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The Nexus Between Climatic Variables and Diarrhoea, Tuberculosis (TB), and Typhoid in Selected South-South States, Nigeria

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ABSTRACT

Temperature, rainfall, vapour pressure, diurnal temperature range (DTR), relative humidity, and other climatic variables have all been connected to the transmission and spread of diseases like diarrhoea, Tuberculosis (TB), and typhoid. However, the complicated interactions between these climatic variables and illness incidence remain poorly understood. This study examined the interactions between climatic variables, diarrhoea, Tuberculosis (TB), and typhoid in the selected South-South States, Nigeria. To achieve this, annual rainfall, temperature, vapour pressure, and diurnal temperature range (DTR) were employed using the ex-post facto research approach. The data on diseases were extracted from the various states' Ministry of Health for the period 1962 - 2021. The correlation results showed that there was a significant but moderate positive relationship between rainfall and diarrhoea, r [360] = [.345], p = [< .001]. DTR had a weak and negative significant relationship with diarrhoea, [-.266], p = [< .000]. While vapour pressure and temperature had a significant but weak positive relationship with diarrhoea, [.290], [.258], p = [< .000] respectively. The regression results showed that there was a significant but weak negative relationship between rainfall and typhoid, r [300] = [-.292], p = [< .000]. Vapour pressure and DTR had a weak positive significant relationship with typhoid, [.149], [.152], p = [< .000], p = [< .008] respectively. While temperature had a significant but moderate positive relationship with diarrhoea, [.290], [.369], p = [< .000] respectively. To mitigate the effects of diseases, Nigerians are advised to strengthen their safe-drinking water, sanitation, and hygiene (WASH) systems.

***Keywords*:** Temperature, Rainfall, Vapour Pressure, Diurnal Temperature Range (DTR), Diarrhoea, Tuberculosis (TB), Typhoid

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1. INTRODUCTION

Climate and weather have consistently impacted human health, and variations in these factors especially in weather extremes impact the natural environment that gives us access to security, nutritious food, clean water, a place to stay, privacy, and security (Patil & Jeffery, 2020). Research has shown that the second most common cause of illness and death in young children is diarrhoea. In Nigeria, the disease is estimated to kill 150,000 newborns annually, accounting for 10% of all fatalities in children under five years. Despite this, the national prevalence of the disease is still as high as 13.2% (The Wellbeing Foundation Africa [Wbfafrica], 2023).

Research has shown that Nigeria has the highest rate of tuberculosis (TB) in Africa, which claims the lives of 268 people each day. However, the significant risk of transmission is increased by the underreporting of TB cases. According to estimates, one missed case can spread tuberculosis to fifteen individuals per year (World Health Organization [WHO] Regional Office for Africa, 2024). In terms of cases of tuberculosis, Nigeria is ranked third, behind China and India. An estimated 245,000 Nigerians lose their lives to tuberculosis (TB) each year, and an additional 590,000 cases are reported; approximately 140,000 of these cases are HIV-positive. In Nigeria, tuberculosis (TB) causes almost 10% of all deaths. Despite the availability of modern therapies, the disease claims the lives of roughly thirty people every hour (Copenhagen Consensus Centre [CCC], 2022). The Institute for Health Metrics and Evaluation (2019) revealed that Nigeria is endemic for typhoid with at least 291,909 cases of the disease (136 cases per 100,000 people), and there were 3,584 typhoid fatalities and 273,473 disability-adjusted life years (DALYs) lost due to the disease. Typhoid is rarely fatal, but healing from it is a drawn-out process. The illness has multiple adverse effects and costs time, money, and productivity to the afflicted and their families.

Variability in the climate can impact the persistence and spread of germs and viruses (Nguyen, 2023). A large body of research has shown that infectious diseases and temperature are positively correlated (Wu et al., 2016). Severe weather conditions have been linked to higher rates of child mortality and malnutrition (Mullins & White, 2020; Pottier et al., 2021). While the detrimental impacts of extreme weather and climatic events are undeniable, opinions differ regarding the extent to which these effects affect health and the spread of illness (Jaber, 2022). Due to variances in exposure to and resilience to climate events, the effects of climate events vary for different countries, regions, communities, and individuals (Nagy & Veresné, 2022).

