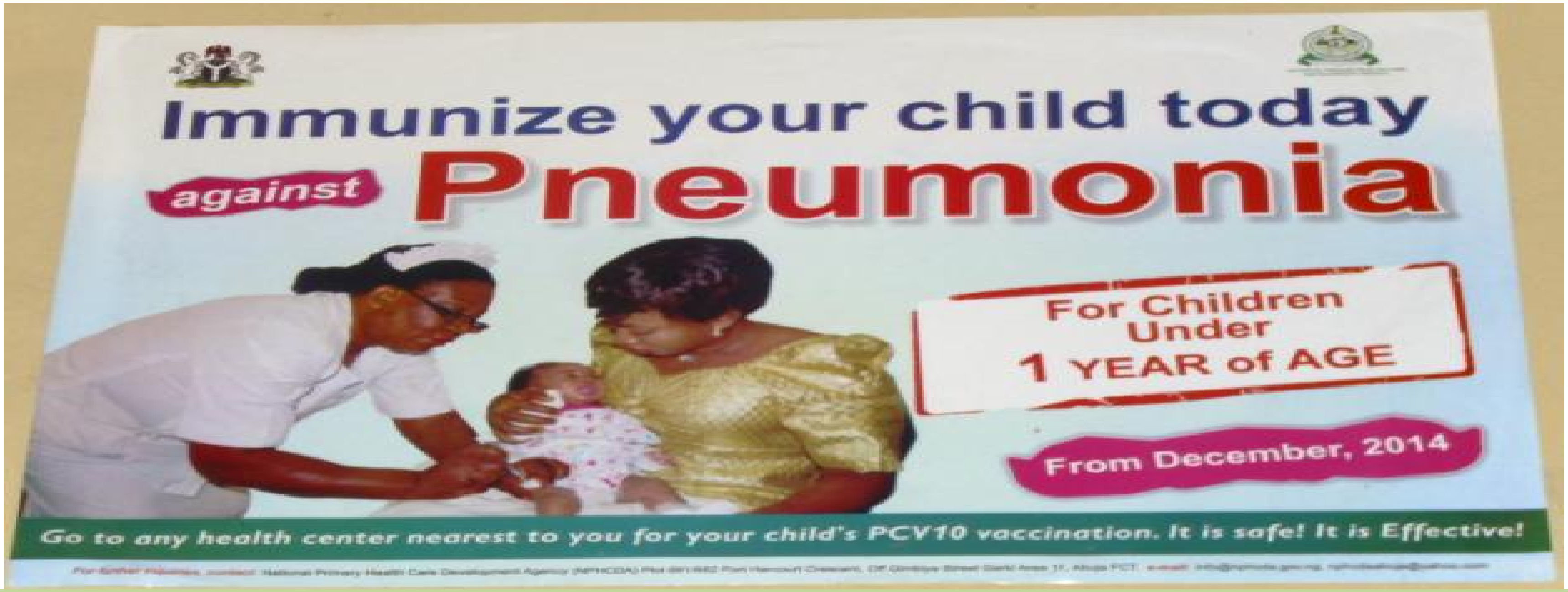
Pneumonia Occurrence in Relation to Population and Thermal Environment in Ondo State, Nigeria

OMONIJO Akinyemi Gabriel

B.Tech (Hons), MEMP, Ph.D

Department of Water Resources Management & Agrometeorology, Federal University Oye-Ekiti, Nigeria



E³S Cross community workshop on Extreme Events and Environments from Climate to Society held on 14th to 16th February, 2016 in Berlin, Germany

PREAMBLE (1)

Climate and weather events play a role in determining the incidence and geographic range of infectious diseases. The scientific interest in the role of the environment, including weather and climate, in the dynamics of infectious disease has been further stimulated by the growing problems of emergence and re-emergence of infectious diseases despite series of intervention policies worldwide (Lipp et al., 2002).

Pneumonia is inflammation of the lung that is often caused by infection with bacteria, viruses, fungi and other agents. There are different types of pneumonia and it's usually classified according to its location in the lung.

Multiple studies have found a relationship between environmental factors and pneumonia incidence; among them are the study of Bull and Morton (1978), which revealed that there is positive correlation between air temperature and lobar pneumonia. According to them, high air temperature causes profound physiologic changes such as an increase blood viscosity and cardiac output leading to dehydration, and even endothelial cell damage.

