maiduguri, Borno Nigeria

[4] Department of Geography and Environmental Management,
Ahmadu Bello University Zaria

Email: larabamohammad@gmail.com

Abstract
Meningococcal disease is a contagious disease caused by the meningococcus (Neisseria meningitidis), a Gram-negative bacterium. Today epidemic meningococcal meningitis is a major public health problem affecting tropical countries, particularly in sub-Saharan Africa, it causes considerable morbidity and mortality. Frequent epidemics and control measures have met with limited success. This study analyzes the incidence, and influencing factors of meningitis in Kano metropolis, Nigeria. The study made use of both primary and secondary data. Primary data was collected using questionnaire while secondary data was obtained from hospital records. The study adopted systematic sampling to select four Local Government Areas. Purposive sampling technique was employed to select houses for the administration of 384 copies of questionnaire. Data was analyzed using both descriptive and inferential statistics as well as GIS-mapping such as: line graph, percentages, kernel density estimation and regression. The result showed that out of the 8724 cases of meningitis recorded from 2008 – 2017, LGA recorded the highest incidences (37.3%), where population is high and estimated density shows very high cluster. Also, incidence of meningitis, though with fluctuating pattern, appeared to be increasing from 2014 to 2017. Factors like overcrowding of people sleeping in the same room (0.0674) and increase in temperature (0.0641) were the most significant factors of meningitis in the study area. Awareness should be made on the need for a ventilated housing especially during the high temperature season (March to April) in the area.

Keywords: Meningitis, Prevalence

INTRODUCTION
Bacterial meningitis is among the 10 top causes of death worldwide. It has a case fatality rate (CFR) of 90% to 100% if un-treated. Its global burden was estimated to 5 million of new cases and 290,000 deaths globally in 2019 (GBD Results Tool, 2019), mainly due to three major bacteria: *Neisseria meningitidis* (Nm), *Streptococcus pneumoniae* (Sp) and *Haemophilus influenzae*

*Author for Correspondence

type b (Hib) (WHO, 1998 in Mazamay *et al.,* 2020). Twelve sero-groups of Nm have been identified, of which six (sero-group A, B, C, X, Y and W135) have been implicated for about 90% of bacterial meningitis in Africa. Predominantly the Nm sero-group C, commonly designated as cerebrospinal meningitis (CSM), remains a major public health challenge mainly in the semi-arid areas of sub-Saharan African region (stretching from Senegal to Ethiopia), called the meningitis belt (Agier *et al.,* 2017; Mazamay *et al.,* 2020). CSM is an airborne infectious disease spread by droplet (saliva) and throat secretion from infected persons (Sultan *et al.,* 2005 in Zakari *et al.,* 2018): It begins with host acquisition of bacterium by nasopharyngeal colonization through large respiratory droplet and spread from person to person (Kamal 2009 in Zakari *et al.,* 2018).

Repeated large scale epidemics have been reported in the 21st Century, about 200 years after the disease was first reported in Geneva, Switzerland. Mortality from the disease remains high, despite major achievement in the treatment modalities. It was reported that about 10% of patients who had the disease will not survive despite effective treatment (Peter & Mercel, 2005). Sero-groups B, C, Y, and W-135 are responsible for most of invasive disease in America and other developed countries.

In Nigeria, CSM is relatively a common disease in Northern part and notable in Kano State. It is called *ciwon sankarau* in Hausa Language which literally means stiff neck. Outbreak in the country was observed in December 2016, as at April, 2017, of the 9,646 suspected cases reported, 277 (2.9%) were confirmed, and 839 deaths (8.7%) recorded. About 43 Local Government Areas (LGAs) were reported to have reached alert/epidemic threshold in seven states and Kano inclusive (Nigeria Centre for Disease Control [NCDC], 2017). In Kano state, the general spatial pattern was influenced by the number of cases in a particular year. Thus, diffusion originates with less number of cases from Northeast or North as observed between 2010 and 2017, and from Southwest or South when cases are much (Zakari *et al.,* 2018). However, the Kano Metropolis with its unique urban sprawl and density (about 1000/km^2) which are some of the predisposing factors for CSM, seems to be in the face of death/disability of children and young adults from CSM (Umaru, *et al.,* 2014).