DTR may be an additional risk variable for asthma among children and diarrhoea (Xu et al., 2013a, 2013b). Temperature variations have a significant impact on the frequency of development and continued existence of infectious diseases, including viruses, parasites, and bacteria, since they lack thermostatic systems (Meerburg & Kijlstra, 2009). DTR fluctuations might hurt people's health because they may make it harder for the body to quickly adjust to drastic changes in temperature. DTR is linked to cellular and humoral immunity, cardiovascular events, and even death. These factors may make people more susceptible to infectious infections (Xu et al., 2013b). Research suggests that vapour pressure, or temperature and humidity (Halsby et al., 2014), may be related to the incidence of sporadic disease (Conza et al., 2013).

Rainfall and vapour pressure can affect the occurrence of diarrhoea diseases as well as the ability to survive and spread pathogens. Rainfall events have the potential to promote water system pollution or affect the migration of viruses from environmental holding tanks into surface and groundwater. However, the effects of vapour pressure tend to be species-specific and can have both positive and negative survival implications on bacteria that cause diarrhoea in the environment (Tang, 2009). The bidirectional influence of vapour pressure on the incidence of diarrhoea cases in both the wet and dry seasons, even though rainfall is only significant during the wet season, highlights the complexity of this climate variable and the need for more thorough research to determine the process of its contribution to the prevalence of diarrhoea disease (Alexander et al., 2013).

According to Asadia et al. (2023), the first study on the relationship between typhoid fever and climatic characteristics was carried out by Cherrie et al. (2018). The study examined the seasonality of pathogens and established a correlation between them and the meteorological parameters in Wales and England. The study found that wind speed, humidity, ground frost, and air frost all exhibited negative correlations with typhoid fever. Temperature, sunlight, and vapour pressure all showed positive correlations with typhoid fever, and moderately positive relationships with rainfall. Wang et al. (2012) claim that weather factors including temperature, vapour pressure, and rainfall have a significant impact on the spread and distribution of typhoid illnesses in human populations. Studies have shown that environmental factors like high temperatures (Rao et al., 2016) and solar radiation (Ralph et al., 2013), rainfall levels (Sadeq and Bourkadi, 2018), altitude (Murray et al., 2014), wind speed (Cao, 2016), and high temperature seem to increase the incidence of tuberculosis (TB). Additionally, due to ecosystem modification and/or biogeochemical cycles, temperature variations correlated with humidity alter the rainfall regime and increase pollution levels (Wingfield et al., 2014). According to de Castro Fernandes et al. (2021), the three localities had a 4.6–5.8-fold higher risk of tuberculosis infection due to wind speed and vapour pressure compared to the Federal District.

To establish a scientific foundation for the prevention and control of tuberculosis (TB), Chang et al. (2024) investigate the impact of meteorological conditions on the incidence of TB in Yingjisha County, Kashgar Region, Xinjiang. To explore the association between various meteorological parameters and the daily incidence amount of tuberculosis in Yingjisha County, the distribution lag nonlinear model analysis and Spearman correlation analysis were performed on the number of daily reported cases of tuberculosis from 2016 to 2023. The study results showed that 13, 288 cases of tuberculosis were reported from January 2016 to June 2023, the months of June through October represent the highest annual incidence of tuberculosis. The results of the Spearman correlation analysis showed that the incidence of tuberculosis (TB) was negatively correlated ($r_{RH} = -0.093$) with average daily relative humidity (RH) and average daily temperature (AT) and wind speed (WS) favourably correlated ($r_{AT} = 0.110$, $r_{WS} = 0.090$).

Khaliq et al. (2015) investigated the seasonal and temporal trends in tuberculosis incidence in newly diagnosed cases of pulmonary tuberculosis in Lahore, Pakistan, between 2006 and 2013. Software from SPSS version 21 was utilised for time series analysis to identify seasonal fluctuation and correlation to ascertain the temporal link. At the 0.01 level, temperature was found to be substantially correlated with the incidence of tuberculosis (TB) with $p = 0.006$ and $r = 0.477$.

