Changing Weather/Climate and Prevalence of Cerebro Spinal Menigitis in Some Selected Stations in Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

This study examines the effects of some weather parameters, such as maximum and minimum temperature (°C), rainfall (mm) and relative humidity (%), on the prevalence of Cerebro Spinal Meningitis (CSM) in South west and North West, Nigeria. Monthly data of reported cases of in- and out- patients of this disease between 1990 and 2007 were collected from Ondo State Specialist Hospital, Akure, and Specialist Hospital, Sokoto while data of relative humidity, rainfall, maximum and minimum temperatures for the same years were collected from the Nigeria Meteorological Agency, Oshodi, Lagos. CerebroSpinal meningitis (CSM), showed a strong correlation with all the weather elements considered but much stronger in the northern station. The study also reveals that CSM occurrence is linked with low minimum temperature (usually less than 20°C) and relative humidity (of less than 40%) which is more common in the northern region. In the south, the numbers of CSM cases are few throughout the year but have a peak during the dry season which is also when the effects of the north east trade winds are being felt. Minimum temperature and relative humidity combinations were used to distinguish between areas with high and low risk of epidemics. Findings from this work can be used for designing early warning decision support systems that can enable the efficient and timely spatial targeting of preventive and control measures against the disease.

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1.INTRODUCTION

Cerebrospinal meningitis (CSM) is a major public health problem in many parts of the world [1,2,3,4]. Meningitis (CSM) is a contagious infection disease which is caused by the bacteria *Neisseria meningitis*. CSM epidemics occur worldwide but the highest incidence is observed in the "meningitis belt" of sub-Saharan Africa, stretching from Senegal to Ethiopia [5,6]). This belt extends some 4,200 km from Ethiopia to Senegal [7], and an average of 600 km from north to south within the 300-mm and 1,100-mm rainfall lines, with a southward digitation going deep into Benin republic. Across this Sudano-sahelian area, endemo-sporadic infections occur annually during the dry season (October-May), while large epidemics appear at longer intervals [8]. The mean annual incidence is about 70 cases per 100,000 persons, yet attack rates during epidemics range from 100 to 1,000 per 100,000 inhabitants per year. CSM is known in Mali as finyabana, literally 'wind illness'. In other countries, people have also noted that the outbreak of the epidemics nearly always coincides with the setting in of the harmattan, a north to east wind, blowing from the Sahara towards the Gulf of Guinea [9,10,11,4]. The harmattan, described as forming part of the trade wind circulation [12], is most prevalent from November till February, when the barometric gradient between the subtropical anticyclonic cell and the equatorial trough is most marked, although the wind can be experienced in some locations as late as May. Temperatures during this period are low (sometimes 16-19°C at 06:00 h), but they rise sharply towards the end of the season. The inhaled air is so dry that children and adults have badly chapped lips and nasopharyngeal mucosa become irritated. However, presumably the most distinctive characteristic of the harmattan is the dust it carries - almost impalpable particles of quartz and clay, colloids or fine mika flakes which can remain airborne for days and which occasionally reduce visibility below 200 metres for up to forty-eight hours. Therefore, the spread of CSM during the harmattan season was empirically recognized, as was the belief that meningitis activity reduces at the onset of the rains. From the revealed literature above, it is almost possible to believe that no research work has been extended to study and model cases of prevalence of this disease and weather parameters in Nigeria. Therefore, the present study attempts to describe the effects of some weather parameters on the prevalence of CSM at two locations in different climatic zones in Nigeria.

2. METHODOLOGY

2.1 Study Areas

Akure is the capital city of Ondo State in the South West, Nigeria, with population of about 500,000 people (Census 2006). It is situated in the humid forest zone of Nigeria. It has an annual rainfall which exceeds 1400 mm, and falls between March and November. Average relative humidity is about 55% during the dry season and 90% during the rainy (wet) season. The mean daily maximum temperature ranges from 26°C to 35°C, while the mean daily minimum temperature range is between 15°C and 23°C.

