AN EVALUATION OF THE EFFECTS OF ENVIRONMENTAL FACTORS ON THE OUTBREAK OF CEREBROSPINAL MENINGITIS (CSM) IN ZARIA

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ABSTRACT

This study evaluates the effects of environmental factors on the outbreak of Cerebrospinal Meningitis (CSM) in Zaria. Data on monthly maximum temperature, rainfall and reported cases of CSM, for a period of 20 years (1990-2009) were collected and analyzed. Three hundred and seventy two (372) questionnaires were used to collect data on the socio-economic conditions influencing outbreak of CSM. The study aimed at determining the prevalence rate of CSM in Zaria and identify the relationship between climatic parameters and the outbreaks of CSM in Zaria. The results reveal that within the 20 years period under review, there were 2595 patients affected with CSM in the study area. Also, the results obtained shows that the reported cases of CSM disease are high between April and May when temperatures are also higher. The research shows that Zaria Local Government Area has a high spatial spread of CSM within the period under review with 1349 total patients compared with Sabon Gari Local Government Area with a spatial distribution of 779 total patients while the remaining 467 patients reside outside the study area. The temporal spread of the disease shows that year 2003 has the highest rate of 322 (12%) followed by 2009, 1996 and 1993 episodes with a total of 269 (10.4%), 170 (6.6%) and 137 (5.3%) patients respectively. Besides, the correlation analysis indicates that the reported cases of CSM are positively and significantly related to temperature. Also, socio-economic conditions of the people was also observed to be a factor responsible for the outbreak of CSM as the total dependent population was 2281 (87.9%) and also 172 (4.3%) of the patients were traders. Accordingly, appropriate recommendations were proffered to minimize the effects of environmental factors on CSM outbreak in Zaria.

Key words: Cerebrospinal meningitis, Environmental factors, Evaluation, Meningococcal, Outbreak and prevalence.

INTRODUCTION

Cerebrospinal Meningitis is inflammation of the protective membranes covering the brain and spinal cord, known collectively as the meninges (Saez-Llorens and McCracken, 2003). It is an infection of the meninges, caused by the bacterial *Neisseria meningitides* that causes high death rates in African communities. Although, meningitis occurs in many countries, the exact incidence rate is unknown (Logan and Macmohan, 2008). The agent is highly contagious, and person-to-person aerial transmission occurs through respiratory and throat secretions (WHO, 2003). Interaction between different environmental parameters e.g. immune receptivity of individuals, a poor socio-economic level, the transmission of more virulent serotype such as the recent emergence of the Serogroup W135 in West Africa, social interactions such as pilgrimages,

tribe migrations, and meetings and some specific climatic conditions may play a part in Cerebrospinal Meningitis disease outbreaks and spread within local populations (WHO, 2003).

Environmental factors are major determinants of the outbreak of CSM. Environmental factors include numerous aspects of the physical milieu, such as climate and quality of drinking water. It also encompasses the social environment, for example, population density, housing design and construction, and agricultural and industrial processes and pollutants. Including biological components of the environment, which greatly influence meningitis outbreak? These include hazards such as viruses and bacteria (Jones and Moon, 1987). Though, CSM outbreaks in West Africa usually start at the beginning of February, and then disappear in late May (Rodo *et al.*, 2002).

The geographical distribution of disease cases is called the (meningitis belt) and is roughly circumscribed to the bio- geographical Sahelo-sudanian band (Lapeyssonnie, 1963; Cheesbrough *et al.*, 1995). The 'meningitis belt' of Sub- Saharan African stretches from Senegal in West to Ethiopia in the east (WHO, 2012). The countries that constitute the 'meningitis belt' are Nigeria, Kenya, Senegal, Ghana, Mozambique, Somalia, Liberia, Ethiopia and South Africa (Wiki.answer.com, 2012). Annual rates of 500 cases per 100,000 are encountered in this area, which is poorly served by medical care. These cases are predominantly caused by meningococcal bacteria (Attia *et al., 1999).* The most recent epidemic, affecting Nigeria, Niger, Mali and Burkina faso, started in January 2009 and is ongoing (WHO, 2009). Thus, in the Sub –Saharan region, meningitis outbreaks occur on an annual basis. The belt includes much of Nigeria territory (Akande and Olu, 1998). Indeed, while the connections between climate and health cannot be denied, they are poorly understood (Vaughan, 2009). In genenal, meningococcal disease remain an important cause of death or disability in children and young adults (Murfin and Dyfed, 1999).

