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SPATIO-TEMPORAL ANALYSIS OF CEREBROSPINAL MENINGITIS (CSM) IN KANO STATE

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ABSTRACT

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Spatio-temporal, CSM, Prevalence, Case Fatality Rate.

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Over hundred years now, CSM outbreak has been occurring in West Africa and Nigeria. However, the spatio-temporal prevalence micro scale of Local Government (LGAs) in Nigeria can help in understanding the micro impact of the epidemic as just did for 2017 by Nigeria Center for Disease Control. This study examined the spatio-temporal prevalence of CSM in Kano State 2012, 2015-2017 and vulnerable population (age and sex group) using record from the epidemiology unit, Kano State Ministry of Health. Descriptive statistic is used for data analysis of temporal prevalence and case fatality rate (CFR), Choropleth maps were used to analyses spatial pattern of prevalence and CFR for each LGA, while chi-square analysis was used to determines age and sex relation with CSM infection. The result of the annual analysis shows a decreasing trend and seasonally is a disease of dry and hot (*Bazara*) season, where over 55% of all the cases occur within this period. The prevalence was highest in Fagge LGA in 2012 and 2017 with 3.17/100,000persons and 18.35/100,000persons prevalence rates respectively and Kura with record of 2015. Male to Female ratio of cases is 1.2:1. Age groups 1-20 year are the most vulnerable constituted about 62% of all the cases, the chi-square result of both sex and age group show a relationship with the CSM infection. The CFR is least during the epidemic year. In May to June the CFR was high of about 60% of all death. Fagge records high CFR of 11.1% above the standard average of 10%, female group record high of about 12.1% constituted 48% of the total and the vulnerable age groups are 1-10 and 21-25 years. Conclusively CSM is an endemic disease of dry and hot season and its risk is all over the state, across all age and sex groups. This paper recommended the need for the provision of CSM treatment and prevention facilities at all level and anytime in the state.

INTRODUCTION

Meningitis epidemic can occur everywhere World Health Organization (WHO, 1998). WHO (2012) in CoMo (2013) stated that, every-year more than 1.7 million people worldwide suffer meningitis. Bacterial meningitis, which is the most severe and common form, causes around 170,000 deaths globally every-year.

The inflammation of the meninges of both brain and spinal cord; specifically an infectious often epidemic and fatal meningitis caused by the meningococcus—called also cerebrospinal fever, transmitted from person-to-person through droplets of respiratory or throat secretions from carriers (infected person).

Close and prolonged contact – such as kissing, sneezing or coughing on someone, or living in close quarters (such as a dormitory, sharing eating or drinking utensils) with a carrier, all facilitate the spread of the disease. The average incubation period is 4 days, but can range between 2 and 10 days (WHO, 2015). Mace (2008) opined that Meningitis can occur at any age and in previously healthy individuals. She grouped the host risk factors into four categories of age, demographic/socioeconomic factors, exposure to pathogens, and immune suppression.

After the first recorded outbreak of the disease in West Africa in 1905, subsequent large and deadly outbreaks tended to occur every 5-10 years, usually during the winter of the meningitis belt. The most widespread outbreaks occurred in 1996 and 2009 first 11 weeks of the outbreak. In 1996, over 250,000 cases were reported and more than 25,000 deaths occurred. While in Nigeria alone over 8423 cases were reported with 1181 death (Case Fatality Rate CFR 14%) which range from 2.5% to 30% in different states in the North, over 12 LGAs in Kano state were affected, (WHO, 2016a). In 2009, more than 24,000 suspected cases were reported and there were an estimated 1,500 deaths in northern Nigeria and Niger Republic. Basse et al., (2016) asserted that, out of 24 most affected states in Nigeria during the outbreak in 2009, Kano State ranked 4th (6811 cases, 2.4% CFR), now Bagwai and Dambatta stand as the two most affected Local Governments. However, Kano state ministry records the total case of about 9054 cases in 2009 (Malumfashi, 2010). The general key issues regarding Cerebrospinal Meningitis CSM (sporadic and epidemic) management are enormous. Obaro (2000) brought up that the exact scale of CSM epidemic and it remains unknown, as only portion of family take their ill relative to health facilities during the outbreaks, or under-reporting of the cases, for one reason or the other. This leads to the underestimation of the exact population effected. Secondly, the meningitis belt countries entirely depend on International Coordinating Group (ICG) and other international donors on CSM for the immunization vaccine against CSM, and their supplied is based on request, when the

epidemic threshold reaches (WHO, 2016b). the high CFR of the infected persons during the years with less number of cases, can be attributed to the response timing (Zakari et al., 2017) as observed in the conducted in four countries of meningitis belt (Burkina Faso, Ghana, Niger and Nigeria).