Sokoto, the capital of Sokoto State is a city located in the extreme northwest of Nigeria, near to the confluence of Sokoto and the Rima Rivers. As of 2006 it has a population of about 427,760. Sokoto is in the sandy savannah. It has an annual average temperature of 28.3°C, Sokoto is one of the hottest cities in the world, however the maximum daytime temperatures are most of the year generally under 40°C, and the dryness makes the heat bearable. The warmest months are February to April, where daytime temperatures can exceed 45°C. Highest recorded temperature is 47.2°C, which is also the highest recorded temperature in Nigeria. The rainy season is from June to September, during which showers are a daily occurrence. The showers rarely last long and are a far cry from the regular torrential showers known in many tropical regions. From late October to February, during the 'cold season', the climate is dominated by the harmattan wind blowing Sahara dust over the land. The dust dims the sunlight, thereby lowering temperatures significantly and also leading to the inconvenience of dust everywhere in the house. Fig. 1 shows the stations used for the study.
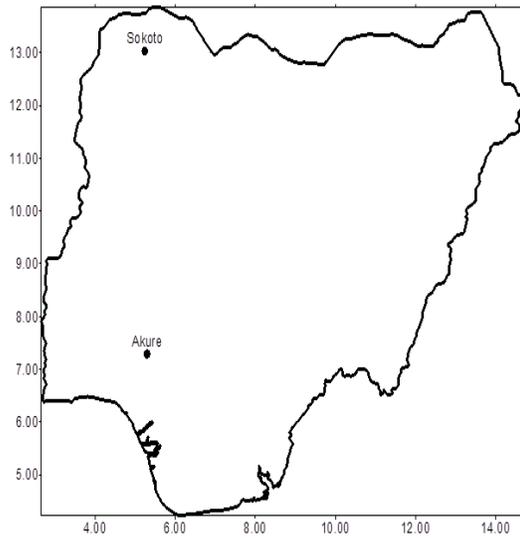
Fig. 1. Map of Nigeria showing the stations used for the study

2.2 Data

Monthly data of reported cases of in- and out-patient and death of CSM data were collected from standard government hospital in Akure and Sokoto between 1990 and 2007. These were extracted from the records of the standard government hospital in the study areas which are the major hospitals located within the cities. Akure data were collected from the Ondo state General Hospital while Sokoto data was collected from Specialist Hospital, Sokoto. These data were obtained for at least ten years spanning between 1990 and 2007. However, only continuous health data were used in the analysis. Monthly maximum and minimum temperatures (°C), rainfall (mm) and relative humidity (%) data were collected for the same stations as the medical data from Nigerian Meteorological agency (NIMET), Oshodi, Lagos. This agency is the only approved government agency that collects and archives meteorological data in Nigeria. These data were collected for at least twenty years spanning between 1990 and 2010.

2.3 Method of Analysis

The CSM data and meteorological variables were analysed using time series analysis ranging from monthly, seasonal and annual levels. For each time frame, the mean of all the variables over the period were calculated. Time series analysis to assess the periodicity was conducted on CSM data and meteorological variables [13]. The CSM data and meteorological data were deseasonalized in order to control seasonality and assess the influence of weather variables on CSM prevalence. The statistical relationship between CSM prevalence and meteorological variables before and after deseasonalization of data were carried out in order to determine correlation coefficient (r), coefficient of determination ($R2$) and p-value [14,15]. In order to assess the magnitude of meteorological variables (independent covariates) on CSM occurrence (dependent variable), Poisson multiple regression models in Generalized Linear Models, GLMs [16,17] was used after deseasonalization of both meteorological and malaria data.

2.3.1 Meteorological conditions

The harmattan ambiance was identified and defined to an extent, an arbitrary matter, but it was based on a long experience of the study areas and it had already proved to be relevant in climatopathological studies [12,18].

To get an expression of harmattan exposure, the following specific meteorological situation were identified when these conditions were simultaneously satisfied, namely a minimum mean temperature of less than 20°C and a mean relative humidity of less than 40%.

3.RESULTS

3.1 Descriptive Epidemiology

The stations for this study fall within different climatic zones. The mean monthly occurrence of this disease is presented in Fig. 2(a and b).