PREAMBLE (2)

The air temperature at which the lowest lobar pneumonia occurred in this study was around 27°C. In other areas of the globe, the most favourable air temperature varies, from 26°C – 29°C in Taiwan, 22°C in Sao Paulo, Brazil and 16°C in the Netherlands (Pan et al., 1995). Such variation may be explained by differences in housing conditions and by a process of acclimatization to the local climate. Thus, this study emphasizes the importance of thermal comfort, as well as outdoor weather protection for disease prevention. The study of Tromp (1980) demonstrated that maximum air temperature combined with relative humidity influence occurrence of pneumonia.

This work analysed the occurrence of pneumonia transmission with respect to thermal environment based on human-biometeorological approaches in order to ascertain the significant role of human-biometeorological variables in the transmission of the disease because of its seasonal pattern.

DATA AND METHODS

Location and description of study area

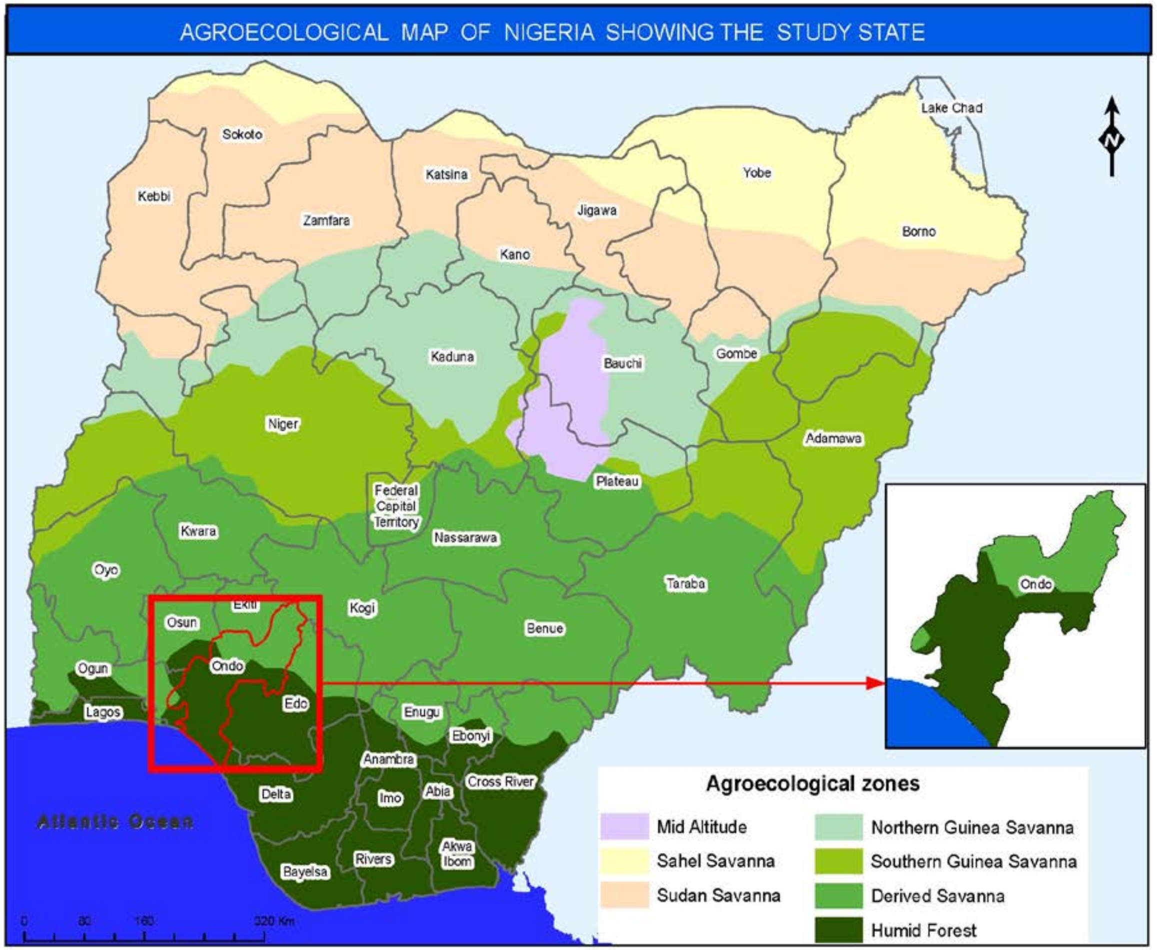
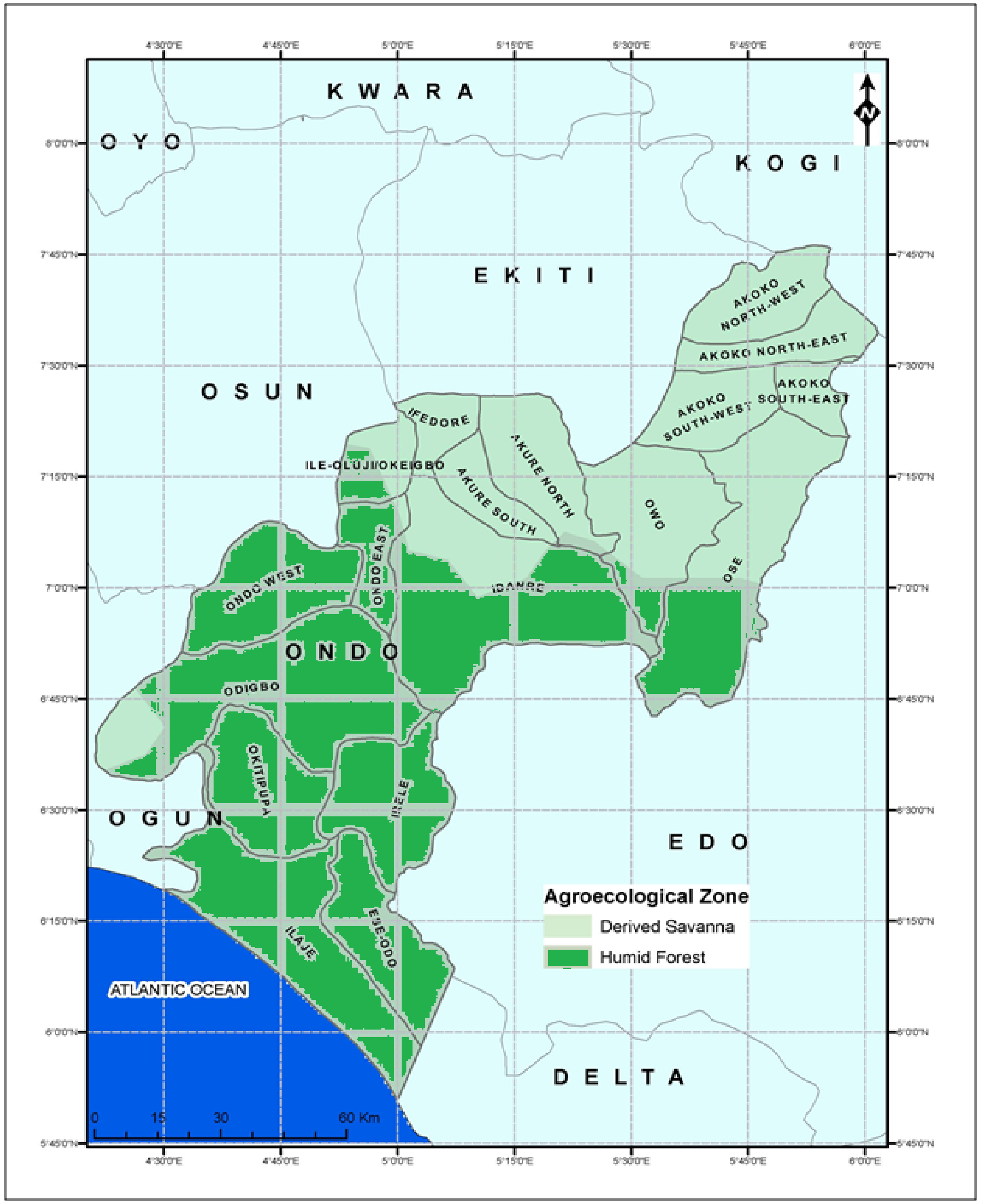