Nigerian Best Forum News (NBF) (2009) acknowledged that the Minister of Health Federal republic of Nigeria has said that over 29 states of the Federation were infected by the CSM epidemic in 2009. Added that the outbreak is occurring every 10 years, mainly in 19 states in the North, but now spread into other states of the South (Oyo, Ebonyi, Enugu, Imo, Anambra and Cross River state), yet the most affected states remain in the Northern part (Katsina, Sokoto, Kano and Jigawa). The number of the infected states in Nigeria rose to 23 in 2017 Nigeria Centre for Disease Control (NCDC, 2017), which gives the management a hard time in the states, where the incidence was higher, like Zamafara, Sokoto and others.

Study area

Kano state of Nigeria lies in the northern part, approximately between latitude 10° 30'N to 13°N and longitude 7°40'E to 10°39'E, at an altitude of about 472.45 meters above sea level. It has 44 LGAs and at presents 36 LGAs are outside the metropolitan area. It has of about 20.760 km² land area (Kano state, 2012), and the projected population as at 2015 is about 12,687413 persons (NPC 2006) which over 70-75% is outside the metropolis. The State has as at 2010 about 1240 public and private health care facilities with at least one General hospital per Local Government (Figure 1), the ratio of doctor per patients was 1.7 doctors for 100,000 in the government service at all levels (Kano state, 2015). the climate of Kano is typically dry and wet, classified as AW by Koppen, temperature ranges between 30°C-33°C between march-may and as low as 10°C between December –January, the average warms to hot is 27°C (Olofin and Tanko 2002). The Harmattan winds prevail at this time (dusty condition). Rainfall ranges between 850-870mm with an average of 600mm (Kano State, 2012), and predominant period of maximum rainfall is from June to September, almost 40% of the rainfall comes in August.

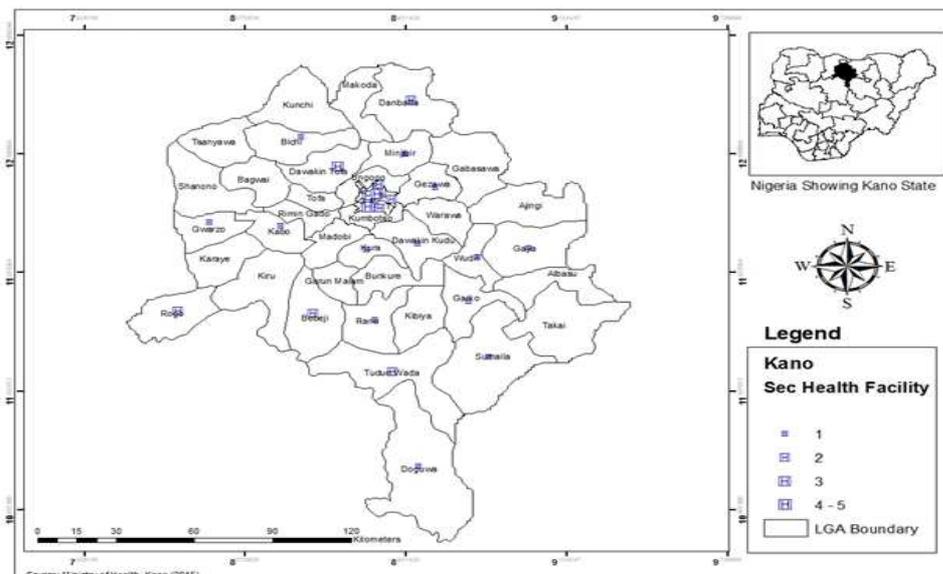


Figure 1. Study Area Showing the Secondary Health care Facilities

Research Methods

Kano State CSM-line list (2012 – 2017): an inventory of individual CSM patient in Kano state was collected from Kano State ministry of Health, Public health department Epidemiology unit 2017. The inventory includes all the records at the different health facility across the state, from 2012 to 2017 (Note: only 2012, 2015, 2016 and 2017 records were available in the archive), and it treats each patient as a record. The variables captured are; state epidemic number, local government, ward, settlement, name, age, sex, date of birth, date of onset of disease/date seen at the facility, week of onset, CSF taken, result, hospital, outcome, comment and remark.

Data presentation and analysis employed the use of tables, chart (bar chart and line graphs),

descriptive statistic for temporal analysis as well as nonparametric chi-square (X^2) for determining the relationship between CSM incidence and other independent variables (sex and age). Bar chart was used to analyses the yearly cases recorded in the state for 2012, 2015, 2016 and 2017. For the seasonal pattern of occurrences the line graphs were used to analyses the monthly trend from 2012, 2015, 2016 and 2017 and monthly total occurrence for the general seasonality of CSM cases. Chropleth map were used to analyse the spatial prevalence rate and CFR by local government areas in the state for each years and total for all the years, cases for each year were normalized with the corresponding projected population (pp) of the LG.

$$\text{Prevalence Rate} = \frac{\text{total cases in an area for the year}}{\text{total population of an area for the year}} \times 100,000$$

$$pp = (\text{previous population} \times \text{population change rate})^{\text{number of years from previous}}$$

Annual, seasonal and spatial CFR were computed and analysed.

$$CFR = \frac{\text{Number of death}}{\text{Total Cases of the same time}} \times 100\%$$

RESULTS AND DISCUSSION

Temporal cases and CFR Analysis of CSM

The CSM line-list record of 2012, 2015, 2016 and 2017 in Kano shows the variation of the annul total cases in the state, the cases are generally less in the first three recorded years, which constituted only 24% of the total of the four years, where 2017 constitute the remaining of 76% (321 cases) of the total annual (figure 2). The high cases in 2017 were due to the

epidemic condition of the year, which was declared by the Federal Ministry of Health (Nigeria). Kano state ranked 6th after Zamfara, Sokoto, Yobe, Katsina and Kebbi, out of about 25 infected states. Total cases recorded in Kano constitute not less than 3.1% of the national total, while Zamfara alone constitute about 70% of the total (NCDC, 2017; eHealth, 2017).

