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Effects of Climate on Malaria and Typhoid Fever in Ilorin, Nigeria.

By

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Abstract: *Climate plays an important role in the propagation of diseases. Indeed diseases of various types vary in prominence from one climatic belt to the other. This research examines the effect of climate on human health in Ilorin Kwara State. The data used for this work are mainly from secondary sources. They are maximum and minimum temperature, rainfall, sunshine, wind speed and relative humidity. These were collected from Nigerian meteorological Agency (NIMET) office, Ilorin International Airport. Data on diseases types and casualties were collected from the University of Ilorin Teaching Hospital, Ilorin. Both descriptive and inferential statistics were used for data analysis. The descriptive methods used are mean, standard deviation, variance, range and coefficient of variation. The inferential methods include principal components analysis, multiple correlations and regression analysis in addition to analysis of variance (ANOVA). The results of the multiple correlation showed that all the diseases types and their cases of casualties were strongly associated with one climatic variable or the other as the results of the multiple regression shows that climatic variables are strong predictors of diseases in Ilorin. The results of the factor analysis further suggest the prominent causes of diseases are mostly temperature and moisture variables*

Keywords: Climate, Diseases, Effect, Malaria, Typhoid Fever, Nigeria.

Introduction

According to Ayoade (2004), the effects of climate on human health are, however, not all negative. Favorable climatic conditions can help the human body in warding off disease and in promoting recovery from illness. Fresh air, mild temperature, moderate relative humidity and sunshine all have therapeutic values (Critchfield, 1974). For instance, fresh air and sunlight will help recovery from tuberculosis. Rickets and some skin diseases do respond to Sunshine. Favorable climatic conditions only aid recovery; they are no substitute for proper medical attention, good nutrition and cleanliness.

Studies so far carried out, indicate that the capacity of a society to absorb adverse climatic impacts is not a simple linear function of its wealth or degree of development. It has been hypothesized by Burton et al (1978) that the most vulnerable societies to adverse climatic impacts are neither the poorest and least developed nor the wealthiest and most highly developed, but those societies in the process of rapid transition or modernization where the traditional social

mechanisms for absorbing and sharing losses among the community have virtually disappeared but have not yet been replaced by the accumulated wealth and response capacities of modern developed societies.

There are several ways in which climate and climatic variations exercise an influence on man and his activities. The essentials of life for mankind on this planet, namely air, water, food, clothing and shelter, are all weather dependent or weather related. Human health, energy and comfort are affected more by climate than by any other element of the physical environment (Critchfield, 1974). The physiological functions of human body respond to changes in weather; certain illnesses are climate induced while several diseases that afflict man show a close correlation with climatic conditions and season in their incidence. The climatic elements, which directly affect the physiological functions of the human body include radiation (sunshine), temperature, humidity, wind and atmospheric pressure.

Human physiological comfort is determined mainly by temperature, wind and humidity (Ayoade, 2004). Generally, high temperature and humidity tend to decrease physical vigour as well as mental vigour. Very dry air or extremely low temperatures may also impact physical vigour and adversely affect attitude to mental work.

Severe epidemics of cholera strike regularly in many parts of the developing world (Huq, 2001; Lobitz, 2000). The timing of these epidemics is partly explained by environmental and ecological conditions that are influenced by climate. In particular, a significant reservoir of the cholera – causing organism, “*vibrio cholerae*” appears to reside in marine ecosystems where it attaches to 200 plankton (Colwell, 1996; Huq, 2001). Populations of these small crustaceans in turn depend on the abundance of their food supply (phytoplankton). Phytoplankton populations tend to increase (boom) when ocean temperatures are warm. The result is that cholera outbreaks are associated with warmer ocean surface temperature via a series of ecological relationships.

Githeko et al (2001) compared monthly climate and malaria data in highland Kakamega and found a close association between malaria transmission and monthly maximum temperature anomalies over three years (1997-2000).

Patz and colleagues studied the effect of soil moisture to determine the effects of weather on malaria transmission. Compared to raw weather data, hydrological modeling has several potential advantages for determine mosquito-breeding site. High soil moisture conditions and vector breeding habitats can remain long after precipitation events, depending on factors such as watershed, run-off and evapotranspiration. For Angambiae, the soil moisture model predicted up to 45% and 56% of the variability of human biting rate and eritomological inoculation rate respectively (Patz, 1998).