Fig.1: Map of Nigeria showing the study area (Ondo State)



Ondo State (5° 45′ N – 8° 15′ N, 4° 45′ E – 6° 00′ E) is situated in the South-western part of Nigeria (Figs. 1, 2). The state has 18 local government areas (LGAs) with a population of about 3,441,024 according to the 2006 population census and a land area of about 14,606 km^2 (NPC 2006). It has a tropical wet-and-dry climate. Ondo State has a mean annual rainfall of about 1,500 mm and 2,000 mm in the derived savannah and humid forest zones (Adefolalu 1997).

Fig.2: Map of Ondo State (study area) showing the two eco-climatic zones and local government areas (LGAs)

Data Collection and Methods of Analysis (1)

The source of the pneumonia data for the period 1998 to 2008 used in this study is the Monitoring and Evaluation Unit, Ministry of Health, Ondo state. The pneumonia data were collected after approval was given by the ethical committee of the Ministry of Health. The following limitations in this data are recognized: (1) not everyone visit hospital for medical care/treatment, (2) there is no separation between suspected and confirmed pneumonia cases. The information therefore may not represent the true number of cases of pneumonia in each local government areas across the state. However, the data present a general picture of the occurrence of pneumonia in the study area.

Meteorological data—air temperature, relative humidity, wind speed, solar radiation and rainfall—used in this study were provided by the Agro-climatological and Ecological Monitoring Unit, Akure, Ondo State; other meteorological data used were the vapor pressure calculated by RayMan model. The weather stations were located in all the 18 LGA areas headquarter of Ondo State (Fig. 3).

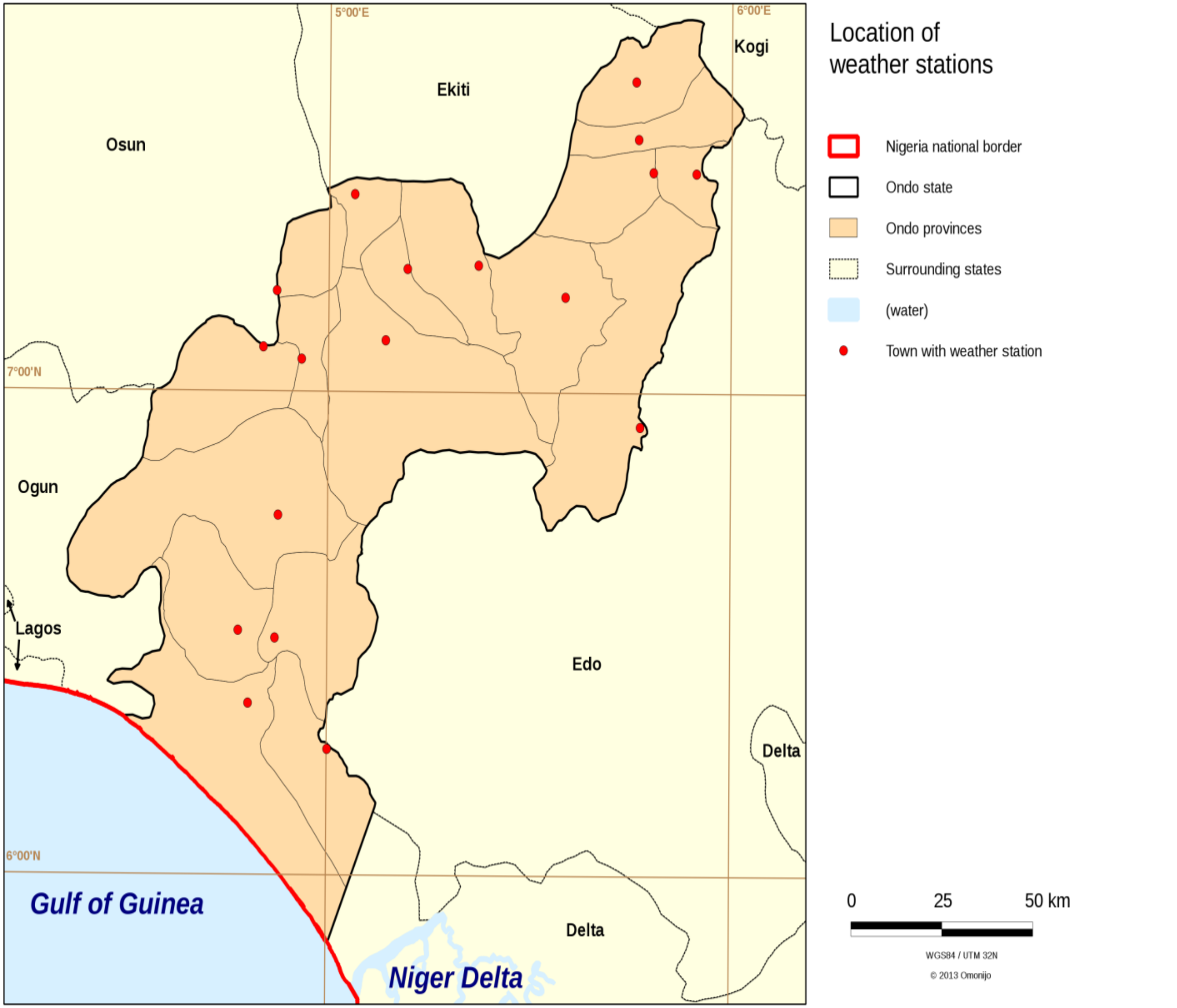


Fig. 3: Map of Ondo State showing location of weather stations

Data Collection and Methods of Analysis (2)

Measurements were taken at 0900 daily; the daily data were aggregated into monthly data by finding the average of daily data over a month SPSS was used to interpolate the missing data. The sea surface temperatures (SSTs) over the area 5°N –5°S, 150°–90°W, known as the Niño3 region in the equatorial Pacific Ocean, obtained from the website http://www.esrl.noaa.gov/psd/data/gridded/ were also included in this study. SSTs over the Niño3 region have been linked to weather patterns over Nigeria, most especially rainfall pattern as noted by Adedoyin (1989); Wassila and Kingtse (2005); Giannini et al. (2003).