Many retrospective studies of meningitis examined the antibacterial sensitivity pattern, and seasonal variation of community acquired acute bacterial meningitis in Africa. Laboratory results seems to expose the resistivity of particularly Nm to most antibiotics including the popularly co-trimoxazole among gram-negative bacteria (Tegene *et al.,* 2015; Obaro, & Habib, 2016; Cooper *et al.,* 2019; Effah *et al.*, 2020 etc.). A better understanding of the mechanisms and factors (environmental, demographic and socio-economic parameters) of meningitis epidemics which intervene behind CSM within the metropolitan Kano, along with appropriate geographic information system (GIS) models (like Kernal Density Estimation-KDE) is therefore needed. This would help identify hotspot-zones and optimize distribution of resources. The use of GIS in epidemiological studies may help in better understanding of pattern, trends hotspots and prediction over space and time. Richard (2013) uses cluster analysis in GIS using climate variables and CSM cases where he predicted that not all areas with same climatic condition have same CSM, while Zakari *et al.,* (2018) used IDW and linear trend surface analysis to show the premise of understanding and predicting the diffusion pattern of CSM in Kano State. The use of KDE to delineate hotspots is seen in Jayakumar and Malarvannan (2013), the study mapped spatial distribution and density of cholera in Chennai India. Also Giwa *et al.,* (2018) mapped poliomyelitis hotspot in Kaduna Nigeria using KDE.

There seems to be cases of meningitis that have been reported and recorded for quite a period of time and considering the increase in the outbreak of the disease in other neighboring LGAs of Kano state, it is therefore necessary to examine the situation in the city core where previous studies have not yet covered. This is in order to have a clear picture of the disease prevalence in recent time and densities (clusters). The aim of this study is to analyze the incidence of meningitis (2008-2017), density and risk factors in Kano Metropolis, Nigeria