Oloukoi et al. (2014) explore the types and preferences of adaptation techniques that are available at the household and community levels in the Oke-Ogun region of Nigeria, as well as the perceived and observed patterns of associated health risks with seasonal climatic variability. The study used key informant interviews, focus groups, and a household survey to quickly assess the data. Cases of noteworthy diseases were correlated with monthly mean temperature and rainfall from 2006 to 2008 to conduct a short-term climate health consequences investigation. The results demonstrate comparable patterns with local perceptions of climate-related health hazards and documented instances of several prominent illnesses during seasonal variations. During the dry season, measles, malaria, and diarrhoea were common, but flu rates rose when harmattan and the rainy season's monsoon arrived.

Olabode (2023) concentrated on figuring out how the observed weather factors varied and how they related to the pattern of particular diseases in Ondo State, Nigeria. The Ondo State Specialist Hospital provided data on the prevalence of malaria, asthma, typhoid, and pneumonia, and the Ondo State Agro-Climate Office provided data on temperature (maximum and minimum), rainfall, and relative humidity for the years 2011 to 2021. For data analysis, descriptive and correlation coefficient statistics were employed. The spread of pneumonia, typhoid, asthma, and malaria was found to be impacted by changes in temperature, rainfall, and relative humidity in the research locations. There was a significant association ($r > 0.7$) between malaria and the weather pattern. However, the survey also revealed that pneumonia and malaria were more common than typhoid fever and asthma.

In Onitsha North L.G.A, Anambra State, Anumonye (2016) investigates the impact of temperature, relative humidity, and rainfall on the prevalence of typhoid, TB, and malaria. The relationship between the three diseases' occurrence and the climatic parameters was done using Pearson Product Moment Correlation (PPMC). The correlation study showed that the different meteorological factors have distinct effects on tuberculosis, typhoid, and malaria. Temperature showed no significant relationship with any of the three diseases: malaria had a r value of -0.194, typhoid had a r value of -0.253, and tuberculosis had a r value of -0.102. In contrast, rainfall showed a significant relationship with malaria with an R-value of 0.646 and an insignificant relationship with typhoid and tuberculosis with R-values of 0.519 and -0.341, respectively. Relative humidity had an insignificant correlation ($r = -0.427$) with tuberculosis and a substantial correlation ($r = 0.852$ and 0.807, respectively) with malaria and typhoid.

The impact of rainfall on the prevalence of tuberculosis (TB) in South-Southern Nigeria is examined by Efe et al. (2023). Outcomes showed that between 1991 and 2021, there were 695, 959 cases of tuberculosis (TB) in the six states, with the highest number of cases occurring in the Cross River state (546, 204) and the lowest number in the Delta state (1,723). Annual rainfall of 2391 mm was recorded. Additionally, it revealed an R-value of 0.71 and an R square value of 0.50, suggesting that in the South-South states of Nigeria, rainfall contributes 50% to the incidence of tuberculosis. The regression model indicates a 29.326 F-value and 4.609 t-value with $P < 0.05$. This suggests that the prevalence of tuberculosis in southern Nigeria is significantly impacted by rainfall.

Most of the cited studies were carried out in other countries of the world, studies carried out in Nigeria focused on other regions of the country due to the neglect of the South-South region. For instance, Olabode (2023) studied the pattern of climate change and the related health diseases in Ondo State, Nigeria, Anumonye (2016) examined the effects of climatic variables on the occurrence of malaria, typhoid and tuberculosis cases in Onitsha North LGA, Anambra State, Nigeria and Efe et al. (2023) examines the problem of rainfall on the prevalence of tuberculosis (TB) in the South-Southern Nigeria. The study carried out in the South-South only looked at rainfall and tuberculosis neglecting other climatic variables and diseases that are prevalent in the region, the data for the study was collected from 1991 – 2021. To the best of the researcher's knowledge, there is no other study that has correlated weather elements of rainfall, temperature, vapour pressure, and diurnal temperature range (DTR) with diarrhoea, Tuberculosis (TB), and typhoid, especially in the south-south region of Nigeria. It is this knowledge gap this study intends to fill.

Temperature, rainfall, vapour pressure, diurnal temperature range (DTR), relative humidity, and other climatic variables have all been connected to the transmission and spread of diseases like diarrhoea, TB, and typhoid. However, the complicated interactions between these climatic conditions and illness incidence remain poorly understood. Climate change, such as the increasing frequency of extreme weather events and rising temperatures, may enhance the illness load, especially among vulnerable populations. These climatic variables must be considered while developing strategies for disease prevention, surveillance, and control measures. Thus, this study examines the connection between rainfall, temperature, vapour pressure, and diurnal temperature range (DTR) and diarrhoea, tuberculosis (TB), and typhoid in the South-South regions of Nigeria from 1962 to 2021.

