



NEXUS BETWEEN CLIMATIC ELEMENTS AND DISEASES: AN INSIGHT INTO TEMPORAL PATTERN OF MEASLES INCIDENCE IN BADE LGA, YOBE STATE, NIGERIA

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ABSTRACT

Measles incidence have been a recurrent phenomenon and had posed huge challenge to public health in developing countries, especially the Sahel. This study analyzes the nexus between weather elements and measles incidence in Bade Local Government Area (LGA), Yobe State, Nigeria from 2013 to 2022. Daily meteorological data from the Nigerian Meteorological Agency (NiMet) and measles cases from Bade LGA Health Department were subjected to stepwise multiple regression, Pearson correlations, and seasonal averaging. Models explained 8–65.3% of measles variance (mean $R^2 = 37.5\%$), with significant positive associations for humidity (r up to 0.717, $p < 0.001$) and wind speed (r up to 0.599, $p < 0.001$). Peaks occurred in dry-hot months (March–July), coinciding with low rainfall and high temperatures. Grounded in disease ecology, findings reveal climate as a key driver via temperature, relative humidity and aerosol stability. The study recommends integrating meteorological data in early warning systems and synchronizes vaccinations with dry seasons by public health agencies. This evidence aids climate-adaptive strategies in Sahelian Nigeria.

Keywords: Climate Variability, Measles, Seasonality, Disease Ecology, Sahel, Public Health

INTRODUCTION

Measles, an acute viral disease caused by Morbillivirus, remains a major public health challenge in many developing countries due to its high transmission and potential complications among infants (World Health Organization [WHO], 2025). Despite substantial global progress through immunization efforts, measles continues to exhibit persistent endemicity and periodic outbreaks in regions with suboptimal vaccination coverage (Luo et al., 2025). In Nigeria, the burden of measles is especially pronounced in the northern states, where routine immunization coverage often falls below targets required to ensure herd immunity, and incidence peaks are frequently observed during specific seasons (Ojasanya et al., 2025; Saleh, 2016). Understanding the temporal dynamics of measles occurrence and its relationship with climatic factors is essential for effective disease control strategies.

Climatic conditions influence the transmission dynamics of infectious diseases by affecting pathogen viability, human behavior, and host susceptibility (Jia et al., 2023). Environmental variables may alter viral survival outside the host, modulate contact patterns among susceptible populations, and interact with socio-ecological conditions that facilitate exposure (Abdullahi et al., 2024; Yang et al., 2014). Empirical evidence from diverse geographic contexts demonstrates that meteorological conditions exhibit measurable associations with measles incidence. For example, in Shandong Province, China, specific climatic conditions such as lower relative humidity and temperature, combined with higher wind velocity and sunshine hours, were significantly linked to increased measles risk across spatial units over time (Jia et al., 2023). Similarly, studies in southern China indicated that low relative humidity constituted a risk factor for measles morbidity, highlighting the potential influence of weather transitions on transmission patterns (Yang et al., 2014).

In the Nigerian context, research on the relationship between climatic parameters and measles outcomes is emerging but highlights notable seasonal patterns. Time series analyses of national surveillance data have consistently identified

seasonal peaks in measles incidence in the first quarter of the year, coinciding with dry season conditions characterized by high temperatures and low humidity (Ojasanya et al., 2025; Saleh, 2016). Correlation studies in parts of northern Nigeria have suggested that reductions in rainfall are associated with changes in measles occurrence, although the strength and direction of these relationships vary by location and climatic parameter (Dahiru, Abaje, & Ati, 2025; Ibrahim and Bulama, 2023). On the flip side, regarding weather and infectious diseases pattern in Nigeria evidence flourished in many studies. Ekpo et al (2020) revealed that an upward trend in temperature and rainfall is capable of increasing the occurrence of malaria in Zaria. These findings align with broader evidence that environmental drivers interact with socio-behavioral and immunological factors to shape the temporal patterns of measles transmission.