METHODOLOGY

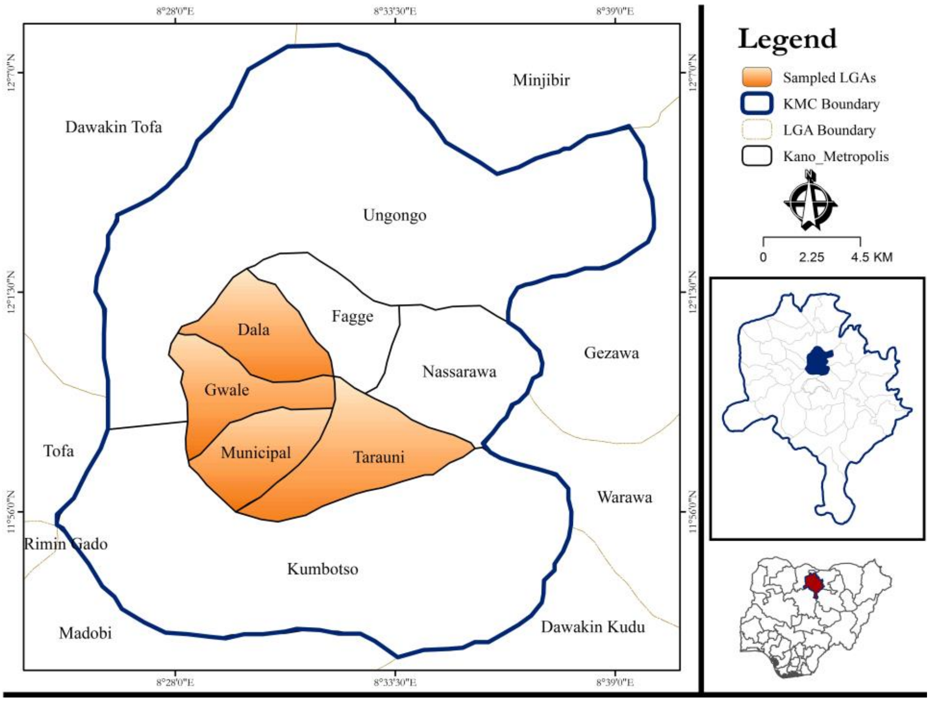

Fig. 1: The Study Area
Source: Adapted from Administrative and Topographic Maps

Study Area

Metropolitan Kano lies between Latitudes 11^0 52′N to 12^0 7′N and Longitudes 8^0 22.5`E to 8^0 47′E and is 472.14 meters above sea level. It comprises of eight LGAs of Dala, Fagge, Gwale, Municipal, Nassarawa, Tarauni, part of Kumbotso and Ungogo. This is in addition to part of Local Government areas which were integrated in to Kano Metropolis for planning purposes (Fig. 1). The climate of the area is tropical dry-and-wet. Annual rainfall is about 850-750mm. The temperature is averagely warm to hot throughout the year at about 27 ºC± 7 ºC (Brandow *et al.*, 2014). The terrain is basically a plain and part of what Olofin and Tanko (2002) described as the High plains of Hausa land. The elevation of this plain is about 430 – 450 meters above mean sea level. For the immediate locality the plain descends from Gwauron Dutse to the channel of Watari River with only one perceptible river terraces. The channel of Watari River is estimated at about 425 meters above mean sea level (Olofin & Tanko, 2002). The activities in Kano state reflect mainly the commercial activities although other activities such as, administrative, industrial, transport and professional services are also available to serve the needs of the state (Umar, 2016). There were about 210 primary, over 15 secondary and tertiary healthcare facilities. Aminu Kano teaching Hospital, Murtala Mohammed Specialist Hospital, Ideal Hospital and Women and Children Specialist Hospital are some of the few (Kano State Ministry of Health, 2017). According to 2006 census, population Kano state was 9,383,683 while that of Kano metropolis was 2,165,223 (NPC, 2009). The figure using equation 1 was projected to 3,113,118 by 2020.

Sources of Data

For this study, primary data (socio-demographic data and factors influencing meningitis) were sourced via questionnaire. Secondary data were obtained from record office (CSM incidences of meningitis) of the Kano State Ministry of Health. Also administrative map of Kano State from the Ministry of Land and Physical Planning was obtained. Other materials were gotten from related books, journals, published and unpublished articles.

Sample Size

The sampling frame for this study are residents of Kano Metropolis. The study adopted systematic sampling to select four (Dala, Gwale, Municipal and Tarauni) LGAs.

Table 1: Sampled Local Government Areas

S/N	LGAs	Population of LGA	Population of selected LGA	Number of questionnaires	Percentage (%)
1	***Dala**	**492,590**	492,590	117	30.4
2	Fagge	233,869			
3	***Gwale**	**421,562**	421,562	100	26.0
4	Kumbotso	342,333			
5	***Municipal**	**444,136**	444,136	105	27.4
6	Nasarawa	488,338			
7	***Tarauni**	**261,100**	261,100	62	16.2
8	Ungoggo	429,190			
Total		**3,113,118**	**1,619,388**	**384**	**100%**

Source: Author's compilation, 2021.
***Selected LGAs**

Cochran's (1999) provides a simplified formula to calculate sample size (equation 2). The study used it at 95% confidence level and 5% sampling error and 50% standard deviation to obtain a total of 384 sample size. Yamane (1976) formula (equation 3) was used to derive the proportion of respondents to be sampled from the LGAs (Table 1). Purposive sampling technique was employed to select houses in each of the selected LGAs for questionnaire administration. The selection criterion is CSM experience within the last two years.

Method of Data Analysis

Descriptive statistics in addition to map representation such as: percentage, composite map and line graph were used to analyze socio-demographic characteristics, incidences and trend of meningitis. Inferential statistics using the simple regression (equation 4) was used to determine risk factors of meningitis, where incidence of meningitis was the dependent variable (y) while the independent variables were the risk factors. Incidences and population data collected were typed in Microsoft Excel and saved in "comma delimited" (.CSV) format for Geographic Information System (GIS). The administrative maps were integrated into ArcGIS (10.5) software as "Shapefiles", which were geo-referenced, projected (UTM-zone-32) and spatially overlaid, to create a base-map for subsequent GIS analysis. The incidence and population data were also checked and symbolized to show distributions. "KDE" (equation 5) was employed to estimate hotspots density: which were represented as very low-very high risk-zones of meningitis. This KDE calculates the length of the portion of each point that falls within the circle and then multiplies it by the population field value. A smooth curved surface is fitted over each point feature. The surface value is highest at the location of the point, and diminishes with increasing distance from the point, reaching zero at search radius distance from the point.