2. MATERIAL AND METHODS

2. 1. Study Area

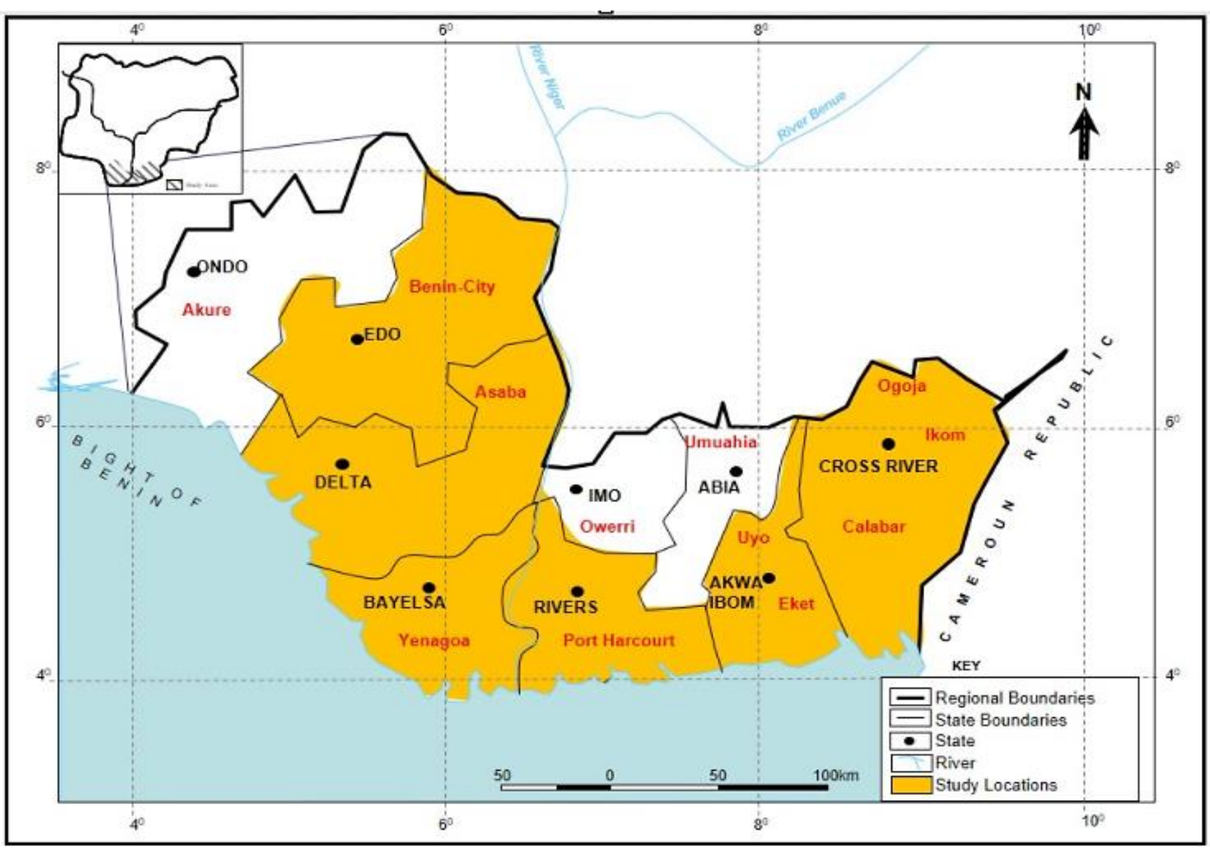

Figure 1. South-South Nigeria Showing the Six Selected States Employed in the Study

The South–South States lies within latitudes 4°5'N and 7°10'N to the north and longitudes 6°40'E and 8°30'E to the east. The South-South region of Nigeria is made up of

Akwa-Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers States. The South-South region covers 84,587 km^2 and roughly 9.2% of the country's total land area of 923,768 km^2 (See Fig. 1). The Nigerian Meteorological Agency [NiMet] (2022) estimates that the average annual rainfall in this region is 2000 mm, with variations for both inland and coastal locations. These regions have monthly mean temperatures that vary from 23 °C (73 F) at night to 31 °C during the day in the dry season (NiMet, 2022). While, Bayelsa, Delta, and Rivers are a few locations that experience the tropical monsoon.