The incessant outbreak of Cerebrospinal Meningitis in Zaria in recent times resulting in the death of many persons is alarming. A recent outbreak occurred around March 2008 in which about 14 people died (Weekly Trust, 2009). Even the World Health Organization (WHO) has raised a serious health alarm on its possible reoccurrence. The prediction is already unfolding in the northern parts of the country as some areas are already experiencing the outbreak of Cerebrospinal Meningitis. The objectives are to determine the prevalence rate of Cerebrospinal Meningitis in Zaria, identify the relationship between climatic parameters and the outbreak of Cerebrospinal Meningitis in Zaria, determine the spatio-pattern distribution of Cerebrospinal Meningitis in Zaria and to determine the impact of socio-economic conditions and housing structures on the outbreak of Cerebrospinal Meningitis in Zaria.

STUDY AREA

Zaria is approximately 650 km from the Atlantic Ocean. Zaria covers an area extent of 6100 hectares; located within latitudes 10°15' to 11°6' North of the Equator, and longitudes 07°04' to 08°05' East of the Greenwich Meridian (Fig. 1). The region is located on a plain that forms part of the North Central Plateau at an average height of about 650m above sea level.

This latitudinal and continental location of the region suggests that the climate is Tropical Continental. It is a transitional type of climate found between the equatorial climate and the hot desert. The monthly temperature ranges between 11^{o}C and 14^{o}C (Abbas and Arigbede 2011).

