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Effects of Weather and Climatic Elements on the Incidence of Pneumonia in Kaduna South Local Government Area, North Western Nigeria

Felix Ike*, Chioma Mbonu

Department of Geography and Planning, Faculty of Environmental Science, Abia State University, Uturu, Nigeria

Email address:
chiemzy@yahoo.com (F. Ike), mbonuchioma09@gmail.com (C. Mbonu)

*Corresponding author

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Abstract: This study assessed the relationship between weather and climatic elements on the incidence of pneumonia in Kaduna South Local Government Area, North Western Nigeria. The main objective of the study was to determine the incidences of pneumonia and assess its relationship with weather elements. This paper also reported on the seasonality of Weather parameters and how they can affect pneumonia occurrence in the study area. The data used were meteorological (Rainfall, Humidity and Temperature) and pneumonia records collected from Nigerian Meteorological Agency and Government General Hospital, Kakuri respectively. Multiple regression model and seasonality metrices were employed in the analysis of the data to determine the strength of relationship between the weather parameters and the frequency of pneumonia outbreak. The model run indicated that the combined effect of temperature, rainfall and humidity significantly accounts for variations in Pneumonia occurrence at different level of probability. However the weather elements could only explain 16% of the variations in the incidence of Pneumonia in the study area for the period between 2008 and 2015. The examination of the seasonal occurrence revealed that pneumonia occurred mostly in the cold & wet season and the cold & dry seasons. The study concluded that weather elements play a role in the incidence of pneumonia in the study area and should be considered along with other factors in mitigating its occurrence.

Keywords: Seasonality, Pneumonia, Trends, Rainfall, Humidity and Temperature

1. Introduction

It is generally acknowledged that our climate is changing and these changes have the potential to affect human health [1]. The population of all organisms depends upon the supplies of food and water, freedom from excess infectious diseases and the physical safety and comfort conferred by climatic stability. The characteristics, geographical distribution and seasonal variations of most infectious diseases are evidence that their occurrences could be linked to weather and climate factors. Extremes of temperature, precipitation and humidity affect the life cycle of many disease pathogens and vectors (both directly and indirectly) and this potentially affects the timing and intensity of disease outbreak [2]**.** More acutely, disaster and disease outbreaks have occurred very often in response to extreme regional climate cycles such as El Nino/ Southern oscillations (ENSO) cycles [3]. Climate can affect human health directly through the impact of thermal stress, death and injury in flood and storms and indirectly through changes in ranges of disease vectors, water-borne pathogens and air borne pathogens. Climatic factors are important determinants of various respiratory diseases. Relationship between year to year variations in climate and respiratory diseases are more evident where climatic variations are marked with vulnerable populations [3, 4]

Pneumonia accounts for more under –fives mortality than malaria, AIDS and meningitis combined [5]. A recent community-based survey indicated that 20% of Kaduna children die before their 5th birthday and pneumonia alone accounts for 16% of under-five mortality [6]. Weather elements affect the timing and intensity of the outbreak of

respiratory diseases (pneumonia) which the people are ignorant of and this seems to be the reason for ill health, increased hospitalization and death rate in the locality which the forgoing literatures have not addressed.

The physiological function of the human body responds to changes in weather condition. Indeed the seasonal or periodic nature of outbreaks of some human diseases such as respiratory diseases suggests that climate conditions play an important role in the seasonal variations [7]. Most vector-borne diseases exhibit a seasonal pattern [8] which clearly suggests that they are weather sensitive. Rainfall, temperature, relative humidity, wind, cloud and sunshine affect in many ways both the vectors and pathogens they transmit spatially and temporarily. They may have a profound impact on transmission cycles of diseases by influencing the availability of vector longevity and altering host breeding and migration pattern. For example, high temperatures can increase or reduce survival rate, depending on the vector, its behaviour and many other factors [6, 8]. Thus the probability of transmission may or may not be increased by higher temperatures.