2. 2. Methods of Data Collection

The Climatic Research Unit (CRU) Time-Series (TS) version 4.05 of high-resolution (0.5 × 0.5 degree) gridded data of month-by-month variation was accessed via the Google Earth interface to obtain the annual rainfall, temperature, vapour pressure, and diurnal temperature range (DTR) data used for this study (Harris et al., 2020). The information spans the years 1962 to 2021. To conduct the statistical analyses, IBM SPSS 28.0.1 was used. Numerous research on climate studies have used CRU data in their work in different parts of the world (e.g. Horn et al., 2018; Eyefia et al., 2023; Eyefia, 2023). The Diseases Surveillance Unit of each state Ministry of Health was used to gather the yearly incidences of diarrhoea, TB, and typhoid cases in the states of Cross River, Delta, Edo, Bayelsa, Rivers, and Akwa Ibom for the periods of 60 years (1962–2021). Descriptive statistics (mean) and inferential statistics (correlation analysis and multiple regression) are used to analyse both climatic factors and diseases.

3. RESULTS AND DISCUSSION

Table 1 shows the collinearity statistics for climatic variables and diarrhoea in selected South-South States, Nigeria. To test to see if the data met the assumption of collinearity, the table indicated that multicollinearity was not a concern (Rainfall, Tolerance = .757, VIF = 1.321; VAP, Tolerance = .158, VIF = 6.342; Temperature, Tolerance = .190, VIF = 5.265; DTR = .347, VIF = 2.878).

Table 1. Collinearity Statistics for Climatic Variables and Diarrhoea in Selected South-South States, Nigeria.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1232.965	1861.477		.662	.508		
	Rainfall	-9.571	1.435	-.350	-6.669	.000	.757	1.321
	VAP	-35.571	88.123	-.046	-.404	.687	.158	6.342
	Temp	267.634	136.224	.206	1.965	.050	.190	5.265
	DTR	-561.751	116.175	-.375	-4.835	.000	.347	2.878

a. Dependent Variable: Diarrhoea

Table 2 shows the collinearity statistics for climatic variables and tuberculosis in the selected South-South States, Nigeria. To test to see if the data met the assumption of collinearity, the table indicated that multicollinearity was not a concern (Rainfall, Tolerance = .757, VIF = 1.321; VAP, Tolerance = .158, VIF = 6.342; Temperature, Tolerance = .190, VIF = 5.265; DTR = .347, VIF = 2.878).

Table 2. Collinearity Statistics for Climatic Variables and Tuberculosis in the Selected South-South States, Nigeria.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-15775.808	17827.010		-.885	.377		
	Rainfall	74.719	13.743	.290	5.437	.000	.757	1.321
	VAP	-3769.410	843.933	-.522	-4.466	.000	.158	6.342
	Temp	3633.881	1304.596	.297	2.785	.006	.190	5.265
	DTR	1599.132	1112.587	.113	1.437	.152	.347	2.878

a. Dependent Variable: Tuberculosis

Table 3 shows the collinearity statistics for climatic variables and Typhoid in the selected South-South States, Nigeria. To test to see if the data met the assumption of collinearity, the table indicated that multicollinearity was not a concern (Rainfall, Tolerance = .754, VIF = 1.326; VAP, Tolerance = .156, VIF = 6.418; Temperature, Tolerance = .175, VIF = 5.705; DTR = .442, VIF = 2.261).

Table 3. Collinearity Statistics for Climatic Variables and Typhoid in the Selected South-South States, Nigeria.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-2633.494	519.518		-5.069	.000		
	Rainfall	-.721	.377	-.115	-1.915	.056	.754	1.326
	VAP	-57.927	24.044	-.318	-2.409	.017	.156	6.418
	Temp	171.977	37.065	.578	4.640	.000	.175	5.705
	DTR	-7.883	35.326	-.018	-.223	.824	.442	2.261

a. Dependent Variable: Typhoid

Table 4 shows the result of standard residuals for climatic variables and diarrhoea. To identify if there are any outliers, an analysis of standard residuals was carried out, and the result showed that the data contained no outliers (Std. Residual Min = -2.171, Std. Residual Max = 2.889).