In addition, since some studies (Omonijo et al., 2012; Checkley et al., 2000) have linked effects of El Niño to different diseases in several regions of the world, it will be necessary to attempt to assess the role of this ENSO indicator (SSTs) in the occurrence of pneumonia because its seasonal occurrence usually coincides with periods of rainy season and surface wetness in the study area.

Data Collection and Methods of Analysis (3)

The bio-meteorological parameters are the mean radiant temperature (Tmrt) (Matzarakis et al. 2010), physiologically equivalent temperature (PET) (VDI, 1998) and Universal Thermal Climate Index (UTCI) (Jendritzky et al., 2009) were calculated using the RayMan model (Matzarakis et al., 2007). The advantage of bio-meteorological parameters that are indicators of human thermal comfort in an environment using just meteorological variables is the inclusion of both meteorological components of the thermal environment and physiological components of the human body, e.g., activity level, age, and clothing, in their calculation. Therefore, in this study, biometeorological parameters are used because these indices capture human physiological comfort better than any of the single weather variables.

Spatial Analysis Based on Human Population

A population factor (*Pf) and the logarithm of* reported pneumonia cases in relation to population (*Ncp) (*Egunjobi,1993; Ferrari et al., 2010) *were also determined for objective* comparison between the 18 LGAs in the state.

Data Collection and Methods of Analysis (4)

$$Pf = \frac{Population\ of\ LGA,\ Px}{PN}$$

$$Ncp = \frac{\ln N_m}{Pf} = \frac{log_{e\ N_m}}{Pf}$$

Where, *x varies from LGA to LGA as shown in* Table 1, *PN is the population of the least populated* LGA (Ondo East), *Nm is the approximate number* of cases of pneumonia in the respective LGAs over the study period. In addition, a demographic analysis of pneumonia' patients was carried out. For further analysis, the 18 LGAs were divided along the two eco-climatic zones in the state (Fig. 2) for simplicity and easy handling of the data.

Data Collection and Methods of Analysis (4)

Table 1: Logarithm of reported pneumonia cases in relation to population of each local government areas (LGAs) in Ondo state, Nigeria

LGA	*Population*	*Population factor (Pf)*	*Average reported pneumonia cases for the period 1998 to 2008 (Nm)*	*Logarithm of pneumonia cases in relation to population of each LGA (Ncp)*	*Rank*
Akoko North West*	213,792	2.86	151	1.75	15
Akoko North East**	175,409	2.35	275	2.39	10
Akoko South East**	82,426	1.10	57	2.05	13
Akoko South West*	229,486	3.07	195	1.72	16
Ose**	144,901	1.94	120	2.47	8
Owo*	218,886	2.93	206	1.82	14
Akure North**	131,587	1.76	133	2.78	6
Akure South*	353,211	4.72	551	1.34	18
Ifedore**	176,327	2.36	232	2.31	12
Ile-Oluji/Okeigbo**	172,870	2.31	211	2.31	11
Ondo West*	283,672	3.79	484	1.63	17
Ondo East***	74,758	1.00	110	4.70	1
Idanre***	129,024	1.73	279	3.26	5
Odigbo**	230,351	3.08	2900	2.59	7
Okitipupa**	233,565	3.12	1877	2.41	9
Irele***	145,166	1.94	1455	3.75	3
Ese-Odo***	154,978	2.07	2478	3.77	2
Ilaje***	290,615	3.89	2899	3.67	4

*** $N_{cp} \geq 3.00$; ** N_{cp}: (2.00 – 2.99); * N_{cp}: (1 – 1.99)

*** N_{cp} (5 LGAs) = 41.0%; ** N_{cp} (8 LGAs) = 41.3%; * N_{cp} (5 LGAs) = 17.7%

Data Collection and Methods of Analysis (5)

Lag associations: Cross correlation analysis

Cross correlation is used to compare two different time series, covering the same time span and with equal and even sampling frequency with the aim of finding possible time delay between the correlations of the two series (Draper and Smith, 1981).