Bade Local Government Area (LGA), a Sahel region characterized by semi-arid climatic conditions, presents unique environmental conditions that warrant focused investigation. Climatic variability in this region, including pronounced dry and wet seasons and high inter-annual temperature fluctuations, may exert significant influence on viral circulation and host interactions, yet empirical studies specifically addressing measles in this setting remain limited. Elucidating the link and temporal pattern of measles incidence relative to climatic elements in the region is critical to refining predictive models and enhancing targeted surveillance and immunization strategies in similar ecological zones.

Conceptual Framework: A Disease Ecology Perspective

This study is grounded in Pavlovsky's (1939) disease ecology framework, which conceptualizes infectious disease emergence as the outcome of triadic interactions among pathogens, vectors or hosts, and environments. Ecological processes spanning temporal and spatial scales integrate climate variability, human behaviours, population immunity, and socio-environmental factors to shape disease patterns (Ostfeld et al., 2005). Climatic elements emerge as pivotal

distal drivers, altering pathogen viability, vector and host dynamics, and transmission chances.

Applied to measles, a highly contagious lipid-enveloped paramyxovirus transmitted via respiratory droplets. Beyond proximal determinants like vaccination gaps and susceptibility thresholds, environmental modulators critically influence viral persistence, contact networks, and host resilience (Ojasanya et al., 2025). Temperature affects

envelope stability; relative humidity governs aerosolization and desiccation; wind speed disperses droplets; and rainfall indirectly shapes mobility and crowding (Tang, 2009). By leveraging disease ecology, the study bridges climatology and epidemiology, furnishing a robust theoretical scaffold for dissecting the climate–measles nexus in Bade LGA and informing adaptive strategies under global change.

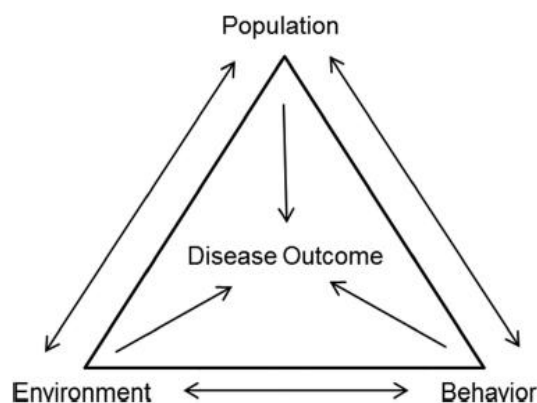


Figure 1: Disease Ecology Model Illustrating Climate-mediated Measles Transmission Pathways. Adapted from Messina (2011)

MATERIALS AND METHODS

Study Area

Bade Local Government Area (LGA) is located in the Sahelian zone of northeastern Nigeria, within Yobe State, between approximately 12°50'–13°30' N and 10°30'–11°20' E. Its administrative headquarters is Gashua, a major urban centre in northern Yobe State. According to the 2006 National Population Census, Bade LGA had a population of 139,782, with projections indicating steady growth largely driven by natural increase (National Population Commission [NPC], 2006). The livelihoods of the people is based mainly on agriculture, fishing, livestock rearing, and petty trading. Major crops include millet, sorghum, maize, and rice, especially along the floodplains of the Komadugu–Yobe River system, which is central to local agricultural

productivity and food security (Jajere et al., 2022). The population is ethnically diverse, comprising Bade, Hausa, Kanuri, and Fulani groups.

Bade LGA experiences semi-arid conditions with pronounced seasonal variability. The climate is controlled by the seasonal interaction between the dry tropical continental air mass from the Sahara and the moist tropical maritime air mass from the Atlantic Ocean. Two distinct seasons prevail: a long dry season (October–May) and a short rainy season (June–September) (Ayoade, 2003). Mean annual rainfall ranges from 500–800 mm with high inter-annual variability (Jajere et al., 2022; Nigerian Meteorological Agency [NiMet], 2020). Temperatures often exceeding 35 °C in the hot months, while the Harmattan period (November–February) is marked by dry, dusty conditions and reduced humidity.