$$Po = P1\,(1+r)^{n} \quad (1)$$

Where Po= projected population,

P1= Initial population, r= Growth rate=3% =0.03

n= Number of years projected

$$n = N \times \frac{\frac{Z^2 \times p \times (1-p)}{e^2}}{\left[N - 1 + \frac{Z^2 \times p \times (1-p)}{e^2}\right]} \quad (2)$$

Where: n= sample size,

N = total projected population,

Z = confidence level (set at 95% = 1.96)

p = standard deviation (set at 50% = 0.5),

e = margin of error (set at 5% = 0.05)

$$Pp. = \frac{n \times 384}{N} \quad (3)$$

Where: Pp. = proportion of respondents

n=Population of each ward

N=Total population figure

$$Y = X_1 + X_2 + X_3 + X_4 \ldots\ldots + X_n \quad (4)$$

Where: Y = incidences per household

X_1-X_4= independent variables

$$f(x, y) = \frac{1}{nh^2} \sum_{i=1} K\left(\frac{d_i}{h}\right) \quad (5)$$

Where: f(x, y) = density estimate at location *(x,y);*

h = search radius

n = numbers of observations

K = kernel function;

d_i = distance between the location *(x,y)* and of the i^{th} observation

RESULTS AND DISCUSSION

Socio-demographic Characteristics of Respondents

From Table 2, most of the respondents (77.7%) are male compared to 22.2% females. The age distribution shows that 31-35years as represented by 34% are the majority of respondents in the survey while the least (3.9%) represented those with 21-25 years. This is so because 31-35years are mainly the working age who are presumed to have families. Most (44%) of the respondents had Secondary education and more than half were into trading (50.1%). Monthly income is relatively high, with the majority (43.4%) earning between N41, 000 and N50, 000. This is attributed to the massive commercial activities within the metropolis. Majority (79%) of the respondents are married and most of them (64.3%) were also polygamous; with children between 9 and 10 (41.1%) mostly per household and about 46.1% of the respondents which constitute the majority have 3–4 persons living in a room. This shows some level of overcrowding, and according to NCDC (2015), one among the factors influencing CSM is overcrowding. More than 50% of the respondents confirmed that, they have lost between 1 and 2 children to meningitis within the study period, while only few (19.3%) lost between 5 and 6 children.

Table 2: Socio-demographic and economic Characteristics of Respondents

	Frequency	%		Frequency	%
Sex			**Marital Status**		
Male	298	77.6	widowed/Separated	37	9.7
Female	86	22.4	Divorced	45	11.6
Total	**384**	**100**	Married	302	78.7
Age			**Total**	**384**	**100**
21-25years	12	3.0	**Type of marriage**		
26-30years	104	27.0	Monogamy	137	35.7
31-35years	130	34.0	Polygamy	247	64.3
36-40years	88	23.0	**Total**	**384**	**100**
40years and above	50	13.0	**Number of children born**		
Total	**384**	**100**	1 – 2	15	3.9
Level of education			3 – 4	21	5.5
Primary	150	39.0	5 – 6	55	14.3
Secondary	169	44.0	7 – 8	77	20.1
Tertiary	65	17.0	9 – 10	158	41.1
Total	**384**	**100**	11 and above	58	15.1
Occupation			**Total**	**384**	**100**
Trading	192	50.1	**Number of persons per room**		
Farming	71	18.6	1 – 2	101	26.3
Artisan	55	14.2	3 – 4	177	46.1
Civil servants	66	17.1	5 – 6	53	13.8
Total	**384**	**100**	Above 6	53	13.8
Monthly Income			**Total**	**384**	**100.0**
Less than N10,000	91	23.7	**Mortality meningitis**		
N21,000 - N30,000	44	11.4	Less than 2	201	52.3
N31,000 – N40,000	43	11.3	3 – 4	109	28.4
N41,000 – N50,000	167	43.4	5– 6	74	19.3
Above N50,000	39	10.2	**Total**	**384**	**100**
Total	**384**	**100.0**	**-**	**-**	**-**