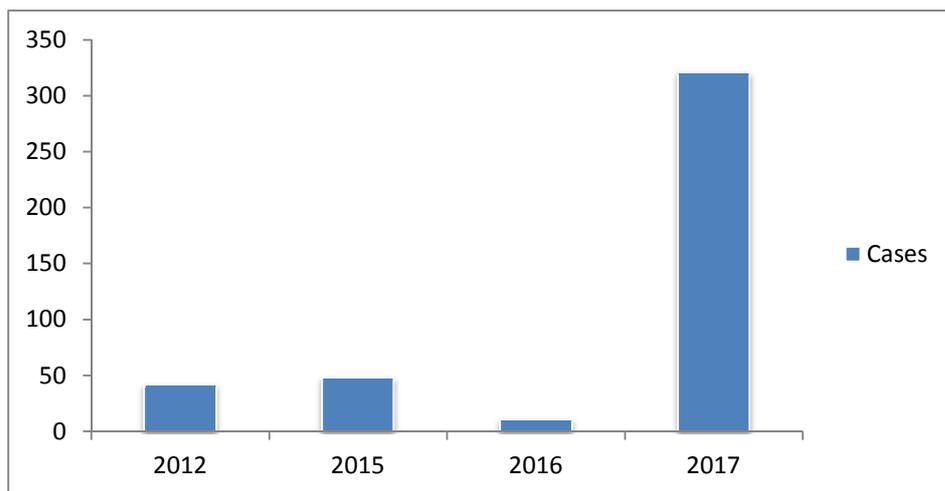


Figure 2: Annual Distribution of CSM cases in Kano (2012, 2015-2017) Source: Survey (2017)

The state annual record of CFR 2012, 2015-2017 revealed that in 2015 the CFR of 37% is been recorded despite having relatively less cases. It is then followed by 2016 with CFR of 9% with

fewer cases than 2015. In 2017 the cases were much while the recorded CFR is 7.8% less than the total average of all the years CFR of 11% (figure 3).

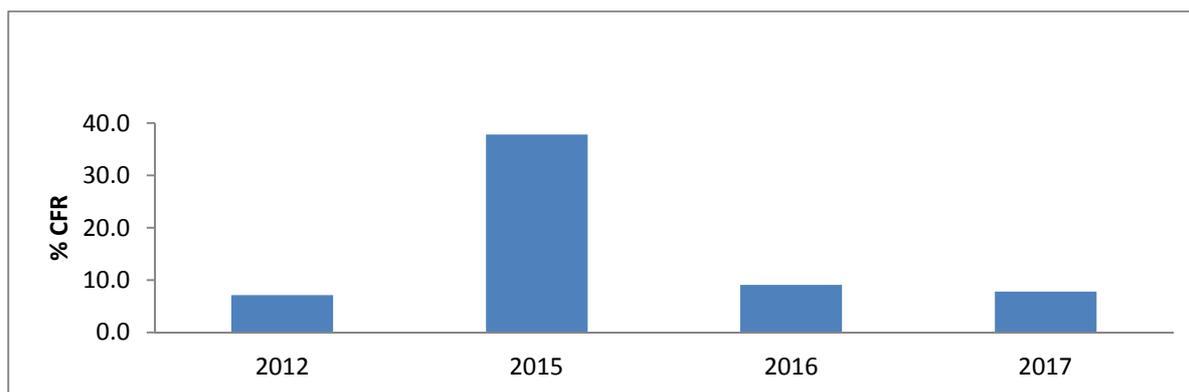


Figure 3: Annual CFR for the State (Kano)

Source: Survey (2017)

The result obtained from the annual distribution of CFR analysis indicates that high CFRs are recorded during the years with fewer recorded cases. And the result is similar to the National pattern of high CFR, while having less cases records (WHO, 2016b). This can be attributed to more treatment provided during the epidemic than the other periods, when national and other government agencies are at alert. This is evident from the participation of Government (Federal Ministry of Health, National Primary Healthcare Development Agency (NPHDA), Nigeria Centre for Disease Control (NCDC) and other NGOs (WHO,

UNICEF, eHealth, AFENET, Africa CDC, and other) in the 2017 epidemic to halt the situation (NCDC, 2017), even though, they arrived when the epidemic is about to subside.