From the above figure, occurrence of CSM varies from station to station and from month to month. It is observed that it occurs all year round in Akure while about four months have no reported cases in Sokoto. However, a very high number of cases were reported within the epidemic months of January and April in Sokoto. The highest number of cases in Akure is 30 which were observed in January while about 6000 cases were observed in March in Sokoto. The total number of cases between 1990 and 2007 in Sokoto is 15,600 while that of Akure
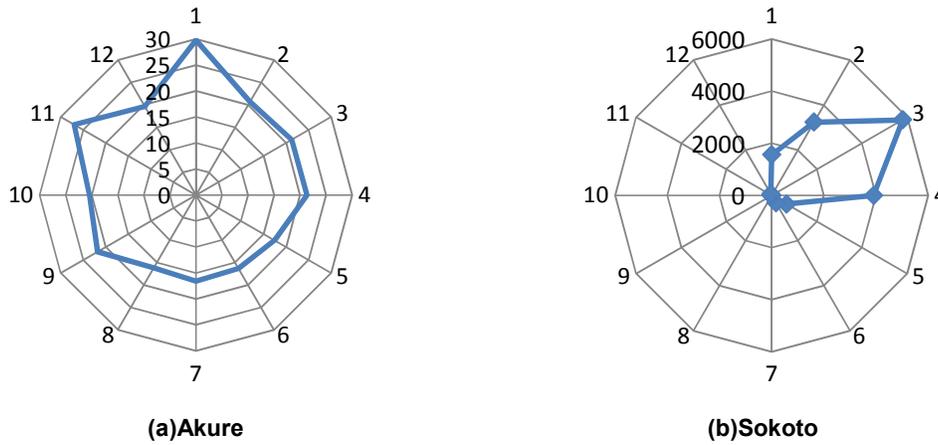
(a)Akure

(b)Sokoto

Fig. 2(a, b). Mean monthly occurrence of CSM (a) Akure and (b) Sokoto

(a)

(b)
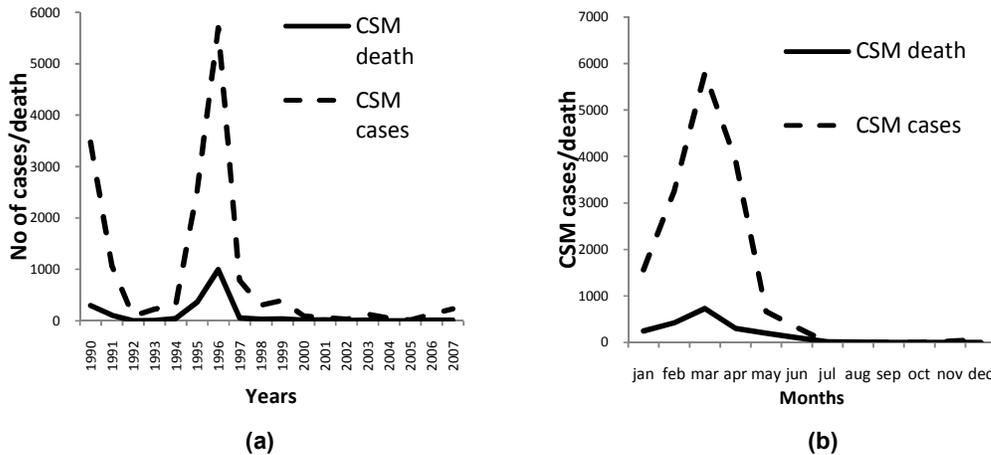
Fig. 3. (a) Annual variation of CSM cases and death (b) Mean monthly variations at Sokoto

is only 2,983 cases. It is therefore, evident that meteorological conditions have roles to play in the occurrence and spread of this disease since the stations fall in different climatic zones resulting in a marked difference in the distribution of the disease.

From the figure, the period 1990 to 2000 can be considered to be epidemic years because reported cases were high especially in 1996. Also, maximum number of cases and deaths occur between the months of January to May. This indicates that most occurrences and death occur during the dry season. Considering the case-death ratio, it is as high as 3:1 in April and May while it is 5:1 in 1996 the year of maximum, which is still high. Thus, CSM appeared to be proportionally the most deadly in the area.

3.2 Relationship between Csm and Meteorological Variables

The relationship between CSM and some weather elements was considered by looking at their correlation coefficients. These coefficients are presented in Table 1.

From the table, a positive relationship exists between CSM and Temperature (maximum and minimum) while it is negative with both rainfall and relative humidity in both stations. These correlation values are significant. Howeverlow values less than 0.50 were observed in Akure for minimum temperature and rainfall in Sokoto.

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3.3 Regression Equation

The analysis of the effects of weather parameters on CSM suggests a need to distinguish between two main geographical areas, northern and southern Nigeria. Table 2 shows the regression equations for the stations while Table 3 shows the observed and estimated number of CSM patients.

The regression model showed an undeniable statistical dependency of CSM on the weather variables (Table 2) .Thus, with R square values ranging from 0.46 in Akure to 0.81 in Sokoto shows that the strong dependency is not in doubt.

The strong association is obvious in Table 3 which shows the closeness of the observed and estimated number of CSM patients.