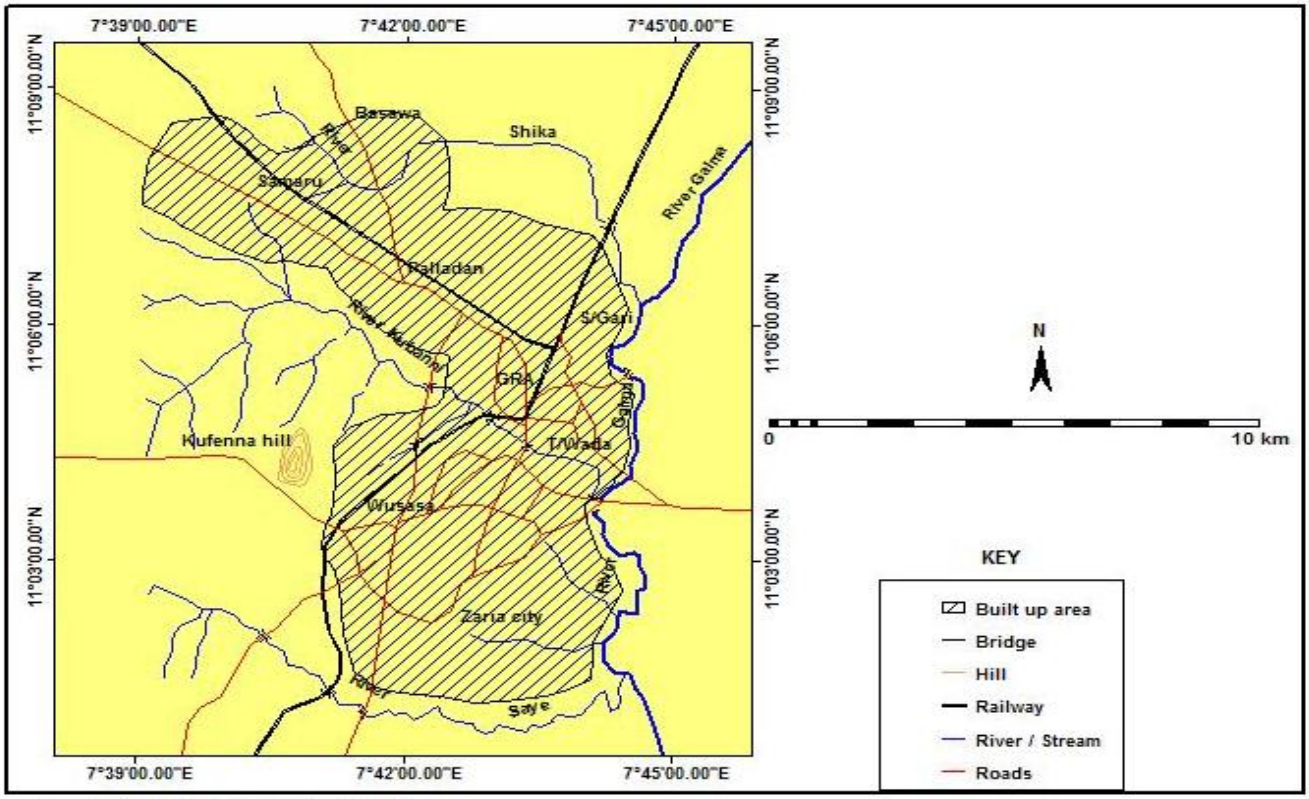

FIGURE 1: LOCATION OF STUDY AREA

Source : Adapted and Modified from Topographic Map of Zaria, 2012

MATERIALS AND METHODS

The data used for this study was obtained from the Meteorological Section, Federal Ministry of Aviation, Zaria, consisting of 20 years monthly maximum and minimum temperature. Also, 20 years record of reported cases of CSM (1990 – 2009) from January to December each year were sourced from the Ahmadu Bello University Teaching Hospital (ABUTH), Zaria, Gambo Sawaba Hospital, Zaria City, Saint Luke's Hospital, Wusasa, Salama Hospital Kwagila and Jama'a Hospital, Samaru,. This decision of choosing two major government hospitals and three major private hospitals well spread in the study area was to ensure adequate coverage of the study area. More so, the reconnaissance survey shows that these five hospitals have the data for the study period of 20 years targeted by the research and importantly willing to release this data required for the research. Reported cases of CSM for each month of the year obtained from the hospital records were used to determine the prevalence rate.

To identify the relationship between temperature and the outbreak of CSM, simple regression analysis was applied to show how much variation in the outbreak of Meningitis was due to

temperature change; and correlation analysis was then used in order to determine the statistical relationship between the outbreak of meningitis and environmental factors.

To determine the spatio-temporal variation in the occurrence of CSM: Reported cases of CSM for each month of the year were calculated to determine the variation from month to month and to determine the month with the highest cases. In order to determine the statistical relationship between the outbreak of meningitis and environmental factor (temperature) correlation analyses was used.

A field survey was conducted using questionnaires to solicit information on: (i) the occurrence of the disease in the study area (ii) the period or season of occurrence (iii) areas in Zaria that frequently experience the disease in Zaria (iv) associated weather conditions (v) the housing structures and dwelling units and (vi) the socio-economic conditions of the inhabitants among others. Thus, primary data for this study was collected through questionnaire survey of 384 respondents in 24 wards spread over the two local government areas in the study area. Out of the 384 questionnaire administered, 372 returned correctly answered were used for the socio-economic aspect of the study area.

RESULTS AND DISCUSSION

Relationship between Climate and CSM

Table 1 shows the relationship between climate and CSM within the period under review in the study area. It reveals that most of the cases start rising from January and attain their peaks in March, April and May when more cases seem to occur in each year. There is, however, a gradual decline of occurrence (epidemic) of cases until December and begins to rise again in January. When the numbers of cases for each month in the twenty years period were added, highest occurrence (719) was seen in the month of April which actually marks the month with highest temperature in Zaria (Abbas and Arigbede, 2011).