Seasonal Cases and CFR analysis of CSM

In 2012, 2015-2017 the Seasonal variation indicates the seasonal fluctuation from month to month and the years (figure 4), in all the years from March to May, and peaked in April. Over sixty percent (60%) of all cases occurred in the same month, however, March and May show their spillover effect to and from April respectively, zero percentage from July to December.

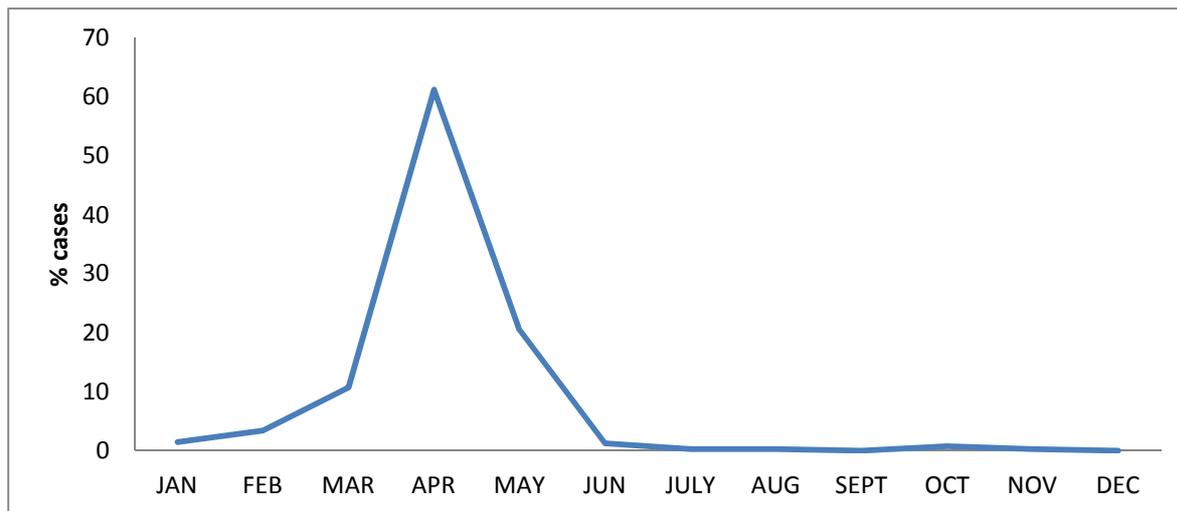


Figure 4: Mean Seasonal variation of CSM in Kano (2012, 2015-2017) Source: Survey (2017)

The result obtained in figure above indicated that CSM incidence is more severe in April, while seasonally can be categorised as disease of hot and dry season and it's dissipating as rainfall started in the region. This finding agreed with findings of Mudi, 1995 (Kano); Molesworth, *et al.*, 2002; Molesworth, *et al.*, 2003 (parts of Africa); El-Tayib, 2004 (Sudan); Sawa and Buhari, 2011; Inobeme, 2012 (Zaria) and Isa, 2015 (Plateau State).

The temporal analysis of CFR in the state from 2012, 2015-2017 shows that high CFR is in the month of June of about CFR OF 60%, while all other months are less than CFR OF 10-11%, while July-December having mostly CFR of 0% (figure 5), this indicates deviation from the result of monthly cases where April constituted high cases records.

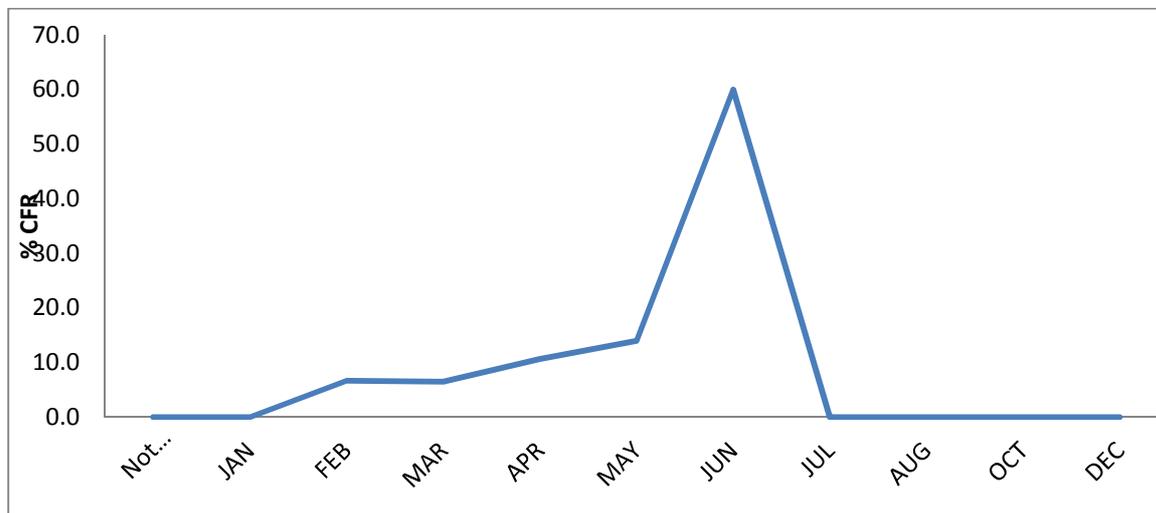


Figure 5: Monthly CFR for the state (2012, 2015-2017) Source: Survey (2017)

The analysis of this result may favour the high chance of survival of CSM patient when the cases are much. This may have the replica explanation of the annual CFR, but here commitment at health facility and people's awareness are at the peak. People are now monitoring the symptoms, and the Health personnel can at a spot predict the patient

problem without much observation then periods of few or no case, and treatments are sought and received in time. All sort of delays are relatively avoided. This finding agreed with Faustini, (2007) who stated that the later the CSM diagnosed and treated the greater is the possibility of adverse outcome.