For two series *x and y, the cross correlation* value at lag time *m is*

$$r_m = \frac{\sum(x_i - \overline{x})\sum(y_{i-m} - \overline{y})}{\sqrt{\sum(xi - \overline{x})^2 \sum(y_{i-m} - \overline{y})}}$$

The above equation shows that for positive lags, *x* (meteorological/bio-meteorological parameters in Table 2) is compared to a *y (pneumonia value), that* has been delayed by *m samples. A high correlation* value at positive lags thus means that features in *y* are leading, while *x lags behind. For negative lags,* features in *x are leading.*

Data Collection and Methods of Analysis (6)

Table 2: Correlations coefficient between pneumonia and meteorological/ bio-meteorological parameters in humid forest zone of Ondo State

Variables	Pneumonia (Derived savannah)	Pneumonia (Humid forest)
Air temperature, Ta (°C)	-0.884**	-0.898**
Physiologically equivalent temperature, PET (°C)	-0.842**	-0.885**
Mean radiant temperature, T_{mrt} (°C)	-0.809**	-0.807**
Sea surface temperature, SST (°C)	-0.216*	-0.209*
Solar radiation, SR (Wm^{-2})	-0.626**	-0.628**
Rainfall, Rfall (mm)	0.875**	0.880**
Relative humidity, RH (%)	0.872**	0.920**
Wind speed, u (ms^{-1})	0.192*	0.198*

** - Correlation is significant at the 0.01 level

* - Correlation is significant at the 0.05 level

Data Collection and Methods of Analysis (7)

Temporal analysis: Stepwise multiple regression

In order to identify specific meteorological/bio-meteorological parameters, or their combination, that explains the temporal pattern of pneumonia disease, a stepwise multiple regression analysis was conducted. The multiple regression equation where there are more than two explanatory factors is given below as:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5$$

In order to incorporate the lag period *n* (monthly interval between meteorological/biometeorological parameters and number of monthly reported cases of pneumonia) and time *t (month to* be predicted for pneumonia); the above equation becomes

$$Y = b_0 + b_1 X_{1(t-n)} + b_2 X_{2(t-n)} + b_3 X_{3(t-n)} + b_4 X_{4(t-n)} + b_5 X_{5(t-n)}$$

Results (1)

Table 3: Lagging time between pneumonia disease and meteorological/ bio-meteorological parameters in humid forest and derived savannah eco-climatic zones of Ondo State

Meteorological/ bio-meteorological parameters	Humid forest eco-climatic zone	Derived savanna eco-climatic zone
	Pneumonia	*Pneumonia*
Air temperature (Ta)	0 month	0 month
Solar radiation (SR)	1 month	1 month
Rainfall (Rfall)	0 month	0 month
Relative Humidity (RH)	0 month	1 month
Wind speed (u)	2 months	2 months
Sea surface temperature (SST)	2 months	2 months
Physiologically equivalent temperature (PET)	0 month	0 month
Mean radiant temperature (T_{mrt})	1 month	1 month

Results (2)

Table 4: Linear regression of pneumonia on combinations of meteorological/ bio-meteorological parameters for humid forest zone of Ondo State

	Model terms	Regression coefficients	95% CI	p-value	R^2
	Constant	1113.536	821.460 to 1405.611		
pAH	PET	-32.429	-39.179 to -25.679	0.000	
	Rfall	0.618	0.502 to 0.734	0.000	86.9%
	SST	2.949	-4.246 to 10.144	0.419	
pBH	Constant	975.921	440.040 to 1511.801		
	SR	-1.276	-1.814 to -0.737	0.000	
	RH	2.602	-0.202 to 5.405	0.069	88.2%
	Ta	-35.295	-49.579 to -21.012	0.000	
	Rfall	0.470	0.311 to 0.629	0.000	
	SST	6.357	-0.745 to 13.460	0.079	
	U	74.871	-0.732 to 150.475	0.052	
pCH	Constant	141.337	-105.656 to 388.329		
	RH	4.814	2.292 to 7.335	0.000	
	Rfall	0.535	0.372 to 0.698	0.000	87%
	SST	9.244	1.682 to 16.807	0.017	
	u	56.972	-21.898 to 135.842	0.155	
	Tmrt	-17.300	-21.358 to -13.242	0.000	

95% CI: Confidence interval at 95% level for estimated regression coefficient

pAH, pBH, pCH: Identification term for pneumonia models in humid forest zone

Results (3)

Table 5: Linear regression of pneumonia on combinations of meteorological/ bio-meteorological parameters for derived savannah zone of Ondo State