Ojo, O, [9] reported that weather parameters influence the incidences of diseases in two major ways. Firstly, they affect the resistance of the human body making it more susceptible to diseases. Secondly, weather parameters influence growth, propagation and spread of some diseases like pneumonia, malaria and meningitis. Tania A. et al. [10], reported that exposures to carbon monoxide and nitrogen oxide can cause aggravation of existing cardiovascular diseases, affect breathing, respiratory illness, lung irritation and alterations in the lungs defence system.

It has been observed that in Nigeria, very little effort have been made to identify the effects of weather conditions on the occurrence of respiratory diseases. It is pertinent therefore, that a study of this nature be carried out so as to provide background information for health care practitioners on effects of weather and climatic elements on pneumonia.

2. Methodology

2.1. The Study Area

Kaduna south local government area is one of the 23 L.G.As of Kaduna state. It is surrounded by Kaduna North L.G.A to the North, Igabi L.G.A to the West and Chikun L.G.A to the South and East. It is located approximately between latitude 9°54'N and 10°29'N and between longitude 6°59'E and 8°09'E (Figure 1).

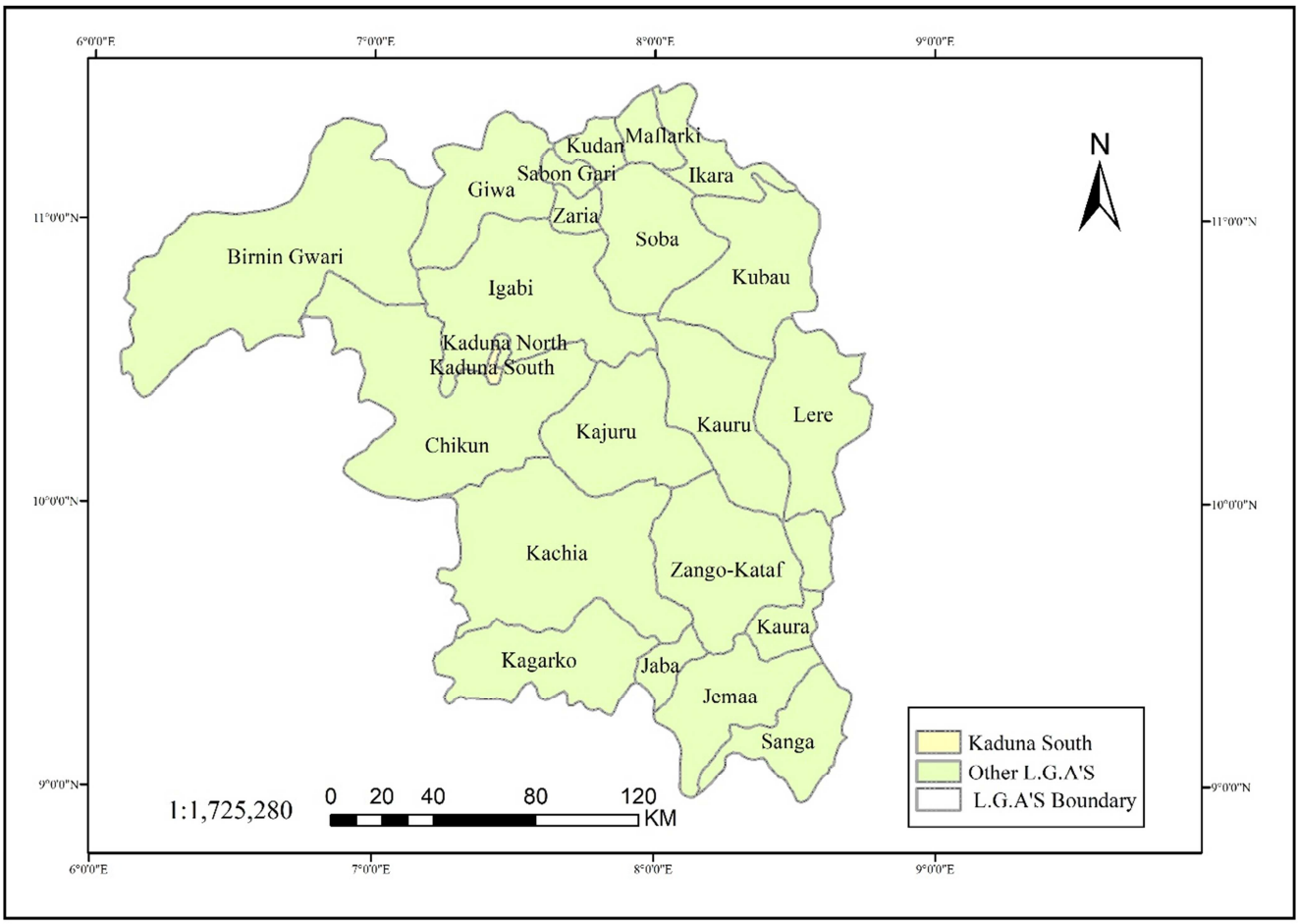

Figure 1. *Kaduna State, Showing the Study Area.*

The climate of Kaduna metropolis is influenced by two dominant air masses namely; the tropical maritime or south-west trade wind which blows across the Atlantic Ocean and the tropical continental or north-east trade wind which blows across the Sahara desert. The rainy season lasts from April-October (about 7 months) with its peak in July to August. The average annual rainfall is about 1000-1400mm. Temperatures are high throughout the year with the highest in March (about 38.6°C). The lowest is in January (about 20.2°C). Relative humidity in the dry season is below 10% in the afternoon and 90% at dawn. During the rainy season, the relative humidity can be over 70% in the midday and 95% at dawn [11]

The vegetation of the area with an annual rainfall of about 1000-1400mm is typical Guinea savannah with tall grasses of about 1.5-2m in height, scattered trees and gallery forest along river courses.