Spatial Distribution analysis of the CSM Prevalence in Kano State

Among the LGAs, Fagge was highest in the state with 3.17/100,000persons prevalence rate in 2012, while Tsanyawa (2.46/100,000) in the non-metropolitan area (Figure 6) and the state rate is 0.37/100,000. In 2015, Kura was the highest having 11.06/100,000persons prevalence rate, it followed by Bagwai (4.34/100,000) and Tudun wada (1.97/100,000) (see Figure 6a), while the state rate is 0.39/100,000persons.

In the year 2016 the cases were less, but the highest record was found in Ungogo LGA,

while the prevalence rate shows that Bagwai has 0.94/100,000 as the highest followed by Shanono (0.54/100,000) than Ungogo (0.49/100,000) all of these are by far greater than the state rate of 0.08/100,000 (figure 6b). In 2017, the cases as recorded, were much and almost affect most of the LGAs with prevalence rate of 2.36/100,000persons. Fagge LGA in 2017 is the most affected among the LGAs in the state followed by Dala, and Gwale, while Tsanyawa recorded the highest cases among non-metropolitan (Figure 6c).

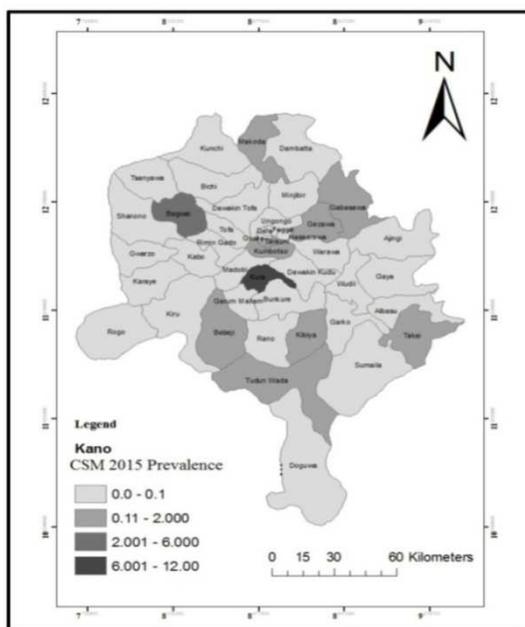
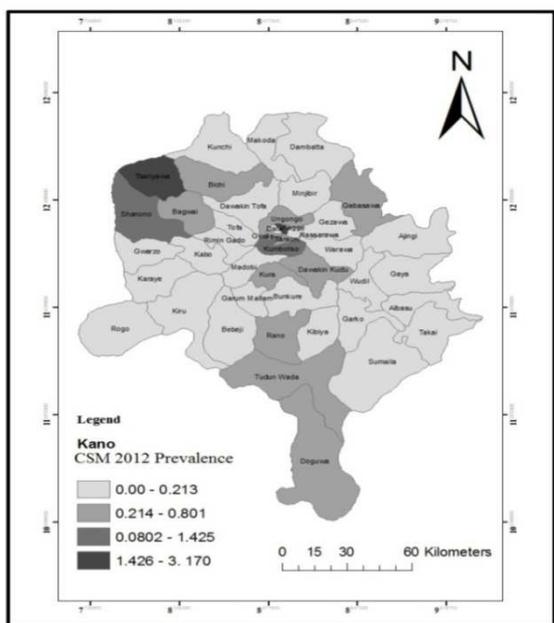