Table 1: Seasonal Variation of Cases of CSM in Zaria and its Environs

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1990	-	-	14	60	33			3	2	1	1	1	115
1991	8	12	14	21	19	8	6	2	2	1	2	2	97
1992	-	-	12	42	21	7	8	1	1	2	1	-	95
1993	11	14	14	31	49	62	3	1	1	-	-	-	137
1994	13	12	9	21	49	4	2	2	-	-	2	-	114
1995	-	21	24	26	34	9	2	1	3	1	-	-	121
1996	19	12	15	47	63	8	-	-	1	2	1	2	170
1997	9	11	12	23	19	4	2	1	-	2	-	-	83
1998	7	9	10	26	14	-	2	1	1	2	2	2	76
1999	6	3	17	21	37	3	-	-	-	-	-	-	87
2000	2	4	6	20	14	2	1	1	1	1	2	1	55
2001	13	11	19	21	41	-	3	4	5	2	-	-	119
2002	1	3	13	22	19	11	10	3	4	3	2	2	93
2003	19	37	57	82	63	18	12	6	7	8	6	7	322
2004	12	35	22	27	38	13	6	7	3	2	3	2	170
2005	2	3	15	21	32	20	15	12	6	7	-	-	133
2006	2	10	13	43	34	12	11	5	4	6	4	3	147
2007	16	15	12	33	24	1	-	-	-	-	-	-	101
2008	3	7	13	19	21	-	11	4	5	3	3	2	91
2009	12	23	31	82	63	16	13	10	11	6	2	-	269
TOTAL	155	242	342	719	669	139	105	64	56	49	31	24	2595

Source: Fieldwork, 2009

Table 2 shows the percentage distribution of monthly cases of CSM from 1990-2009. The result shows that the month of May has the highest recorded cases of CSM with 27.7 %(719 respondents) the next being the month of April with 25.8% (669 respondents); followed by the month of March with 13. 2% (342 respondents), the month of February 9.3% (242 respondents)) and the month of January 5.9% (155 respondents) respectively in that highest order. The months of June and July also record high incidence with 5.4% (139 respondents) and 4% (105 respondents) respectively.

Table 2: Monthly Distribution Cases of CSM – 1990-2009

MONTH	**TOTAL**	**PERCENTAGE**
JANUARY	155	5.9
FEBRURARY	242	9.3
MARCH	342	13.2
APRIL	719	27.7
MAY	669	25.8
JUNE	139	5.4
JULY	105	4
AUGUST	64	2.5
SEPTEMBER	56	2.2
0CTOBER	49	1.9
NOVEMBER	31	1.2
DECEMBER	24	0.92
TOTAL	2595	100

Source: Fieldwork, 2009

The present findings correspond with the WHO (2009) findings on Meningitis which observed that seasonal factors also contribute to the epidemiology of endemic meningococcal disease, in particular in areas with marked seasons. In the Northern hemisphere, including subtropical countries, a seasonal upsurge in Meningococcal disease occurs in winter and spring, beginning in December- January and culminating in March-April (WHO, 2012). Between two-thirds and fourth-fifths of cases occur in the first six months of the year. This substantiates the role of climate in CSM seasonality in the study area.

Similarly, figure 2 further shows graphically the monthly distribution of CSM in the study area. This substantiates the role of climate on this CSM seasonality. This has therefore provided a clear demonstration of the existing connections between CSM epidemics onset and the harmattan winds. This is not unconnected to the fact that during these months, the associated dry and windy weather conditions cause damage to the mucous membranes of the respiratory system and inhibits muscular immune facilitating transfer of the bacterium to the meninges and thus create propitious conditions to the triggering of CSM epidemics.