Source: Field Survey, 2021

Spatial Distribution and Estimated Density of Meningitis in Kano Metropolis

Figure 2 presents the spatial distribution of meningitis from 2008 – 2017, whereas Figure 3 shows the estimated density of meningitis in the study area. Fig. 2 shows that, major incidence in 'dark green' (37.3%) were recorded in Gwale and closely followed by Dala (27.7%) coloured 'citron yellow'. The least shown in 'sky blue' color was in Tarauni (14.6%). From the analysis, areas with high population distribution somewhat had high recorded cases. These are centre of activities, where settlements are clustered, and adequate air ventilation could be scares. In addition to improper urban planning in the ancient traditional setting of Gwale and Dala, with poor sanitation practices, outbreak of diseases including meningitis is inevitable. Fig. 3 corroborated further, where Gwale and some parts of Dala were the zones of very high (in 'red') and high (in 'brown') densities of estimated meningitis. The hotspot seems to be concentrated westward (within Gwale) spreading towards northeastern parts of the study area. Settlements within these LGAs are hence at most highly risk of meningitis outbreak. This finding is in line with Zakari *et al.,* (2018) who stated that the spread of meningitis continued to cover the two areas of Gwale and Tsanyawa and beyond, at the same time spreading the wave of influence in-between.

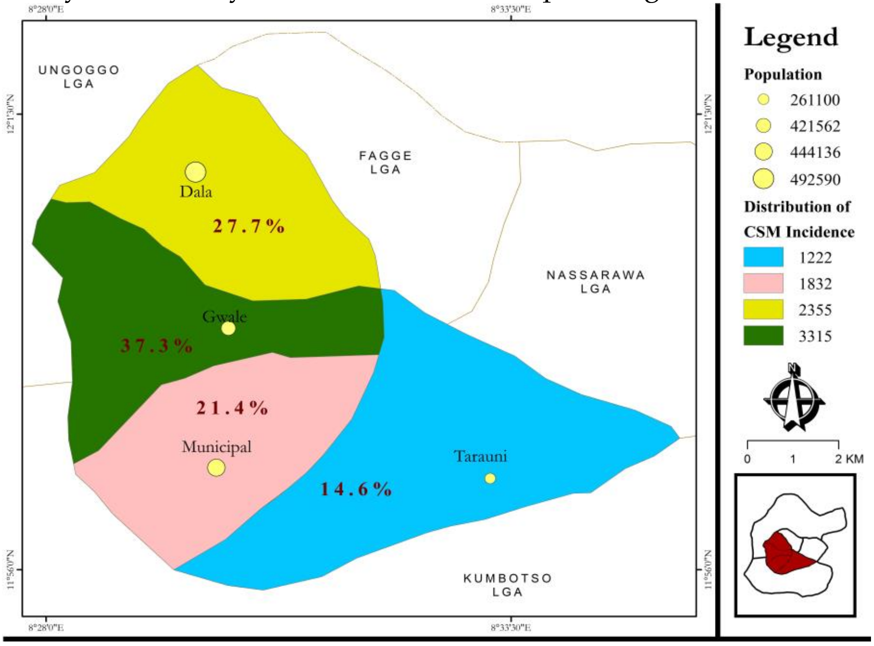

Fig. 2: Distribution of meningitis cases in Kano metropolis
Source: Field Survey, 2021