Figure 6:2012Distribution of CSM in Kano

Figure 6a: 2015 Distribution of CSM in Kano

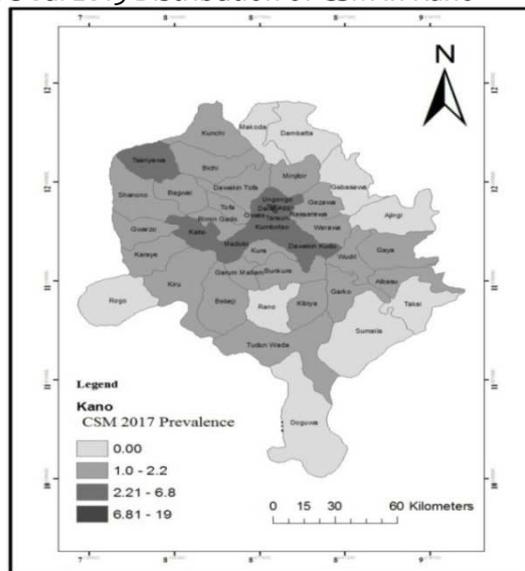
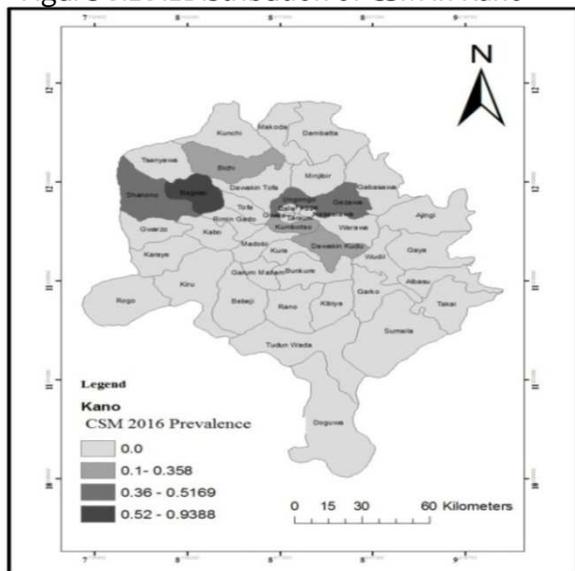


Figure 6b:2016 Distribution of CSM in Kano

Figure 6c: 2017 Distribution of CSM in Kano

Source: Epidemiology Unit Kano State Ministry of Health (2017)

Out of the 44 LGAs in State only four (Ajingi, Rogo, Danbatta, and Sumaila) where found without record of CSM in these four years, whereas Fagge LGA was having the highest record in total and highest in all the years when it appear, followed by Kura, Dala, Tsanyawa, KMC, Kumbotso and Bagwai with 21.27, 12.37, 7.00, 6.79, 6.41, 6.04 and 5.94 per 100,000person respectively The result obtained indicates the shift of the higher concentration of the cases in the past among the non-metropolitan LG to metropolitan LGs where eight metropolitan LG filled in the first eleven high prevalence LG. WHO (2016a) indicates Bagwai and Dawakin Tofa all in the non-metropolitan areas as the highest during the 1996 epidemic, while Bassey, *et al.*, (2016)

indicates Bagwai and Dambatta also in non-metropolitan areas. Additionally, the Dambatta is among the LGs with no case in these four years. Note that the prevalence rate is influence by the population of an area, healthcare system and other factors associated with disease.

Sex and Age Characteristics of CSM

The sex distribution of the infected persons in 2012, 2015, 2016 and 2017 in figure 7 indicates male’s slight vulnerability than female at the ratio of 1:1.2 (43.1%:56.9%), this was obtained in all the years, except in 2016 that shows that female were at disadvantage of infection of CSM accounting for 72.7% and 27.3% males, despite that cases were less in this year.

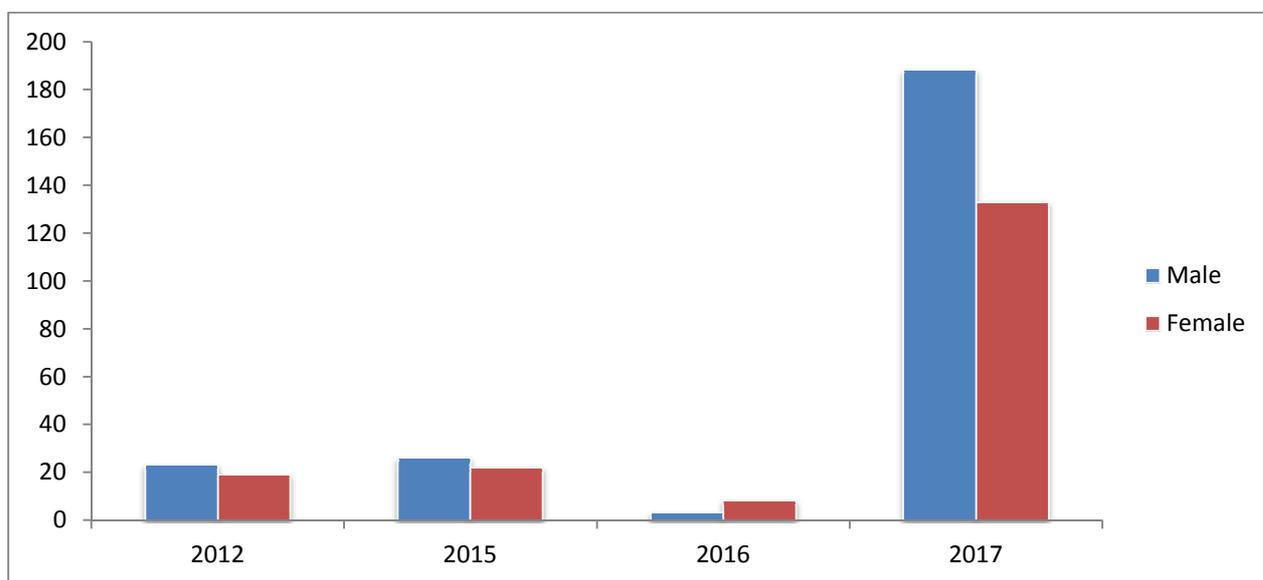


Figure 7: Sex distribution of CSM patient in Kano State (2012, 2015- 2017)

This finding is similar to the findings in many epidemiological studies that shows male having slight risk then females because of their expoure and contant (Greene *et al.*, 2005; Brouwer, 2010; and Frank-Briggs and Alikor, 2013). It is also astonishing to note that the ratio of cases by sex is almost similar with male female population proportion in Kano State.