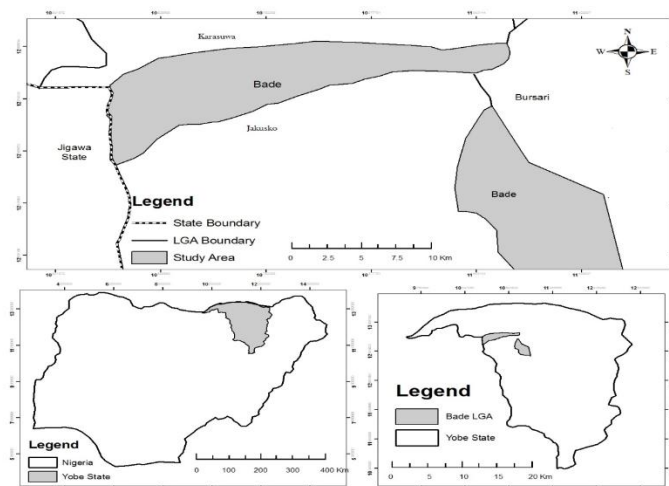


Figure 2: Bade Local Government Area. Source: NASDA, 2012

Data Collection

The study used two set of data: weather elements and measles cases. The daily record of temperature (°C), rainfall (mm), relative humidity (%) and wind speed (Km/h) were collected

from NiMeT for ten years (2013 to 2022) from Nguru weather station. Data on measles cases was obtained from Epidemiological and Diseases Surveillance Centre, Bade Local Government Primary Health Care Department for the

same period. The data were aggregated by weekly for use in the regression, this is based on the fact that many infectious diseases exhibit incubation periods and transmission dynamics that align more closely with weekly temporal scales as assert (Hilbe, 2011; Kutner et al, 2005).

Data Analysis

Multiple regression analysis (stepwise method) was used to assess the relationship between weather parameters (predictors) and disease incidences (dependent). The analysis used measles variables regressed against independent variables (weather). Coefficient of multiple determination(R-square) accessed the join contribution of independent variables on dependent. The value shows the variation of dependent variable as explaining by multiple independent variables. Also, Pearson Product Moment Correlation (PPMC) assessed the bivariate link between disease incidence and weather variables. All these was carried out in SPSS 27.0.1 statistical application. Seasonal pattern was identified using average. The study use the following Multiple Regression Model were Y=dependent variable (measles), X=independent

variable (weather elements), a=Y intercept and b=regression coefficient

$$Y = a + b_1X_1 + b_2X_2 + \dots + b_nX_n$$

RESULTS AND DISCUSSION

Presentation of Result

The data indicate that from 2013 to 2022 temperature seems to have above average in the months of March, April, May and June. Rainfall usually begins in June to September with some trace in May and October of some year. Relative humidity is all year round with months of May, June, July, August, September and October with an above the longtime average. Wind-speed is rambled around the average through most of the months but tend to have higher value in June and July around the early raining season. The measles cases show serial higher occurrences in April, May, June and July and steeply decline around in August. This coincides with driest time of the year and decline when the rainfall has started to reach dominance as shown in Table 1. On annual base, the study shows a decade long mean of weather elements and measles cases in Bade LGA as indicated by Table 2.