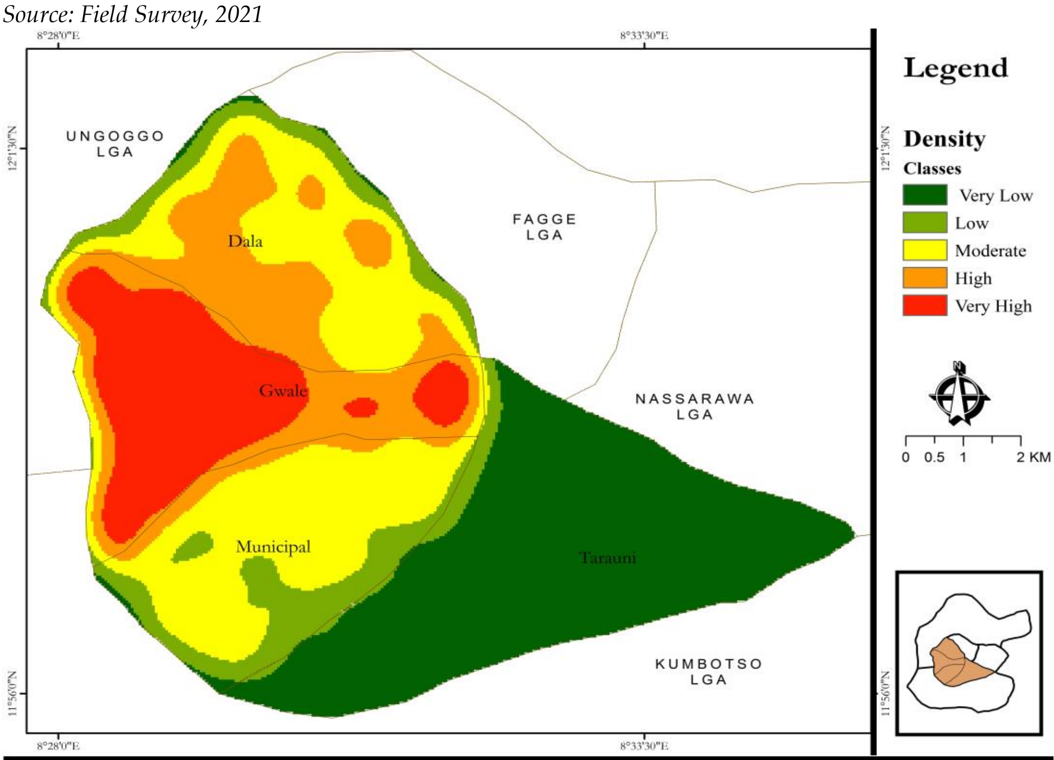

Fig. 3: Density of meningitis incidence in Kano metropolis
Source: Field Survey, 2021

Trend of meningitis in Kano State

The temporal pattern of meningitis in the study is displayed in Fig. 4. It shows that there is a general increase in the incidence. Despite the fluctuating pattern, Gwale, Dala and Municipal recorded the least incidence in 2008 while Tarauni the highest. The fall in meningitis in 2008 and 2013 as the case may be in Dala could be due to government intervention. However, on the average, incidence of meningitis appears to be increasing from 2014 to 2017 in the study area. This result corroborates the report by WHO (2018) which shows that between 2016 to 2017, a total of 14,513 meningitis cases with 1,166 deaths were recorded in northern Nigeria.