The analysis from the result indicates that more male are at risk of dying than female with a ratio of 1.1:1 (52%:48%) as the average total reads CFR of 11%. Among the male total the CFR of 10.2% is calculated, while female total CFR of 12.1% is found, which constituted

that 48% of the total average. Despite that males have high risk of dying than females, but among the females the percentage is high from their total.

Age Distribution of CSM patient in Kano State

According to the age distribution of the CSM patient about 63% of all the cases were between 1-20year age group, while 1-5year was most vulnerable group with regards to CSM infection. It is also indicated that 1 – 11month age group have almost similar vulnerability with age group 36 and above years. In this last category those above 50 years constitute significant proportion of the groups.

The Age-Sex variation indicates that across all age group males are more vulnerable than females, except in age group 26- 30 and 36 and above where more female are slightly high, but in both the sex categories 26- 35 are less vulnerable than the other groups. The chances of infection tend to gradually increase from neonate to 10year age group then decreases between 21 - 35 or thereabout,

then the slight increase can be observe as displayed below figure 8. The higher proportion of 1-20y can be attributed to been within the period of school age, where more contacts at school and play ground are made. However, this finding may also be attributed to the CSM Serotype that is affecting this region (Stephens, *et al.*, 2007) that is more virulent among the young age group.

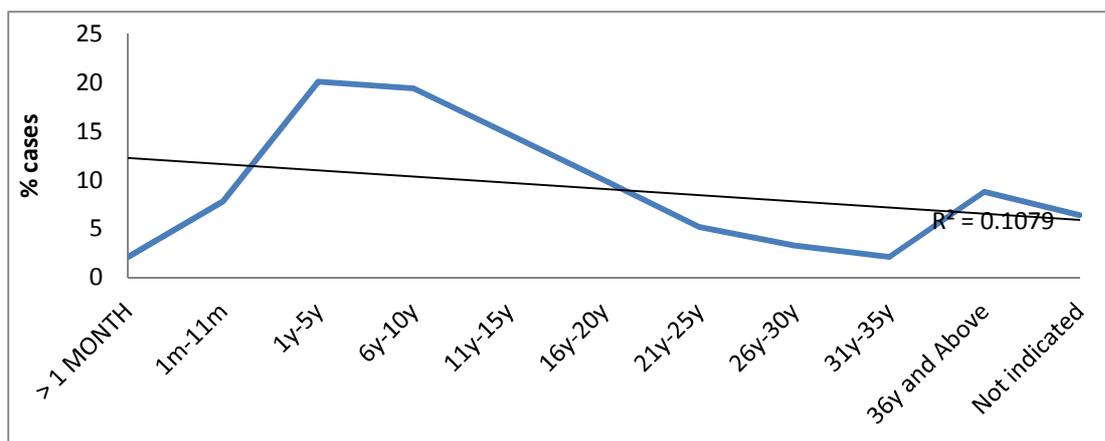


Figure 8: Variation of Cases Vulnerability among Age Groups in Kano (2012, 2015-2017) Source: Survey (2017)

The trend variation among age groups indicate that 1-11years are more vulnerable, while the vulnerability start to decrease at old age, as shown above the R^2 of 0.107 the decrease in the trend from the first to the last age group. This finding was further statistically proven using Chi-Square analysis result of sex distribution (appendix 1) indicated a significant different at 95% confidence level, which indicates the CSM infections varies with age. With regards to CFR analysis by age group in Kano, the 21-25 age groups has the higher CFR of 18.2%, followed by 1-5years and 6-10 with CFR of 16.5% each (figure 9). The result further

shows that from 1year up to 25year the CFR is greater than 10% universal average, while neonate to infant (1year) and age groups greater than 25year have less risk of dying than others. The CFR analysis indicates the high chance of survival among the infected age groups 25year and above. The possible explanation to this is that, most of those below this age are under care of either their parent or someone, whose action or inaction affect the type of delay before seeking and receiving health care, and sometimes fear to complaint to the caregiver.