	Model terms	Regression coefficients	95% CI	p-value	R^2
pAS	Constant	815.339	626.693 to 1003.985		
	PET	-20.908	-24.878 to -16.938	0.000	
	Rfall	0.583	0.481 to 0.685	0.000	86.4%
	SST	0.371	-4.647 to 5.390	0.884	
pBS	Constant	918.415	552.458 to 1284.372		
	SR	-0.594	-0.970 to -0.218	0.002	
	RH	-0.118	-1.021 to 0.786	0.797	86.9%
	Ta	-27.007	-36.915 to -17.099	0.000	
	Rfall	0.500	0.378 to 0.623	0.000	
	SST	2.554	-2.547 to 7.655	0.324	
	U	72.225	11.699 to 132.752	0.020	
pCS	Constant	204.655	20.717 to 388.593		
	RH	0.989	0.203 to 1.775	0.014	85%
	Rfall	0.608	0.487 to 0.730	0.000	
	SST	5.995	0.456 to 11.534	0.034	
	u	41.477	-21.340 to 104.295	0.194	
	Tmrt	-9.543	-12.988 to -6.098	0.000	

95% CI: Confidence interval at 95% level for estimated regression coefficient

pAS, pBS, pCS: Identification term for pneumonia models in derived savannah zone

Results (4)

Table 6: Stepwise linear regression of pneumonia on combinations of meteorological/ bio-meteorological parameters for humid forest zone of Ondo State

	Model terms	Regression coefficients	95% CI	p-value	R^2
pAH*	Constant	1187.935	959.429 to 1416.440		
	Rfall	0.632	0.521 to 0.743	0.000	77.4%
	PET	-32.425	-39.165 to -25.684	0.000	9.4%
pBH*	Constant	1101.262	576.887 to 1625.637		
	Rfall	0.492	0.332 to 0.653	0.000	77.4%
	Ta	-34.652	-49.173 to -20.130	0.000	8.2%
	SR	-1.191	-1.733 to -0.650	0.000	1.3%
	RH	3.625	0.908 to 6.342	0.009	0.7%
pCH*	Constant	159.039	-87.740 to 405.817		
	Rfall	0.537	0.374 to 0.701	0.000	77.4%
	Tmrt	-17.222	-21.295 to -13.149	0.000	6.4%
	RH	5.400	3.003 to 7.797	0.000	2.4%
	SST	8.836	1.264 to 16.408	0.023	0.6%

95% CI: Confidence interval at 95% level for estimated regression coefficient

pAH*, pBH*, pCH*: Identification term for pneumonia stepwise models in humid forest zone

Results (5)

Table 7: Stepwise linear regression of pneumonia on combinations of meteorological/ bio-meteorological parameters for derived savannah zone of Ondo State

	Model terms	Regression coefficients	95% CI	p-value	R^2
pAS*	Constant	824.287	680.096 to 968.477		
	Rfall	0.586	0.491 to 0.681	0.000	74.6%
	PET	-20.897	-24.848 to -16.945	0.000	11.8%
pBS*	Constant	952.965	723.344 to 1182.585		
	Ta	-26.303	-33.567 to -19.039	0.000	75.8%
	Rfall	0.517	0.402 to 0.631	0.000	9.6%
	SR	-0.552	-0.918 to -0.186	0.003	0.7%
	u	66.138	15.692 to 116.584	0.011	0.7%
pCS*	Constant	212.295	28.217 to 396.374		
	Rfall	0.611	0.489 to 0.733	0.000	74.6%
	Tmrt	-8.818	-12.092 to -5.544	0.000	8%
	RH	1.262	0.591 to 1.933	0.000	1.7%
	SST	5.737	0.197 to 11.277	0.043	0.5%

95% CI: Confidence interval at 95% level for estimated regression coefficient

pAS*, pBS*, pCS*: Identification term for pneumonia stepwise models in derived savannah zone

Conclusion (1)

- The study revealed that highest number of cases of pneumonia was recorded in the children below 5 years.

- There is high seasonal variation in the occurrence of pneumonia in the two eco-climatic zones of Ondo State. The transmission peak was in the rainy season.

- The pneumonia infection is modulated by both meteorological and bio-meteorological parameters which impacts on the transmission of *mycoplasma pneumoniae. The individual meteorological and* bio-meteorological parameters with different lag periods influence pneumonia infection; rainfall is the best predictor and the main driving force.

- Conclusively, cases of pneumonia occurrence were higher in humid forest eco-climatic zone of Ondo State within the study period. In addition, the study confirmed the roles of seasons in the occurrence of pneumonia in Ondo State.