The Study Area

The study area for this research is Ilorin, Kwara State, Nigeria. The city is situated in the transition zone between the deciduous woodland of the south and the savanna to the North. It is about 300km away from Lagos and 160KM from Ibadan. The climate of Ilorin is humid type characterized by dry and wet seasons. The seasons are controlled by two surfaces opposing

winds i.e. the south east maritime and the North-east continental wind. The height of the land in Ilorin ranges from 250m to 400m above sea level. The lowest level is along the river valley of Asa and Oyun while the highest point is Sobi hill, north of Ilorin town which is about 390m above sea level. This shows that landscape of Ilorin is characterized by undulating surface with low trend and high land. Ilorin is drained majorly by river Asa, which originates from Osun State and passes through Ilorin. The study area is well drained and planned with the use of natural gift of streams and rivers.

Methodology

Data required in this study can be classified into two. These are Health information records on diseases and their casualties. These diseases are malaria fever and typhoid fever. Climatic data are minimum and maximum temperature, rainfall, sunshine hours, wind speed and relative humidity. Data used in this study were obtained from secondary sources. The data on diseases and their casualties were obtained from University of Ilorin Teaching Hospital, Ilorin. The choice of this health institution was basically because of availability of reliable data. The climate variables namely minimum and maximum temperature, relative humidity, rainfall amount, wind speed and sunshine hours were collected from the Nigerian Meteorological Agency (NIMET) Ilorin Airport. These records were collected using world acclaimed equipments and standard procedures.

Both descriptive statistics (mean, variance and standard deviation) and inferential statistics (multiple regression, correlation analysis and principal component analysis) are employed for the analysis of this work.

Analysis and Discussions

Multivariate relationship between climate parameters and malaria fever

According to Table 1, some levels of relationship between climate variables and malaria fever are measured. Thus, four parameters of climate i.e maximum temperature ($r = 0.17$), minimum temperature ($r = 0.52$), sunshine ($r = 0.12$) and winds (0.34) have positive relationship with incidence of malaria. Suggesting that as these variables increase, incidence of malaria increases.

Two parameters, namely; winds ($r = -0.51$) and relative humidity ($r = -0.25$) are inversely correlated with malaria fever which means that as these variables increase, cases of malaria will decrease, that is the breeding capacity of mosquitoes that transmit malaria vectors will increase at low relative humidity and low rainfall giving rise to mosquito bites. The positive relationship of malaria with maximum

temperature, sunshine, and winds speed expected because these variables encourage formation of rainfall during which incidences malaria fever are common. Githeko et al (2002) findings in highland of Karamoja support a close association between malaria transmission and monthly maximum temperature. Because it shows a strong relationship between climate variables and cases of malaria fever.

Table 1: Intercorrelation between Climate Parameters and Malaria Fever

Malaria	Max T ⁰	Min T ⁰	Sun	Rain	Wind	Rel h	
1	.17	.52	.12	-.24	.34	-.09	Malaria
	1	.43	-.34	.23	.11	-.45	Max T ⁰
		1	-.32	-.20	.05	-.30	Min T ⁰
			1	-.40	.14	-.20	Sun
				1	-.64	.69	Rain
					1	-.43	Wind
						1	Rel. hum

Table 2: Multiple Regression between Malaria Fever and Climate Parameters

Model	R	R ²	Adjusted R ²	Std error
1	0.878	0.772	-0.599	3.549

Source: Author's Survey, 2011

Table 2 shows the results of multiple regression analysis on incidence of malaria in Ilorin. R is 0.878, R² is 0.772, and adjusted R² is -0.599 with standard error of 3.549. This implies that 77.2% of cases of malaria in Ilorin are due to climatic factors.

Causes of Malaria Fever in Ilorin

According to Table 3, three factors are responsible for malaria in Ilorin, and these three factors explain 78.3% of the variance. Component 1 is tagged wet index, it contributed 32.9% to the explanation in variance with three climatic variables (Rainfall, wind, and relative humidity), being highly loaded. Component 2 is

highly loaded with maximum temperature and sunshine. These factors contribute 24.5% to the explanation in the variance and called heat index. Factor 3, is highly loaded only on minimum temperature. It contributes 20.8% of the variance to the incidence of malaria and tagged low heat index. Heat index has the high loading of 32.9% of the three indices that are responsible for malaria in Ilorin. This finding supports Patz and colleagues studies in 1998 on the effects of soil moisture content to determine the effect of weather on malaria transmission in Kenya and eventually concluded that increased temperature and high relative humidity is building ground for malaria transmission.