2.2. Data and Analysis

The data collection exercise involved collection of numerical meteorological and hospital data. Purposive sampling technique was used in the collection of hospital data from Government General Hospital Kaduna. The choice of this hospital was based on the fact that the above named hospital has existed for over 8 years and has the records of permanent residents in the study area treated between 2008 and 2015. The choice was also based on the fact that all pneumonia cases that are reported to all the Primary Health Care centers in the local government are referred to the General Hospital based on government directives.

The meteorological data of the study area was collected from NIMET (Nigerian meteorological Agency-https://nimet.gov.ng/) Kaduna state chapter. The data collected were for temperature, rainfall and relative humidity covering the period between 2008 and 2015. The medical record on the incidence of Pneumonia covering 2008 to 2015 were also collected from Government General Hospital, Kaduna. To determine the relationship between the weather elements (temperature, relative humidity and rainfall) and the incidence of pneumonia in Kaduna South Local Government area, the ordinary least square (OLS) estimates of the multiple regression models was used. To harmonize the data sets for relationship determination, values of climatic elements and reported cases of the disease were also transformed to a common base using log10 [12]. The multiple correlation coefficient formula is given by

$$Yi = B0 + \beta 1\, X1i + \beta 2\, X2i + \beta 3\, X3i + \varepsilon i \quad (1)$$

Where: Yi is the dependent value or incidence of Pneumonia and B0 is the constant showing intercept for regression, X1i, X2i, and X3i represents the temperature, rainfall and relative humidity respectively. β1 to β3 are the independent variable coefficients while εi represents the error term. The seasonal metrices of the occurrences were determined by aggregating the pneumonia counts into for seasonal threshold of Cold/ dry, Hot / dry Warm/ Wet, Cold /Wet and Cold / dry.