Table 1: Decade Monthly Mean for Weather and Disease Variables 2013-2022

Month	Measles	Temperature (°C)	Rainfall (mm)	Relative Humidity (%)	Wind Speed (Km/h)
January	128.6	30.7	0	22.3	41.5
February	69.5	35.6	0	19.9	56.9
March	101.6	38.4	0	20.1	65.8
April	130.3	40.6	0	32.3	53.2
May	115.6	40.7	16.8	44.4	54.4
June	122.2	37.6	51.6	53.2	73.6
July	198.7	34.8	128.6	67.7	76.8
August	78.3	31.8	216.8	75.8	56.2
September	80	34.2	67.8	66.8	51.6
October	52.2	36.5	13.5	46.7	41.5
November	47.7	35.6	0	27.1	45.4
December	30.1	31.8	0	23.8	41.67
Long time Mean	96.2	35.7	82.5	41.7	54.8

Author Computation, 2025

Table 2: The Annual Mean of Diseases and Weather Variables in Bade LGA

Year	Measles	Temperature (°C)	Rainfall (mm)	R-Humidity (%)	Wind speed(Km/h)
2013	968	35.5	96.9	39.2	29.0
2014	238	35.6	92.6	40.7	30.2
2015	414	35.4	79.8	38.5	34.1
2016	385	34.9	58.8	39.2	50.7
2017	426	36.1	61.1	38.0	66.7
2018	4664	36.1	71.2	38.2	54.4
2019	1899	35.5	66.2	42.6	68.4
2020	640	35.5	92.8	45.1	67.0
2021	897	35.9	87.0	46.7	73.8
2022	1017	35.5	118.6	48.5	74.4
Average	1154.8	35.6	82.5	41.7	54.9

Author Computation, 2025

Relationship between Measles and Weather Elements

Table 3 summarizes multiple linear regression results assessing associations between temperature, rainfall, relative humidity, wind speed, and measles incidence in Bade LGA from 2013–2022. Pearson correlations, standardized beta coefficients, percentage contributions, and model diagnostics (R², F-statistics, p-values) indicate that meteorological influences on measles are strongly year-specific. Regression models were robust in most years, with significant F-values and R² ranging from 8% to 65.3%, suggesting that weather

elements explain a substantial proportion of interannual variability in measles incidence. Conversely, 2018 and 2021 recorded non-significant results, likely reflecting model non-convergence or the influence of non-climatic confounders such as intensified immunization campaigns. Overall, the findings support epidemiological evidence that climatic conditions modulate measles transmission by influencing aerosol stability, human behavior, and contact patterns, consistent with disease–environment interaction frameworks (Ojasanya et al., 2025).

Year-by-Year Analysis of Correlations and Contributions

In 2013, weak but significant positive associations were observed, with humidity emerging as the strongest predictor ($r = 0.277$; $R^2 = 8\%$), indicating a modest climatic contribution. In 2014, all variables were significant, and the model explained 45% of measles variance, dominated by wind speed (25%) and humidity (13%), suggesting enhanced airborne dispersion. The 2015 model ($R^2 = 26\%$) again highlighted wind speed and humidity as key drivers, with rainfall exerting a minor influence. In 2016, all weather variables showed strong positive relationships, collectively explaining 55% of variability, indicating a balanced climatic

control on transmission. The strongest climatic signal occurred in 2017, when humidity alone accounted for over half of the explained variance ($R^2 = 65.3\%$), underscoring its pivotal role during peak transmission. In contrast, 2019 exhibited predominantly negative associations, particularly with temperature and humidity ($R^2 = 27.3\%$), implying reduced transmission under warmer, more humid conditions, possibly due to decreased indoor crowding. Results for 2020 showed mixed effects, with modest explanatory power ($R^2 = 19\%$). By 2022, strong positive relationships re-emerged, especially for wind speed (35%) and humidity, with the model explaining 55% of variance.