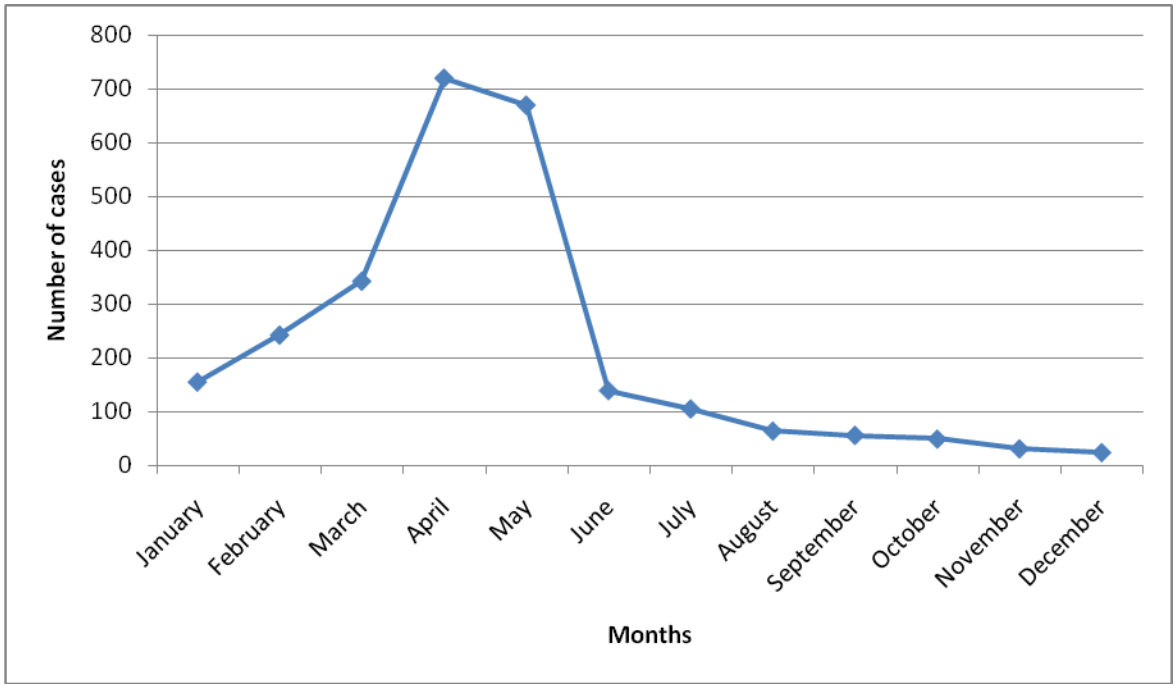

Fig. 2: A Line graph showing monthly distribution of CSM cases (1990 – 2009)

Table 3: Correlation between Temperature and CSM Outbreak

Variable					R	Df	P	R
	N	Mean	S.D	S.E				
TEMP	20	1768.7500	3523.8375		.265	1	.002	.99
CSM	20	129.7500	64.5053					

The result of the test reveals that temperature is a significant factor of CSM outbreak. The observed correlation co-efficient (.265) is less than the critical value of .99 and the observed level of significance (.002) is less than 0.05. This means that the two variables are significantly related, that is temperature can lead to CSM outbreak. This finding relates to the study of Rodo *et al.* (2012) who observed that there relationship between temperature and CSM outbreak.

Trend of CSM in the Study Area

The trend of CSM in the study area reveals how CSM occurs with time within the 20 years period under review in the study area. As presented in Table 4, CSM outbreak has been a recurrent epidemic over the years in Zaria. However, the rate of occurrence differs from year to year. Table 5 shows that there was no year in the 20 years under study that the disease was not experienced either in its mild, moderate or severe form. The temporal pattern indicates that year 2003 has the highest outbreak of 322 (12%) ; followed by year 2009 with 269 (10.4%) occurrence rate; 1996 with an outbreak rate of 170 (6.6%) and the fourth year in the order of magnitude is 1993 with 137 (53%) occurrence rate.

Table 4: Trend of CSM Outbreak

YEAR	TOTAL	PERCENTAGE
1990	115	4.4
1991	97	4
1992	95	3.7
1993	137	5.3
1994	114	4.4
1995	121	4.7
1996	170	6.6
1997	83	3.2
1998	76	3
1999	87	3.4
2000	55	2
2001	119	4.6
2002	93	3.6
2003	322	12
2004	170	6.6
2005	170	5
2006	147	5.7
2007	101	3.9
2008	91	3.5
2009	269	10.4
Total	2595	100

Source: Fieldwork, 2009

The temporal pattern of CSM in the study area is annual in nature. Since there was hardly no year when CSM outbreak was not experienced. This could be due to the fact that the same climatic, socio-economic and socio-cultural conditions prevail in the study area which goes a long way to necessitate the annual pattern of CSM disease in the study area.

Death Cases of CSM Patients from 1990 - 2009

Table 5 indicates the percentage distribution of CSM patients' cases of death for the year under study. The table shows that the year 1996 has the highest death rate with 9.6% (35 cases), next is year 2006 with 8.3% (30 cases), followed by 1992 and 2009 each having the same 6.6% (24 cases); 1991 and 2008 each with 6.1% (22 cases) while 1994 and 2008 each has 4.9% (18 cases) per year.