3. Results

3.1. Trends in Weather Parameters and Incidence of Pneumonia

Table 1. *Temperature metrices (^{0}C) from 2008-2015 in the study area.*

	2008	2009	2010	2011	2012	2013	2014	2015	MONTHLY MEAN
JAN	22.2	24.7	24.0	22.9	23.0	24.7	24.7	22.6	23.6
FEB	24.7	27.1	27.6	27.5	27.3	26.9	26.7	27.7	26.9
MAR	29.3	29.3	29.4	28.9	28.2	29.6	29.2	28.8	29.1
APR	29.2	29.4	29.8	29.4	29.3	29.0	29.3	29.3	29.3
MAY	26.9	28.0	28.3	27.5	26.9	27.6	27.4	29.2	27.7
JUN	26.2	25.7	26.2	26.1	25.5	25.6	30.0	26.4	26.5
JUL	24.6	24.9	24.9	25.1	24.5	24.6	25.3	25.4	24.9
AUG	24.4	24.9	25.0	24.7	24.0	24.1	24.3	25.0	24.6
SEP	25.5	25.6	24.7	25.4	24.9	25.1	25.0	25.2	25.2
OCT	25.1	25.9	26.3	25.8	26.4	25.7	25.6	26.7	25.9
NOV	24.5	24.4	25.4	23.8	25.4	25.5	25.4	24.8	24.4
DEC	24.3	23.5	23.0	22.7	23.8	24.1	23.7	21.5	23.3
ANNUAL MEAN	25.6	26.1	26.2	25.8	25.8	26.0	26.4	26.1	

As indicated in Table 1, maximum annual mean temperature of 26.4°C was recorded in 2014. Generally, for the period between 2008 and 2015, the months of March to June accounted for the maximum temperature readings. Correspondingly, the maximum and minimum monthly mean temperature were recorded in April (29.3°C) and December (23.3°C) respectively.

Figure 2 shows a progressive increase in the amount of rainfall from the month of February to August after which there was a slight decrease in September and a massive decrease in October. There was no rainfall in the months of November, December and January. The highest rainfall for the period under review amount was recorded in August [206.7mm to 521mm] with September being the second highest with a total rainfall amount. Thus, Kaduna south experiences maximum rainfall peak in August/September.