Table 4. Residual Statistics for Climatic Variables and Diarrhoea in the Selected South-South States, Nigeria.

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-377.5644	1630.2646	599.9222	412.39877	360
Residual	-1519.15637	2021.11023	.00000	695.68712	360
Std. Predicted Value	-2.370	2.498	.000	1.000	360
Std. Residual	-2.171	2.889	.000	.994	360

a. Dependent Variable: Diarrhoea

Table 5 shows the result of standard residuals for climatic variables and tuberculosis. To identify if there are any outliers, an analysis of standard residuals was carried out, and the result showed that the data contained no outliers (Std. Residual Min = -1.840, Std. Residual Max = 4.316.

Table 5. Residual Statistics for Climatic Variables and Tuberculosis in the Selected South-South States, Nigeria.

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-2992.5513	13319.5273	3567.5611	3687.21638	360
Residual	-12324.52734	28913.88867	.00000	6662.46420	360
Std. Predicted Value	-1.779	2.645	.000	1.000	360
Std. Residual	-1.840	4.316	.000	.994	360

a. Dependent Variable: Tuberculosis

Table 6 shows the result of standard residuals for climatic variables and tuberculosis. To identify if there are any outliers, an analysis of standard residuals was carried out, and the result showed that the data contained no outliers (Std. Residual Min = -1.849, Std. Residual Max = 7.623).

Table 6. Residual Statistics for Climatic Variables and Typhoid in the Selected South-South States, Nigeria.

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-110.5972	372.9632	86.3633	86.75278	300
Residual	-325.96317	1344.14294	.00000	175.13267	300
Std. Predicted Value	-2.270	3.304	.000	1.000	300
Std. Residual	-1.849	7.623	.000	.993	300

a. Dependent Variable: Typhoid

Characteristics of the Climatic Variables, Diarrhoea, Tuberculosis, and Typhoid in The Selected South-South States, Nigeria

Table 7 indicates the characteristics of climatic variables in the selected South-South States, Nigeria, with vapour pressure having a mean of 27.7HPa, DTR (8.6 °C), Temperature (26.3 °C), and rainfall (1,165.3 mm) with Delta State having the highest vapour pressure of 29 HPa, and Cross River state and Rivers States having the lowest of 27HPa and 26.9 HPa respectively. DTR had the highest of 9.2 °C in Cross River State and Bayelsa state had the lowest of 7.8 °C. Temperature had the highest of 27.0 °C in Delta and Edo States respectively and Cross River, Rivers, and Akwa Ibom States had the lowest of 26.0 °C, 25.6 °C, and 26.0 °C respectively. Rainfall had the highest of 208.6 mm in Cross River State and Edo State had the lowest of 152.3 mm.

Table 7. Characteristics of Climatic Variables in the South-South Region

Variables	**Cross River**	**Delta**	**Edo**	**Bayelsa**	**Rivers**	**Akwa Ibom**	**Mean**
VAP	27 HPa	29 HPa	28 HPa	28.4 HPa	27.4 HPa	26.9 HPa	27.7 HPa
DTR	9.2 °C	8.4 °C	8.9 °C	7.8 °C	8.3 °C	8.9 °C	8.6 °C
Temp.	26.0 °C	27.0 °C	27.0 °C	26.1 °C	25.6 °C	26.0 °C	26.3 °C
Rainfall	208.6 mm	192.5 mm	152.5 mm	202.3 mm	202.6 mm	206.9 mm	1165.3 mm

Table 8 revealed the characteristics of incidences of Malaria, Diarrhoea, Typhoid and Tuberculosis in the selected South-South States, Nigeria, with malaria having a total case of 48,896.7, Diarrhoea (215, 972), Typhoid (25,909), and Tuberculosis (1,267,808). Malaria had the highest cases of 827.1167 in Akwa Ibom state and the lowest cases of 1,868.333 in River's state. Diarrhoea had the highest cases of 99,417 in Bayelsa State and the lowest cases of 3721 in Akwa Ibom State, Typhoid had the highest cases of 4,556 in Akwa Ibom State and the lowest cases of 434 in Rivers State. Tuberculosis had the highest of 1,037,337 in Cross River State and the lowest cases of 3,158 in Akwa Ibom state.