Table 3: Component Loadings, Eigen Value, Cumulative Variance on Malaria Explained by Climatic Factors

Variables	Components		
	1	2	3
Malaria	-.155	-.044	.932
Max T ⁰	-.164	.882	.090
Min T ⁰	-.115	.532	.699
Sun light	-.389	-.677	-.032
Rainfall	.874	.261	-.186
Winds	-.732	-.073	.231
Rel. Humidity	.888	-.347	.059
Total eigen value	2.558	36.546	36.546
% of Variance	1.865	26.639	63.186
% of Cumm. Variance	1.054	15.060	78.245

Source: Author's Survey, 2011.

The Multivariate Relationship between Climate Parameters due to Malaria Fever

Table 4 reflects the relationship between death rate on malaria fever and climate parameters in Ilorin during the years under study. The result shows maximum temperature -0.023, sunshine -0.336 and relative humidity -0.445 are inversely related to the malaria fever death rate, suggesting that as these variables are increasing, death rate on malaria fever will decrease. This means that death on malaria fever normally increase in an environment where heat is relatively low. In addition, minimum temperature 0.434, rainfall 0.226 and winds

0.113 are positively related to death rate on malaria suggesting that as these variables increase, death rate will increase. In rainy season mosquitoes that transmit plasmodium through which people contact malaria fever are developed and this condition is much favoured with minimum temperature, rainfall and low wind speed. Paltz (2001) in his research work supports this finding that soil moisture content is a determinant factor on the effect of weather on malaria transmission and high soil moisture condition is a breeding site for malaria breeding vectors.

Table 4: Interrelation between Climate Parameters and Malaria Mortality

Malaria Death	Max T ⁰	Min T ⁰	Sun	Rain	Wind	Rel h	
1	-.02	.43	-.34	.23	.11	-.45	Malaria Death
	1	.32	-.20	.30	.05	-.28	Max
		1	-.36	-.20	.14	.51	Min
			1	-.74	-.64	-.20	Sun
				1	.06	.70	Rain
					1	-.43	Wind
						1	Rel. humidity

Source: Author's Survey, 2011.

Relationship between Malaria Mortality and Climate Indices

According to Table 5, the level of relationship between malaria mortality and climate parameters is reflected. R is 0.980, R^2 is 0.960, and adjusted R^2 is 0.722 with standard error of 1.403. This suggests that there is a positive relationship between malaria mortality and climate parameters as explained by 98% level of association. The implication of this result

is that the adverse effect of climate, when rainfall is excessive above the threshold will enhance vectors that transmit malaria in the environment. However, Kalkstein (1984) agreed with this finding while comparing winter mortality rates for 13 cities in USA that the Southern cities seemed to exhibit the greatest increase in mortality during cold weather, while little or no response was found in the northern cities with moderate weather.

Table 5: Multiple Regressions between Malaria Mortality and Climate Parameters

Model	R	R^2	Adjusted R^2	Std error
1	0.980	0.960	0.722	1.403

Source: Author's Survey, 2011

Causes of Malaria Mortality in Ilorin

According to Table 6, there are three main components in explanation of malaria mortality in Ilorin. In component 1, there are two factors that are highly loaded; these are rainfall 0.834 and relative humidity 0.824. They contribute 38.6% to the explanation in the variance and therefore tagged the index of wetness. In component 2, the only climate factor that is highly loaded is winds -0.740 and contributes 26.9% to the explanation in the variance. It is therefore tagged index of winds. Maximum temperature 0.862 and sunshine -0.752 are highly loaded in component 3 and contribute 14.7% to the explanation in the variance; hence index of heat is used to tag these variables.

During the rainy season, high soil moisture is a breeding ground for mosquitoes

that transmit malaria vectors and in dry season when temperature ought to have been risen, some part of the tropics still experience cloud cover leading to low insulation on the surface, most especially in Ilorin when wind was statistic. Ilorin is surrounded with 2 major water sources, Agba dam and Asa dam, let alone surrounded stagnant waters during the period of rainy season (wet index). All these are directly altering the timing of pathogen development and time history. This assertion is supported by Harb (1993) and Thompson (1996) that an inverse in soil moisture associated with irrigation development in the southern Nile Delta, following the construction of Aswan high dam has caused a rapid rise in the mosquito culex pipens and consequential increase in the mosquito borne disease.

Table 5: Component Loading Eigen Values and Cumulative Variance of Malaria Mortality

Variables	Components		
	1	2	3
Casualties	.103	.932	.060
Max T^0	-.217	-.100	.862
Min T^0	-.605	.432	.513
Sun light	-.256	-.128	-.752
Rainfall	.834	.295	.372
Winds	-.469	-.740	.009
Rel. Humidity	.824	.298	-.153
Total eigen value	2.703	1.888	1.034
% of Variance	38.6	26.9	14.7
% of Cumm. Variance	29.8	55.5	80.4

Source: Author's Survey, 2011.