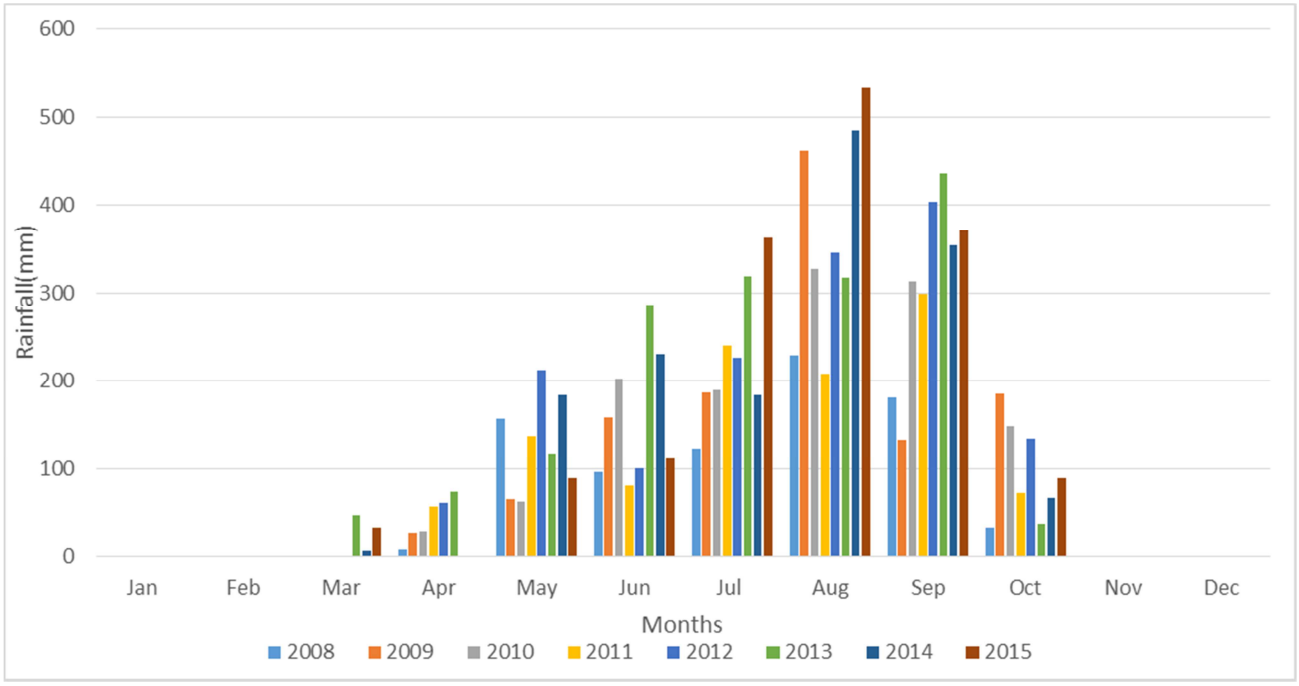

Figure 2. *Rainfall Trends in Kaduna South Local Government Area.*

Table 2. *Relative humidity (%) from 2008-2015, along with monthly and annual means.*

MONTH	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL	MONTHLY MEAN
JAN	29	26	25	21	24	25	29	23	202	25.3
FEB	18	18	23	29	22	32	29	26	197	24.6
MAR	27	20	25	22	19	40	34	31	218	27.3
APR	41	57	43	40	58	60	47	28	374	46.8
MAY	68	67	70	73	70	71	71	62	552	69.0
JUN	75	77	78	76	76	76	77	74	609	76.1
JUL	79	79	82	78	78	78	80	78	632	79.0
AUG	83	81	83	82	83	82	82	83	659	82.4
SEP	78	78	71	80	80	79	79	81	626	78.3
OCT	65	78	77	73	75	65	71	74	578	72.3
NOV	33	44	49	39	46	39	42	39	331	41.4
DEC	31	27	30	26	30	30	29	28	231	28.9
TOTAL	627	652	656	639	661	677	670	629		
ANNUAL MEAN	52.3	54.3	54.7	53.3	55.1	56.4	55.8	52.4		

With reference to table 2, Kaduna South experiences a fairly high percentage of relative humidity ranging from 69-82% in the months of May to October. While the remaining months experience low relative humidity of about 25-47%. The highest relative humidity was recorded in the month of August with 82.4% relative humidity while the lowest was recorded in February 24.6%.

Table 3. *Number of Pneumonia cases from 2008-2015, along with monthly and annual means.*

MONTH	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL	MONTHLY MEAN
JAN	7	6	137	91	2	2	9	4	258	32.3
FEB	3	3	6	85	10	0	42	26	175	21.8
MAR	7	9	8	104	6	22	13	15	184	23.0
APR	7	3	6	55	7	8	14	1	101	12.6
MAY	7	34	12	8	8	4	7	0	130	16.3
JUN	15	2	8	25	9	2	13	20	94	11.7
JUL	9	12	9	25	5	8	2	14	84	10.5
AUG	11	6	76	9	31	22	0	27	182	22.7
SEP	2	2	65	7	11	8	11	29	135	16.8
OCT	5	2	56	3	10	20	30	7	133	16.6
NOV	7	12	42	7	17	5	0	4	94	11.7
DEC	2	6	83	3	0	6	13	3	116	14.5
TOTAL	82	147	508	422	116	107	154	150		
ANNUAL MEAN	6.8	12.3	42.3	35.2	9.6	8.9	12.8	12.5		

Table 3 indicates that the number of pneumonia cases varied from month to month. The month of January, February, March and August had high cases of pneumonia.

January, February and March are characterized by low relative humidity, suggesting that the lower the relative humidity, the higher the number of pneumonia cases. January and February are also characterized by low temperatures, suggesting that the lower the temperature the higher the number of pneumonia cases. What this means is that a combined effect of both low relative humidity and low temperature could lead to an increase in the occurrence of pneumonia.

August which is the month with the maximum rainfall amount recorded the second highest number of pneumonia cases. Rainy days are usually cold days and as such are characterized by relatively low temperature. This could also explain the reason for the high occurrence of pneumonia in the month. This also affirms that low temperatures could lead to an increase in the occurrence of pneumonia. The year 2010 recorded the highest total number of pneumonia cases. In this same year, the month of January, followed by December and August recorded the highest cases of pneumonia revealing the same pattern discussed above. This observation is also in the affirmation that low temperature and low relative humidity could lead to an increase in the occurrence of pneumonia.