Table 8. Characteristics of Incidences of Malaria, Diarrhoea, Typhoid and Tuberculosis in the South-South Region.

Disease	Cross River	Delta	Edo	Bayelsa	Rivers	Akwa Ibom	Total
Malaria	801.7167	361.1833	25,799.73	19,238.57	1,868.333	8,27.1167	48,896.7
Diarrhoea	8,112	6,816	93,841	99,417	4,065	3,721	215,972
Typhoid	3,383	876	16,660	-	434	4,556	25,909
Tuberculosis	1,037,337	4,160	4,800	170,025	64,842	3,158	1,267,808

Table 9 shows the correlation statistics for climatic variables, diarrhoea and tuberculosis in the selected South-South States, Nigeria. A Pearson correlation coefficient was performed to evaluate the relationship between climatic variables (rainfall, vapour pressure, temperature, and diurnal temperature range (DTR) and diseases (diarrhoea and tuberculosis). The result showed that there was a significant but moderate negative relationship between rainfall and diarrhoea, r [360] = [.345], p = [< .001]. The present result is in consonant with the work of Tang (2009) who found that rainfall can affect the occurrence of diarrhoea diseases as well as the ability to survive and spread pathogens. DTR had a weak negative significant relationship with diarrhoea, [-.266], p = [< .000].

Table 9. Correlations Statistics for Climatic Variables, Diarrhoea and Tuberculosis in the Selected South-South States, Nigeria.

		Diarrhoea	Tuberculosis	Rainfall	VAP	Temp	DTR
Diarrhoea	Pearson Correlation	1	-.160**	-.345**	.290**	.258**	-.266**
	Sig. (2-tailed)		.002	.000	.000	.000	.000
	N	360	360	360	360	360	360
Tuberculosis	Pearson Correlation	-.160**	1	.172**	-.370**	-.161**	.343**
	Sig. (2-tailed)	.002		.001	.000	.002	.000
	N	360	360	360	360	360	360

**. Correlation is significant at the 0.01 level (2-tailed).

The result is in line with Xu et al. (2013a) who observed that DTR may be an additional risk variable for diarrhoea. While vapour pressure and temperature had a significant but weak positive relationship with diarrhoea, [.290], [.258], p = [< .000] respectively. The outcome of this study is in tandem with the work of Conza et al. (2013) and Halsby et al. (2014) who revealed that vapour pressure and temperature may be related to the incidence of sporadic disease. On tuberculosis, rainfall had a weak positive significant relationship with tuberculosis, [.172], p = [< .001].

The result of this study is in consonant with Efe et al. (2023) which revealed that tuberculosis in southern Nigeria is significantly impacted by rainfall. DTR had a moderate positive significant relationship with tuberculosis [.343], p = [< .000]. While, vapour pressure had a moderate negative significant relationship with tuberculosis [-.370], p = [< .000].

This result is in tandem with the work of de Castro Fernandes et al. (2021) which shows that three localities had a 4.6–5.8-fold higher risk of tuberculosis infection due to vapour pressure. Temperature had a weak negative significant relationship with tuberculosis, [-.161], p = [< .002].

Table 10. Correlations Statistics for Climatic Variables and Typhoid in the Selected South-South States, Nigeria.

		Typhoid	Rainfall	VAP	Temp	DTR
Typhoid	Pearson Correlation	1	-.292**	.149**	.369**	.152**
	Sig. (2-tailed)		.000	.010	.000	.008
	N	300	300	300	300	300

**. Correlation is significant at the 0.01 level (2-tailed).

Table 10 shows the correlation statistics for climatic variables and typhoid in the selected South-South States, Nigeria. A Pearson correlation coefficient was performed to evaluate the relationship between climatic variables (rainfall, vapour pressure, temperature, diurnal temperature range (DTR) and diseases (typhoid).

The result showed that there was a significant but weak negative relationship between rainfall and typhoid, r [300] = [-.292], p = [< .000]. Vapour pressure and DTR had a weak and positive significant relationship with typhoid, (.149), [.152], p = [< .000], p = [< .008] respectively. While temperature had a significant but moderate and positive relationship with diarrhoea, [.290], [.369], p = [< .000] respectively.