This substantiates the fact that CSM disease constitutes a high fatality rate in the study area and there is hardly any year in which its death effect was not felt within the twenty years studied as revealed from the research. This is because, the co-occurrence in both space and time of CSM disease cases and climate variability within the Sahel-Sudanian area suggests that the occurrence of CSM might be directly related to climate (WHO, 2005).

Table 5: CSM Patients Death Cases From 1990-2009

YEAR	DEATH CASES	PERCENTAGE
1990	17	4.7
1991	22	6.1
1992	24	6.6
1993	11	3.0
1994	18	4.9
1995	10	2.8
1996	35	9.6
1997	16	4.4
1998	15	4.1
1999	14	3.9
2000	16	4.4
2001	20	5.5
2002	8	2.2
2003	15	4.1
2004	11	3.0
2005	17	4.7
2006	30	8.3
2007	18	4.9
2008	22	6.1
2009	24	6.6
TOTAL	363	100

Source: Fieldwork 2009

The above finding is in agreement with the study of WHO (2009) which substantiates the fact that excluding epidemics, at least 1.2 million cases of bacterial meningitis are estimated to occur

each year and 135,000 of these patients die. Approximately 500,000 of the cases and 50,000 deaths are due to the meningococcus. In nonepidemic conditions, meningococci cause 10-40% of cases of purulent meningitis. This shows that Cerebrospinal Meningitis (CSM) is really a deadly disease.

Spatial Pattern

The spatial pattern of CSM in the study area was determined using the hospital records. Out of the 2595 total cases of CSM in the study area from 1990-2009, 965 patients residential addresses were not ascertained. Those whose records show their areas of residence in the study area were 1630 people. Thus, the total number of 1630 patients analyzed below show the spatial spread of the disease.

Table 6: Patients' Residential Area

LGA	TOTAL	PERCENTAGE
Zaria LGA	848	52
Sabon Gari LGA	489	30
Outside the Study Area	293	18
Total	1630	100