Multivariate Relationship between Climate Parameters and Typhoid Fever

Table 7 displays the pattern of relationship between climate parameters and typhoid incidences. All these parameters have inverse relationships with typhoid fever with the exception of relative humidity ($r = 0.61$) and rainfall ($r = 0.541$). This implies that as all the other parameters with the exception of relative humidity and rainfall increase, typhoid

incidences decrease. The positive relationship between relative humidity and rainfall is acceptable as it is an established fact that typhoid normally spread at the period of high moisture content in the environment. The work of Lisle and Rose (1995) also supports this assertion that heavy rainfall events can transport terrestrial microbiological agents into drinking-water sources resulting to the outbreaks of cholera, typhoid, amoebiasis and other infections.

Table 7: Intercorrelation between Climate Parameters and Typhoid Fever

Typhoid	Max T ⁰	Min T ⁰	Sun	Rain	Wind	Rel h	
1	-.47	-.65	-.16	.54	-.63	.61	Typhoid
	1	.43	-.34	.23	.11	-.45	Max T ⁰
		1	-.32	-.20	.05	-.28	Min T ⁰
			1	-.36	.14	-.20	Sun
				1	-.64	.70	Rain
					1	-.43	Wind
						1	Rel. hum.

Source: Author's Survey, 2011.

Relationship between Cases of Typhoid and Climate Parameters

Large numbers of people were affected of typhoid fever in which some people died. Table 8 shows the level of relationship between typhoid and climatic variables in Ilorin. R is 0.980, R^2 is 0.960, and adjusted R^2 is 0.717 with standard error of 0.407. This shows that there is a positive relationship between climate and cases of typhoid fever suggesting that environmental

factors which are the products of climate have critical effects of 98% on the incidence of typhoid in Ilorin. Birmingham (1997) in his work supported this finding when he concluded that epidemiological evidence has pointed to a widespread environmental cause for recent outbreaks of cholera and typhoid rather than a point source contamination as seen in Peru in 1991 and East Africa in 1997/1998.

Table 8: Multiple Regressions between Typhoid Fever and Climate Parameters

Model	R	R ²	Adjusted R ²	Std error
1	0.983	0.960	0.717	0.341

Source: Author's Survey, 2011

Causes of Typhoid Fever in Ilorin

From the Table 9, two major components are very relevant to explain the causes of incidence of typhoid fever in the study area. These two components contribute 71.3% to reported cases of typhoid fever. In component 1,

three important variables are highly loaded; these are rainfall 0.902, winds -0.775 and relative humidity 0.783. These variables are tagged index of wetness and contribute 44.5% to the explanation in the variance. In component 2, two

variables that are highly loaded are maximum temperature 0.849 and minimum temperature 0.768. These variables are tagged index of heat contributing 26.8% to the explanation in variance. Hence, in explanation of causes of typhoid fever, wet index and heat index are the major contributor to the explanation in the variance. This means that climate variable is a

function of typhoid fever in Ilorin which is supported by WHO (2002) that climate can increase directly the amount of pathogen in water by increasing the biotic reservoir of the infectious agent (cholera) or by decreasing the amount of water in a river or pond and thus raising the concentration of bacteria (tryphoid).

Table 9: Component Loadings Eigen Value, Cumulative Variance of Typhoid Fever Explained by Climate Factors

Variables	Components	
	1	2
Typhoid	.787	-.494
Max T ⁰	-.094	.849
Min T ⁰	-.259	.768
Sun light	-.455	-.627
Rainfall	.902	.186
Winds	-.775	.015
Rel. Humidity	.783	-.281
Total eigen value	3.118	1.874
% of Variance	44.539	26.764
% of Cum. Variance	44.539	71.303

Source: Author's Survey, 2011.