Table 11 shows the model summary for climatic variables, diarrhoea and tuberculosis in the selected South-South States, Nigeria. The table showed that the data met the assumption of independent errors (Durbin-Watson value = .866 and 1.055) respectively.

Table 12 shows the model summary for climatic variables and typhoid in the selected South-South States, Nigeria. The table showed that the data met the assumption of independent errors (Durbin-Watson value = .1.113).

Table 11. Model Summary for Climatic Variables, Diarrhoea and Tuberculosis in the Selected South-South States, Nigeria.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Diarrhoea	.510[a]	.260	.252	699.59551	.866
Tuberculosis	.484[a]	.234	.226	6699.89407	1.055

a. Predictors: (Constant), DTR, Tem, Rainfall, VAP

b. Dependent Variable: Diarrhoea, Tuberculosis

Table 12. Model Summary for Climatic Variables and Typhoid in the Selected South-South States, Nigeria.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Typhoid	.444[a]	.197	.186	176.31601	1.113

a. Predictors: (Constant), DTR, Temp, Rainfall, VAP

b. Dependent Variable: typhoid

Table 13 shows the summary of ANOVA results for climatic variables and diarrhoea. The table showed that there was a statistically significant difference between groups as determined by one-way ANOVA (F (4,355) = 31.187, p = .000).

Table 13. Summary of ANOVA Result for Diarrhoea in the Selected South-South States, Nigeria.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	61056114.573	4	15264028.643	31.187	.000[b]
	Residual	173749025.250	355	489433.874		
	Total	234805139.822	359			

a. Dependent Variable: Diarrhoea

b. Predictors: (Constant), DTR, Temp, Rainfall, VAP

Table 14 shows the summary of ANOVA results for climatic variables and tuberculosis. The table showed that there was a statistically significant difference between groups as determined by one-way ANOVA (F (4,355) = 27.183, p = .000).

Table 14. Summary of ANOVA Result for Tuberculosis in the Selected South-South States, Nigeria.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4880807691.249	4	1220201922.812	27.183	.000[b]
	Residual	15935446071.407	355	44888580.483		
	Total	20816253762.656	359			

a. Dependent Variable: Tuberculosis
b. Predictors: (Constant), DTR, Temp, Rainfall, VAP

Table 15 shows the summary of ANOVA results for climatic variables and typhoid. The table showed that there was a statistically significant difference between groups as determined by one-way ANOVA (F (4,295) = 18.096, p = .000).

Table 15. Summary of ANOVA Result for Typhoid in the Selected South-South States, Nigeria.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2250287.645	4	562571.911	18.096	.000[b]
	Residual	9170763.752	295	31087.335		
	Total	11421051.397	299			

a. Dependent Variable: Typhoid
b. Predictors: (Constant), DTR, Temp, Rainfall, VAP

4. CONCLUSIONS

The National Tuberculosis and Leprosy Control Programme (NTBLCP) was established in 1989 by the Government of Nigeria to coordinate TB and leprosy control efforts in Nigeria, with a mandate to further expanded to include Buruli Ulcer control in 2006, but after 36 years Nigeria still has the highest TB burden in Africa. The results of climatic variables and diarrhoea showed that DTR, temperature, rainfall, and vapour pressure significantly impact on diarrhoea as determined by one-way ANOVA (F (4,355) = 31.187, p = .000). The results of climatic variables and tuberculosis showed that DTR, temperature, rainfall, and vapour pressure significantly impact on tuberculosis as determined by one-way ANOVA (F (4,355) = 27.183, p = .000). While, the result of climatic variables and typhoid showed that DTR, temperature, rainfall, and vapour pressure significantly impact of typhoid as determined by one-way ANOVA (F (4,295) = 18.096, p = .000). To mitigate the effects of tuberculosis, typhoid and diarrhoea, Nigerians are advised to strengthen their safe-drinking water, sanitation, and hygiene (WASH) systems, create early alert systems for health hazards associated with climate change, implement improved health care delivery and availability, and carry out studies and tracking efforts for improved understanding of the relationships between climatic variables and disease.

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