Table 1. Correlations between CSM and weather variables

Station/Weather variables	Max. Temp.	Min Temp	Rainfall	Relative humidity
Akure	0.50	0.22	-0.46	-0.55
Sokoto	0.60	0.54	-0.40	-0.58

Table 2. CSM-weather relationships: Results of the linear regression for the period 1990-2007

Station/ variables	Constant	Max. temp	Min. temp	Rainfall	Relative humidity	R	R square	Significance
Akure	102.21	2.02	-4.40	0.01	-0.47	0.68	0.46	0.05
Sokoto	-1148.91	319.2	387.95	32.09	-175.29	0.90	0.81	0.05

Table 3. (a-b) Observed and estimated number of CSM patients

(a) Akure

Month	Std. residual	Observed value	Estimated value	Residual
Jan	0.735	30	27	3
Feb	-0.682	21	23	-2
Mar	0.076	21	21	0
Apr	0.302	21	20	1
May	-0.528	17	19	-2
Jun	-0.997	16	20	-4
Jul	-0.063	17	17	0
Aug	-0.305	16	17	-1
Sep	0.776	22	19	3
Oct	0.076	20	20	0
Nov	1.671	27	21	6
Dec	-1.062	20	24	-4

(b) Sokoto

Month	Std. Residual	Observed value	Estimated Value	Residual
Jan	1.015	1561	475	1.09E+03
Feb	0.377	3249	2845	403.529
Mar	0.347	5802	5431	371.099
Apr	0.706	3915	3160	754.626
May	-0.162	661	834	-172.737
Jun	0.223	324	85	238.954
Jul				
Aug				
Sep				
Oct				
Nov	-1.987	24	2149	-2.13E+03
Dec	-0.298	64	382	-318.242

3.4 Meteorological Conditions and Csm Prevalence

A meteorological index was used to investigate whether weather conditions could explain the spatiotemporal variations of CSM. A weather pattern was defined, to a certain extent it's arbitrary, but it has been used by [12,18] based on a long experience of the country of study. It had however proved to be relevant in the climatopathological studies [12,8]. To get an expression of this index, a specific meteorological situation when two conditions were simultaneously satisfied, was identified, namely, a minimum temperature of not more than 20°C, a mean relative humidity of not more than 40%. Fig. 4 was obtained from the index for Sokoto. The condition was not satisfied in Akure, therefore, all the CSM cases reported occurred outside the said meteorological condition.

It is noted that the set meteorological condition is synonymous with the period of harmatan. Therefore, there is a link between harmatan and occurrence of CSM and this condition is common between December and May in Sokoto. This work has clearly identified the spatial variation of the conditions for CSM between northern and southern Nigeria.

4. DISCUSSION

The meteorological factors that can trigger the occurrence of CSM have (to an extent) been identified. However, the results may possibly generate some questions. First, does CSM always prevail during the dry season? Secondly, can changing weather and climate expand the spread of this disease? It can be defended that the results are consistent with the previous findings and actually support the classical explanatory model of CSM-weather relationship [19,20] but these studies identified occurrence of CSM prior to harmatan which was possible because weekly data were used while monthly data were used for this study. In an averaged situation, the risk increases for seasons and locations where the north east trade wind blows with the greatest regularity which actually differentiate the prevalence of these two stations, [21] stated that meningitis is completely in the wake of the harmattan. However, it is probable that the impact of weather/climatic elements could hardly exceed the degree of correlation because two scenarios are interfering with each other; one relating to season and the other relating to people referred or coming from another location. A latent period of 3-8 days usually separates a climatic aggression and the disease outbreak [8]. It follows that monthly report of cases or deaths can only give a rough indication of the prevalence trend, and it is probable that meningitis case counts over a 10-day period would have provided moresignificant results. Similarly, incidence rates at the regional level may not accurately reflect the intensity of the disease at the village or city level since it has been reported that meningitis is never uniform over large areas [22]. Furthermore, a lot has been discussedabout the dry season prevalence of the disease across sub-Saharan Africa with only a few rare exceptions [23,24]. The transmission of aerosol particles containing potentially pathogenic meningococci continues throughout the year. It is also worthy to note that upper respiratory infections and CSM almost follow the same seasonal pattern [20]. In particular, throat infections diagnosed from 1987 to 1992 on clinical grounds peaked between January and February in two health care services