Multivariate Relationship-between Climate Parameters and Mortality Due To Typhoid Fever

Table 10 reflects the degree of relationship between climate and death rate on typhoid fever in the study area. Minimum temperature ($r = -0.047$) and sunshine ($r = -0.168$) are inversely related to the rate of death on typhoid fever, suggesting that when these variables are decreasing in value, death rate on typhoid will increase. This is true in real sense because during the period of rainy season, cloud is formed and sun output is reduced with low temperature on the surface. Maximum temperature ($r = 0.551$), rainfall ($r = 0.459$), winds ($r = 0.316$) and relative humidity ($r = 0.203$) are proportionally related with the rate of death on typhoid fever suggesting that increase value of these variables will increase the death rate. This is as a result of many fruits that thrive well with these climatic variables in Ilorin in

which large number of people live on. These fruits might have being affected with one disease or the others and once they are eating by man, the resulted case is typhoid fever in many places. All the same, stream water might have been contaminated by surface run-off and wells may be affected by winds deposits. All these contribute to the causes of typhoid in which many lives were claimed in Ilorin. High temperature brings about cloudiness; a process of rain formation, when excess water are dropped on the surface. Cowell (1996) agreed with this assertion that Copepod Zooplankton provides a marine reservoir for cholera pathogen and thereby facilitate its long term persistence and disseminated spread to human consumers via marine food-web. However, cholera and typhoid epidemics are associated with positive surface temperature anomalies in coastal and inland lake waters.

Table 10: Intercorrelation between Climate Parameters and Mortality on Typhoid Fever

Typhoid	Max T ⁰	Min T ⁰	Sun	Rain	Wind	Rel h	
1	.55	-.05	-.17	.46	.32	.20	Typhoid
	1	.43	-.34	.23	.11	-.45	Max
		1	-.32	-.20	.05	.28	Min
			1	-.36	.14	-.20	Sun
				1	-.64	.70	Rain
					1	-.43	Rel. humidity
						1	

Source: Author's Survey, 2011

Relationship between Mortality on Typhoid Fever and Climate Indices

Result of multiple regression on climate parameters and typhoid fever mortality in Ilorin shows R is 0.975, R^2 is 0.916, adjusted R^2 is 0.413 with standard error 0.178 respectively Table 11. This result suggests that there is a positive relationship between the climate and death rate on typhoid fever. About 98% level of association explains that death rate on typhoid fever in Ilorin is as a result of influence of

climate.

Changes in these variables have significant effect on the incidence of typhoid, the adverse impacts of which resulted to death probably due to poor environmental planning in the study area. Burton (1993) explained that there is extensive evidence that an extreme climatic event will result in higher losses of life in a developing countries than in the developed countries because of limited coping ability and poor environmental planning.

Table 1: 1: Multiple Regressions between Mortality on Typhoid Fever and Climate Parameters

Model	R	R^2	Adjusted R^2	Std error
1	0.975	0.916	0.413	0.178

Source: Author's Survey, 2011

Causes of Mortality on Typhoid Fever

From Table 12, there are two major components that are closely connected to the explanation of mortality rate on typhoid fever in Ilorin. In components 1, there are three climate factors that are highly loaded; these include rainfall 0.903, winds, -0.782 and relative humidity 0.839. These contribute 33.8% to the explanation in the variance and then tagged index of wetness. Maximum temperature 0.70, minimum temperature 0.830 and sunshine 0.70 are highly loaded in component 2. They

contribute 24.5% to the explanation in the variance and then tagged the index of heat. These two indices contribute 58.3% to the explanation of the causes of mortality on typhoid fever in the study area.

From the findings of Moore (1992), he agreed with this assertion when he concluded that some vector borne diseases e.g. malaria and dengue fever show significant seasonal pattern, whereby transmission is high in the month of heavy rainfall and humidity.

Table 12: Component Loadings, Eigen Value and Cumulative Variance of Death Rate on Typhoid Fever Explained by Climate Factors

Variables	Components		
	1	2	3
Typhoid	1.125	.021	.973
Max T ⁰	-0.141	.685	.606
Min T ⁰	-.218	.830	-.121
Sun light	-.393	-.653	-.148
Rainfall	.903	.080	.369
Winds	-.782	-.155	.422
Rel. Humidity	.839	-.318	.057
Total eigen value	2.368	1.717	1.668
% of Variance	33.824	24.533	23.824
% of Cumm. Variance	33.824	58.357	82.181

Source: Author's Survey, 2011.

Conclusions

This study work examined the responses of Typhoid and Malaria Fever to Climate change in Ilorin. The results indicate that climate change has significant effect on health behavior of people as there exist a perfect positive relationship between climatic variables and these diseases. The study also shows that low temperature with high rainfall and relative humidity encourages the vectors that transmit

malaria. However some climatic variables are responsible for incidence of certain diseases why others are less effective. Disorderliness in body system is as a result of increase or decrease in temperature due to changes in weather condition. Meanwhile the effects of climate change on human health are not all negative because favorable climatic conditions can help the human body in warding off diseases and promote recovery from illness.

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