3.2. Relationship Between Pneumonia and Climatic Variables

The ordinary least square estimates of the multiple regression model for the relationship between pneumonia and the climatic parameters for rainfall, temperature and humidity is presented in Table 4.

Table 4. *Relationship between Pneumonia and Climatic Variables in Kaduna South LGA*

Variables	Coefficient	Standard Error	T-Ratio	P-value
Constant	5.77	5.19	1.17	0.22
Rainfall	0.02	0.31	0.34	0.44
Temperature	0.05	0.02	4.56***	0.001
Humidity	0.03	0.01	-1.17**	0.003
Model Fitness				
R Square	0.16			
F Statistic	5.44			0.0002

Note: ***and ** Significant at 1and 5% Level of Probability respectively.

The F-statistic was estimated to be 5.44 with a P-value of 0.0002. The P-value being less than the standard value (0.01), the model run indicates that the combined effect of temperature, rainfall and humidity was significant at 1% levels of probability. Therefore a significant level of relation exist between Pneumonia and the climatic parameters used. It is pertinent to state that the variation in the reported cases of Pneumonia was low. That is, only 16% of variation in pneumonia was due to the climatic parameters used in this study. In other word, other climatic and human induced factors might be directly or indirectly linked to the incidence of Pneumonia in the study area.

3.3. Seasonal Occurrence of Pneumonia

Table 5 is a report on the seasonal occurrence of pneumonia regarded into five (Cold, Dry, Hot, Warm and Wet) combinations. In 2008 and 2009 the incidence of pneumonia is more during the warm and wet season whereas it recorded low cases in the dry /cold (for 2008) and cold/wet for 2009. In 2010, incidence of pneumonia was more in the cold and dry season with about 83 cases in December. Whereas it recorded low cases during the hot and dry season, as well as the warm and wet season.

Table 5. *Seasonal Occurrence of Pneumonia.*

	Cold and dry		Hot and dry		Warm and Wet		Cold and Wet				Cold and dry	
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2008	7	3	7	7	7	15	9	11	2	5	7	2
2009	6	3	9	3	84	12	12	6	2	2	12	6
2010	6	3	9	3	84	12	12	6	2	2	12	6
2011	91	85	104	55	8	25	25	9	7	3	7	3
2012	2	10	6	7	8	9	5	31	11	10	17	0
2013	2	0	22	8	4	2	8	22	8	20	5	6
2014	9	42	13	14	7	13	2	0	11	30	0	13
2015	4	26	15	1	0	20	14	27	29	7	4	3

The cold and wet season also recorded high cases of pneumonia. For 2011, the cold and dry and the Hot and dry season recorded high cases of pneumonia while some months in the cold and Wet and cold month recorded low cases of pneumonia. In 2012, that the highest case of pneumonia was recorded in the cold and wet season while the hot and dry month recorded low cases of pneumonia. As reported in Table 5, in 2013, the cold and wet season recorded more pneumonia case while the warm and wet season recorded low cases. The year 2014 recorded more pneumonia cases in the

cold and dry season. While the warm and wet season recorded low cases of pneumonia. Finally, in 2015 pneumonia cases occurred more in the cold and Wet season where as it was low in the Hot and dry season.

4. Conclusion

This study have established that weather elements in Kaduna South LGA play a role in the incidence of pneumonia. Therefore Climatic factors are important and should be considered along with other factors in mitigating the spread of pneumonia. The relationship between pneumonia and weather element has been established. But apart from weather, other factors such as indoor smoke, refusal to take vaccines due to ignorance, poverty and others account for the outbreak of pneumonia in the study area. There is need for the public to be enlightened about climate change, its effects and the means of mitigating or moderating its impact in order to reduce the influence of weather on pneumonia and other respiratory diseases.

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