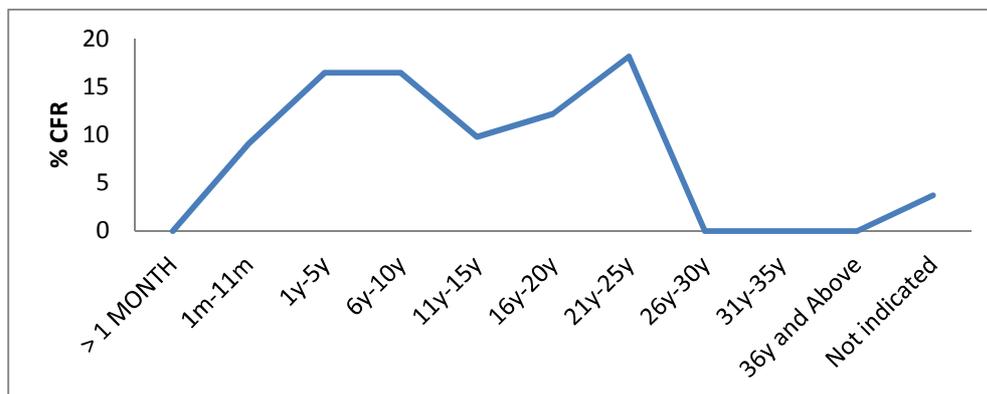


Figure 9: CFR trend by Age Group in Kano (2012, 2015-2017) Source: Survey (2017)

Spatial Analysis of CSM Case Fatality Rate in Kano

Spatial analysis of CSM fatality rate shows that all LGAs along the state boundary have CFR within the range of state average CFR of 11.1%. Fagge is slightly greater than the state total average with CFR of 11.8%, while highest are found outside metropolitan areas, like Rano, Kura, Garko, Kumbotso (metropolitan), Minjibir, Dawakin Tofa, Bagwai, and Kabo (figure 10) highest CFR first in the list. However, the result is from the four year total in which CFR of some year(s) may affect the average total of the LGAs, but still it hold the

ground of providing the clear picture of the spatial CFR distribution among the LGAs in the state, which is a clear indication of uneven distribution of healthcare facilities and treatment that are concentrated in metropolitan areas than outside. Some have no General hospitals where such treatment of CSM can be sought, while the referral system from lower to the high facility is not as good as it can be utilized, this factor may causes delay and subsequent death, as patient suffer and the condition worsen beyond treatment, at the time the case reach appropriate facility.

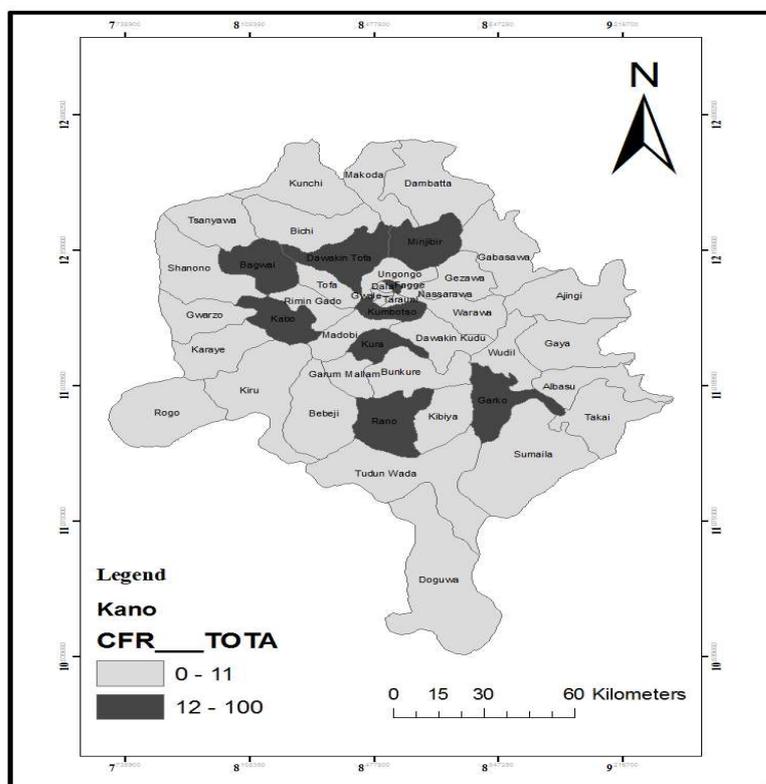


Figure 10: Case Fatality Rate by LGAs in Kano (2012, 2015-2017) Source: Survey (2017)

CONCLUSION

It is evident from the analysis that CSM is an endemic as well as epidemic disease, and the risk is all over the state, across all age and sex group. Temporally, it is the disease of dry and hot season, because of high cases in the month of March, April and May. The CFR is highest during the endemic years and seasonally high during the month of May and July where it constituted over 60% of the

death. High disease prevalence is more in the metropolitan and North-western part of the State. However, there is drastic decline in the CSM cases compared to the previous year's record in the state. This paper recommended the provision of good healthcare treatment at all level and all the time to reduce the delays and subsequent suffering or death in addition to creating more awareness among the caregivers and seekers.

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Appendix 1

Chi-square result by sex

	SEX
Chi-Square	7.972 ^a
df	1
Asymp. Sig.	.005

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 211.0.

Chi-square Test by age groups

	AGE
Chi-Square	1.928E2 ^a
df	10
Asymp. Sig.	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 38.4.