Source: Fieldwork, 2009

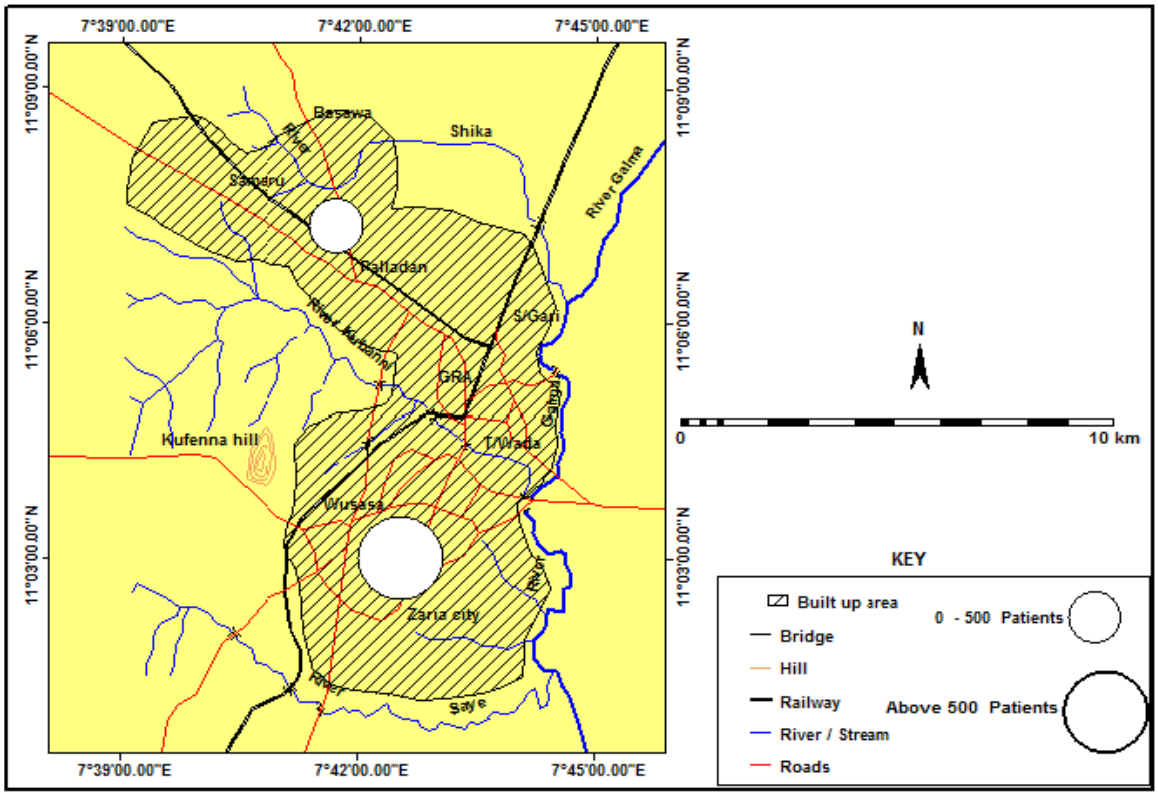

FIGURE 4.5 : SPATIAL DISTRIBUTION OF CSM PATIENTS IN THE STUDY

Source : Adapted and Modified from Topographic Map of Zaria, 2012

Table 6 shows that 52% of the respondents reside in Zaria Local Government Area of Kaduna State, 30% of the respondents reside in Sabon Gari Local Government Area of Kaduna State while the remaining 18% of the respondents reside outside the study area. Fig 4.5 further illustrates the spatial distribution of CSM in Zaria and Sabon Gari Local Government Areas. This distribution indicates that a high concentration of cases of CSM patients is recorded in Zaria Local Government Area than in Sabon Gari Local Government Area. This could be attributed to the housing structure pattern, cultural beliefs, economic status and sanitary condition existing in the area. Zaria Local Government, for instance, is dominated with houses made of mud and other local housing materials compared with Sabon Gari Local Government Area dominated by non-indigenes with relatively better housing conditions, economic status and sanitary condition.

In terms of the socio-economic characteristics, few cases occurred among those belonging to the upper social classes. People of low socio-economic status comprising of workers at low cadres, students, and those engaging in petty trading and farming are most susceptible. Its prevalence it encouraged especially between close contacts such as in households, or between recruits, hostels/borders schools and even in market places. The study also shows that most of the victims of CSM are students and children. Inadequate housing accommodation and poor housing structure also encourage the spread of CSM. It was observed that most patients do not go for medical treatment on time until the infection has reached its critical stage. This often leads to high death rate.

Analysis of the housing types indicates that 111 respondents (30%) reside in modern housing structure while 261 respondents (70%) reside in local housing structure. It also shows that there was evidence of crowding in houses, inadequate number of doors in houses, inadequate windows, in some cases where windows exist there were cases of inadequate sizes and also cases of houses not fenced and being closely situated. All these poor housing conditions pave way to high temperature effect on ventilation which constitute CSM outbreak. Thus, this substantiates the assertion that climatic conditions and the socio-economic characteristics of the people influence the outbreak and prevalence of CSM in Zaria.

CONCLUSION

This study has evaluated the effects of environmental factors on the outbreak of Cerebrospinal Meningitis (CSM) in Zaria. It can be inferred based on the findings of the study that CSM is highly prevalent in the study area occurring on an annual basis. It can also be deduced that climatic parameters influence CSM outbreak especially temperature having a direct relationship with the outbreak of meningitis. The disease is found to have affected the study area throughout the 20 years (1990 to 2009) understudy and has a wide geographical distribution in Zaria.

Poor housing as shown in this study is a high risk factor in outbreaks of meningitis. Thus, there is the need to emphasis good housing during health education sessions in the control of epidemics. The burden of many communicable diseases like meningitis could undoubtedly be reduced by environmental management and adequate housing. This will largely require individual/community participation.

Future outbreaks of CSM can be better prevented or controlled if people can be well mobilized in contrast to the usual practice or reliance mainly on government intervention. Available infrastructure must be improved so that any outbreak will be quickly recognized and controlled.

As an air and water-borne disease, Meningitis will certainly find a fertile breeding ground in dirt, a factor which is not in short supply all over the country. Within our inability to stop it before it strikes, we are left with no option but to try and contain the scourge before it spreads too far. Towards containment, the federal government must make the vaccines available for general immunization so that communities where the disease has manifested and where it has not will be immunized against it.