a. Akure

b. Sokoto
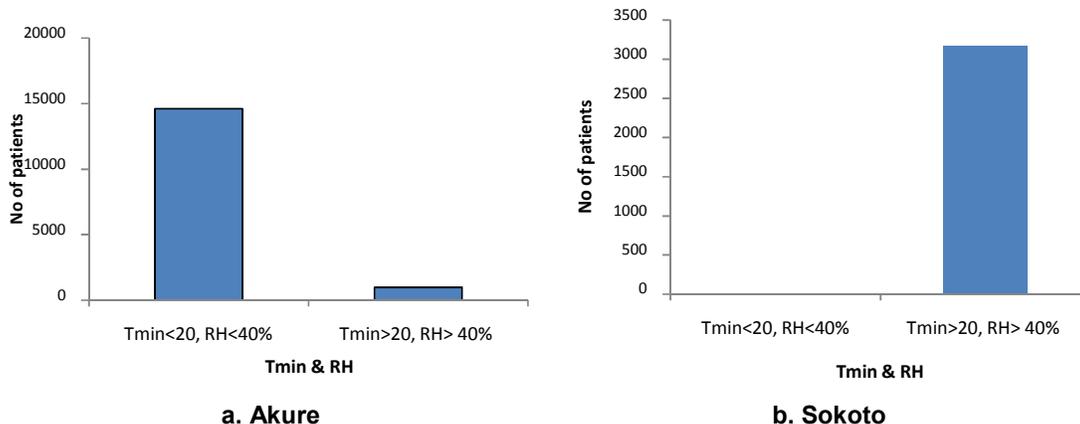
Fig. 4. Different meteorological condition and CSM occurrence

of Natitingou in Benin republic [20], while they reached their highest incidence in June or July at Cotonou in Benin republic [20]. In both locations, the peak of pharyngeal diseases occured about one month before meningitis cases becomes the most frequent. Furthermore, deforestation is also an issue which can cause harmatan to blow with increased force near ground level, [25]. In conclusion it can be said that CSM mainly affects the northernmost regions of Nigeria from November to March, April while few cases are observed in the south throughout the year and peaks in January. Regression analysis confirmed that a notable part of the space/time variability of the disease is due to the weather. However, the climate-meningitis relationship proved to be stronger than is sometimes despite the anthropic effects (vaccination campaigns).

5. LIMITATIONS OF THIS WORK AND DIRECTIONS FORFUTURE RESEARCH

The data analyzed in this study has obvious limitations related to coverage and completeness, and thus can underestimate or overestimate the actual diseases incidence rate in the population. Although the data were of relatively good quality compared to those available in many private hospitals. Nonetheless, this study illustrates the importance of meteorological data in identifying diseases hotspots and distribution, which cannot be accomplished using population surveys.

It is possible that more accurate disease modelling may require the inclusion of non-climatic causes as well. Nonetheless, statistical time-series modelling to analyse meteorology-human disease link appears to be a promising approach to predicting diseases incidence and give room for further investigation.

6. CONCLUSION

This work has investigated the effects of some weather parameters, such as maximum and minimum temperatures, rainfall and relative humidity, on the incidence of CerebroSpina Meningitis (CSM) in some stations in Nigeria. Monthly data of reported cases of in and out patients of these diseases between 1990 and 2007 were collected from Sokoto State specialist hospital, Sokoto while data of relative humidity, rainfall, maximum and minimum temperature for the same years were collected from the Nigeria Meteorological Agency, Oshodi, Lagos.

This human disease can be identified as one of the most deadly diseases in Nigeria which threaten the well- being of the people. This disease is classified as tropical disease because the weather within the region can help in triggering it, which the results of this work have confirmed.

CSM showed a strong correlation with all the weather elements considered but much stronger in the northern station. The analysis indicates not only that they are strongly related but the occurrence is more prevalent in the northern station. The work also reveals that CSM occurrence is linked with low minimum temperature (usually less than 20°C) and relative humidity (of less than 40%) which is more common in the northern region. In the south, the number of CSM cases is few throughout the year but get to the peak during the dry season which is also when the effects of the north east trade winds are being felt. Minimum temperature and relative humidity combinations can be used to distinguish between areas with high and low risk of epidemics.

For public health scientists and officials, the primary goal is to prevent any increases in disease associated with changing weather and climate. Both scientists and policy-makers are interested in the magnitude of potential effects and their distribution, which regions is the most likely to be affected? Why? When? How can vulnerability be reduced and adaptive capacity increased? Findings from this work can be used for designing early warning decision support systems that enable the efficient and timely spatial targeting of preventive and control measures against the disease.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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