Conclusion (2)

- This study stresses the need for further investigation to explore the role played by meteorological/bio-meteorological factors on a day-to-day basis in order to actually determine the weather transition period that has the most significant effect on pneumonia in the study area and also to know the lead-time for predicting the magnitude of pneumonia occurrence, which will assist in preparedness and early warning intervention for pneumonia disease.

Conclusion (3)

Implications of the outcome of this study for the government and health policy

- First, incorporation of close monitoring of the atmospheric environment into health management schemes; this will give health practitioners timely awareness of the prevailing atmospheric conditions that are favourable to the transmission of certain infectious diseases so that they can act in time.

- Second, since there are certain parts of the study area that record higher numbers of pneumonia cases. It is necessary, therefore, to prioritize health problems according to areas, and to direct health investments to areas most in need; a human-biometeorological approach will be of great help in achieving this.

- Third, there is need to protect our environment and also to take adaptation measures in order not to be affected adversely by the impact of global environmental (climate) change.

Bibliography (1)

Adedoyin JA (1989) Global scale sea surface temperature anomalies and rainfall characteristics in Northern Nigeria. Int J Climatol 9:133–144

Adefolalu, D.O. (1997): Hydro-Ecozone mapping of Ondo/Ekiti State, Nigeria. Ondo State project final report; 141 pp. + Appendices.

Bull, G. M. and Morton, J. (1978): Age and Ageing, **7**, 210.

Checkley, W., Epstein, L.D., Gilman, R.H., Figueroa, D., Cama, R.I., Patz,J.A. and Black,R.E. (2000): Effects of El Nino and ambient temperature on hospital admissions for diarrhoeal diseases in Peruvian children. The Lancet 355: 442-450.

Egunjobi, L. (1993): Spatial distribution of mortality from leading notifiable diseases in Nigeria. Soc. Sci. Med. 36 (10): 1267 – 1272.

Ferrari, M.J., Djibo, A., Grais, R.F., Bharti, N., Grenfell, B.T and Bjornstad O.N. (2010): Rural–urban gradient in seasonal forcing of measles transmission in Niger. Proc. Biol. Sci. 277 (1695): 2775-82. doi:10.1098/rspb.2010.0536.

Giannini A, Saravanan R, Chang P. (2003): Oceanic forcing of Sahel rainfall on interannual to inter-decadal timescales. Science 302:1027–1030

Bibliography (2)

Jendritzky G., Havenith, G., Weihs, P. and Batchvarova, E. (Eds.) (2009): Towards a Universal Thermal Climate Index UTCI for assessing the thermal environment of the human being. Final Report COST Action 730

Lipp, E.K., Huq, A and Colwell, R.R. (2002): Effects of global climate on infectious disease: the cholera model. Clinical Microbiology Reviews 15(4): 757-770.

Matzarakis, A., Rutz, F. and Mayer, H (2010): Modelling radiation fluxes in simple and complex environments: basics of the RayMan model. International Journal of Biometeorology 54: 131–139.

Matzarakis, A. (2007): Assessment method for climate and tourism based on daily data. In: A. Matzarakis, C. R. de Freitas, D. Scott (Eds.), Developments in Tourism Climatology, 52-58

NPC (2006): Nigeria population census report. National Population Commission, Abuja, Nigeria.

Omonijo, A.G., Matzarakis, A., Oguntoke, O. and Adeofun, C.O. (2012): Effect of thermal environment on the temporal, spatial and seasonal occurrence of measles in Ondo state, Nigeria. Int J Biometeorol 56:873–885; DOI 10.1007/s00484-011-0492-8

Bibliography (3)

Pan, W. H., Li, L. A. and Tsai, M. J. (1995): Lancet 345, 353

Tromp, S. W. (1980): Biometeorology: The Impact of Weather and Climate on Humans and Their Environment (Heyden and Son Ltd., London, United Kingdom.

VDI (1998): Methods for the human biometeorological evaluation of climate and air quality for the urban and regional planning. Part I: Climate. VDI Guideline 3787. Part 2. Beuth, Berlin.

Wassila MT, Kingtse CMO (2005): Impact of sea surface temperature and soil moisture on seasonal rainfall prediction over the Sahel. J Clim 18:5330–5343

The full length of the paper can be found on:

Omonijo, A.G and Matzarakis, A. (2014): Pneumonia Occurrence in Relation to Population and Thermal Environment in Ondo State, Nigeria; The African Review of Physics 9:0064, 511-525

Thank you for listening