The local people can be used for early recognition and detection of cases. This control measure can be put in place quickly. This will also reduce under-reporting of cases which is common in most cases in the study area. Thus, involvement of the community in early recognition, detection and control of outbreak will assist a lot, more so in rural areas where health facilities and manpower are scarce.

These findings, which have substantial implications for directing surveillance activities and health policy, provide a basis for monitoring the impact of climate variability and environmental change on CSM occurrence in Zaria and its environs. Epidemics occur throughout the study area in the dry season, coincide with periods of very low humidity and dusty conditions, and disappear with the onset of the rains, suggesting that these environmental factors also play an important role in the occurrence of the disease. Thus, all the relevant environmental factors must be put into consideration in the prevention or control of cerebrospinal meningitis in Zaria and its environs.

REFERENCES

Abbas, I.I. and Arigbede, Y.A. (2011). Sustainable Land Management in Zaria Using Remote Sensing and GIS Techniques; *Journal of Ecology and the Natural Environment* Vol. 3(4). Retrieved 23, May 2012 from http://ww.academicjournals.org/jene

Akande, T.M. and Olu, O. (1998). Perception and Attitude to Outbreak of Meningitis. *Nigerian Journal of Medicine* Vol. 7 (4) 154-156

Attia, J., Hatala, R., Cook, D.J. and Wong, J.G. (1999). The Rational Clinical Examination: Does This Adult Patient Have Acute Meningitis?. *JAMA* 282(2):175-89

Cheesbrough, J.S., Morse, A.P., and Green, S.D.R. (1995). Meningococcal Meningitis and Carriage in Western Zaire: A Hypoendemic Zone Related to Climate. *Epidemiol Infect* 114: 75-92.

CRS (2009). Sample Size Calculator. Creative Research System Retrieved June 12, 2009 from http://www.survey system.com

FEPA (1999). National Policy on the Environment. Revised Edition. Nigeria. Federal Environmental Protection Authority, Abuja.

Jones, K. and Moon, G. (1987). *Health, Disease and Society*. London, Routledge and Kegan Paul

Lapeyssonnie, L. (1963). The Meningococcal Meningitis in Africa. *Bull. World Health Organization* 28 (3). pp114

Logan, S.A. and MacMahon, E. (2008). "Viral Meningitis". *BMJ (Clinical Research Ed.).* 336(7634):36-40.

Murfin, D. and Dyfed, A.G.P. (1999). Public Concern about Meningitis. *The Practitioner*. A United News and Media Publication. 240. 401-406

Rodo, X., Pascual, M., Fushs, G. and Faruque, A.S. (2002) Enso and Cholera: A Non Stationary Rink related to Climate Change. *Proc Nat Acad Sci. USA* 99: 12901

Saez-Llorens, X. and McCracken, G.H. (2003). Bacterial Meningitis in Children. *Lancet* 361 (9375): 2139-48.

Vaughan, C. (2000). Climate and Meningitis in Africa. *Climate Matters Columbia.* The Earth Institute. Columbia University.

Weekly Trust (2009). Meningitis Ravages the North; Saturday February 21 2009.

Wikipedia (2012). Global Warming. The Free Encyclopedia. Retrieved 20 May 2012 from Wikipedia.

WHO (2003). Meningococcal Meningitis.*World Health Organization Fact Sheet 2003, No. 141. Available:http://www.who.int/mediacentre/factsheets/2003/fs141/en/indexhtml*

WHO (2005). Weekly Epidemiological Record. Vol. 80 No.1-52. Jan-Dec. 2005. Pub 1: World Health Organization Geneva. Retrieved April 15, 2009 from *http://www.who.int/wer*

WHO (2009). Meningococcal Disease: World Health Organization Situation in the African Meningitis Belt. Retrieved January 24, 2012 from *http://www.who.int/csr/don/2009_03 25/en/index.html. Retrieved on 29--3-2009*

WHO (2012). Control of Epidemic Meningococcal Meningitis. World Health Organization Practical Guidelines. 2nd (Ed.) WHO/EMC/BAC/98.3. Retrieved 16th March from www.who.int/csr/resources/.../meningitis/whoembac983.pdf

WHO (2012). Which Countries Constitute the Meningitis Belts? Meningococcal Meningitis. World Health Organization, retrieved May 20, 2012 from www.who.int/mediacentre/factsheets/fs141/en