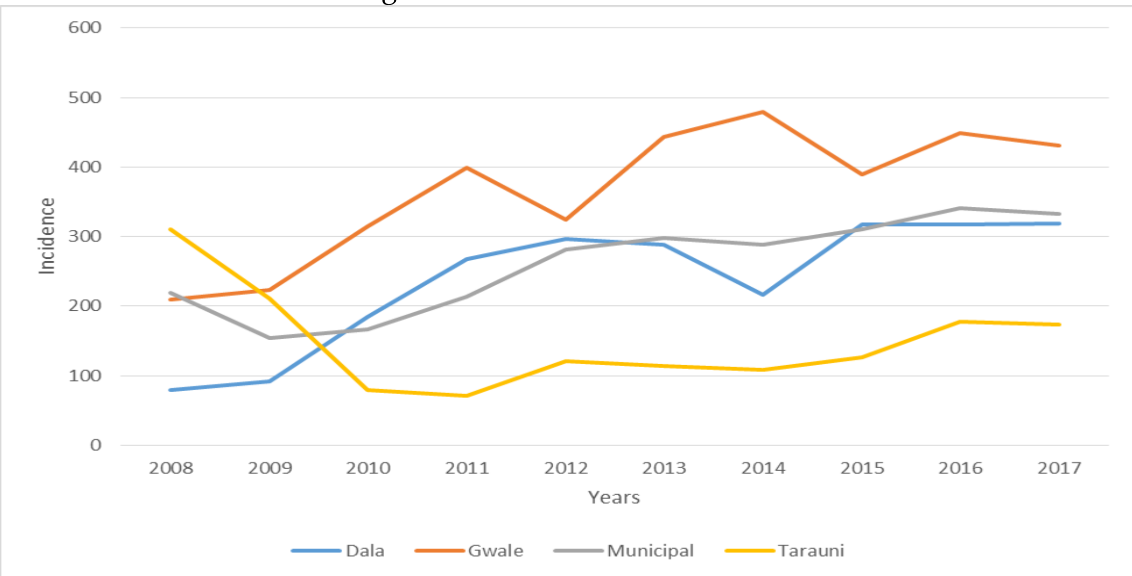

Fig. 4: Temporal Variation of Meningitis in Kano Metropolis (2008 – 2017)
Source: Authors analysis of Secondary Data 2021

Factors of Meningitis

For meningitis to be prevalent in an area, there are certain factors influencing its outbreak and spread. The findings on the influencing factors of meningitis is presented in table 3. Table 2 shows that, overcrowding of people sleeping in the same room is the major significant factor with a coefficient of 0.0674 at 0.05% significant level. This supports the position of Mazama *et al.,* (2020) that overcrowding is a key factor influencing the occurrence of meningitis. It is closely followed by increasing temperature (dry season) with a coefficient of 0.0641. It is also in line with Abdulsalam *et al.,* (2013), whose study reveal that yearly disease maxima of meningitis occurring during the peak of the hot dry season. Further, with the coefficient of 0.0581, -0.0572 and 0.0551 respectively, increasing rate of urbanization, low income level and sharing bedroom (with a victim) constitutes other major factors influencing the incidence of meningitis in the study area. On general note, all the outlined factors exhibit positive relationship with the incidence of meningitis at 0.05 significant and 0.0612 coefficient (Table 3)

Table 3: Factors Influencing Meningitis

Factor	Coefficient	Adjusted R	% contribution
Increase in temperature (dry season)	0.0641	0.061*	25.1
Increase in rainfall (Hot wet season)	0.0272	0.0281	4.2
Poor sanitary condition	0.0457	0.0443	5.1
Overcrowding of people sleeping in the same room	0.0674	0.0611*	24.1
Lack of properly sized windows	0.0497	0.0398	4.7
Poor design of houses which brings about poor	0.0542	0.05791*	23.2

ventilation			
Sharing a bedroom with a victim	0.0554	0.0525*	22.6
Smoking and passive exposure to tobacco smoke	0.0391	0.0322	4.2
Educational attainment	0.0336	0.0331	4.3
Income level	-0.0572	0.0542*	23.1
Significant level	**0.05**		
Adjusted R^2	**0.0694***		
P-value	**0.49**		
Coefficient (all)	**0.0612****		

Source: Field survey 2021

CONCLUSION AND RECOMMENDATIONS

Effort was made to study incidence, density, trend and factors influencing meningitis in Kano metropolis. Cases of meningitis were recorded from 2008 – 2017, most of the cases were found in Gwale, whereas Tarauni had a fewer. However, despite the fluctuating pattern, Gwale, Dala and Municipal recorded the least incidence in 2008 while Tarauni the highest in 2008. Considering the pattern of distribution of the recorded cases of meningitis, it can be concluded that CSM in Kano metropolis is not evenly distributed because more were recorded in some particular areas as compared to others. This therefore means that risk factors may vary across the city. Nevertheless, overcrowding of people sleeping in the same room alongside increasing temperature are the most significant influencing factors of meningitis. Therefore, it can be concluded that there is no adequate housing for the high population of the study area. Owing to the increasing incidence of meningitis in the study area, there is need for public awareness on risk of meningitis. Awareness campaign should be embarked upon on the need for ventilated housing especially during the high temperature season. Further study is needed to examine the socio-economic effects of meningitis and local coping/management strategies in the study area.

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