Table 3: Relationship between Weather Elements and Measles

Yrs.	Weather variables	Correlation	Beta	%	R ²	F-value	P-value
2013	Temperature	.177					
	Rainfall	.217					
	Humidity	.277*	.277	08	8%	4.167	.000
	W-speed	.108					
2014	Temperature	.402*	.291	07		13.253	.000
	Rainfall	.271*					
	Humidity	.476*	.374	13		15.147	.000
	W-speed	.501*	.501	25	45%	16.731	.000
2015	Temperature	.253					
	Rainfall	.176*					
	Humidity	.313*					
	W-speed	.464*	.464	26	26%	13.716	.001
2016	Temperature	.431*		19		17.755	.000
	Rainfall	.400*		04	55%	14.279	.000
	Humidity	.476*	.308	23		14.674	.000
	W-speed	.492*		09		16.442	.000
2017	Temperature	.342	.323	10		44.615	.000
	Rainfall	.520	.265	04	65.3%	33.835	.000
	Humidity	.717	.717	51		59.364	.000
	W-speed	.398					
2018	Temperature	.128					
	Rainfall	.208					
	Humidity	.175					
	W-speed	.244					
2019	Temperature	-.446*	-.446	20		12.391	.001
	Rainfall	-.181					
	Humidity	-.277*	-.272	07	27.3%	9.182	
	W-speed	-.184					.000
2020	Temperature	.325*	.279	07	19%	5.871	.005
	Rainfall	-.139					
	Humidity	-.219					
	W-speed	-.342*	-.342	12		6.637	.013
2021	Temperature	.201					
	Rainfall	.009					
	Humidity	.000					
	W-speed	.094					
2022	Temperature	.304*	.324	12		21.220	.000
	Rainfall	.186					
	Humidity	.501*	.309	09	55%	19.339	.000
	W-speed	.599*	.599	35		28.014	.000

Source: Author computation, 2025* = significant at 1-tailed

RESULTS AND DISCUSSION

Table 3 reveals predominantly positive associations between climatic variables and measles incidence, with particularly strong effects of relative humidity ($r = 0.717$ in 2017) and wind speed ($r = 0.599$ in 2022). These findings are consistent with evidence that measles transmission is optimized with temperatures and relative humidity, which enhance aerosol stability. Wind speed often contributed most to explained variance (up to 35%), suggesting a key role in facilitating

airborne spread, whereas rainfall showed weak and inconsistent effects. In contrast, negative associations observed in 2019–2020 suggest climatic thresholds beyond which elevated temperature and humidity may inhibit viral survival and transmission, this is also in tangent with how climate influence diseases in Africa (Pitzer et al., 2015). Model performance varied interannually, with R^2 values peaking in high-burden years (2016, 2017, and 2022; 55–65.3%) and declining substantially in other years (8–19%),

indicating the influence of non-climatic confounders such as vaccination coverage and reporting bias. Temperature effects were context dependent, while relative humidity and wind speed emerged as the most consistent predictors. These results align with experimental and epidemiological evidence on climate-mediated measles transmission (Tang, 2009; Omonijo et al., 2012; Yang et al., 2014), and seasonal peaks between March and July reflect dry-season transmission and increased social interaction (Onyiriuka, 2011).

CONCLUSION

This study demonstrates a clear climate–measles nexus in Bade Local Government Area, Yobe State, Nigeria, highlighting the role of meteorological variability in shaping temporal transmission patterns between 2011 and 2022. Temperature, relative humidity, and wind speed showed significant but year-specific influences on measles incidence. Temperature exerted positive effects in major outbreak years, explaining up to 20% of annual variance, while relative humidity was the dominant driver during peak periods, accounting for as much as 51% of variability. Wind speed also contributed substantially in several years (up to 35%), supporting its role in facilitating airborne transmission, with occasional inverse effects under high-humidity conditions, consistent with evidence on viral survival thresholds (Tang, 2009). Seasonal peaks between March and July coincided with dry-season conditions and heightened social interactions, reinforcing the importance of seasonal climate dynamics in measles epidemiology. Overall, weather parameters explained 8–65% of annual measles variance, underscoring their epidemiological relevance in semi-arid environments. These findings support the integration of climate information into measles surveillance, vaccination planning, and early-warning systems, with priority given to dry-season interventions in Bade LGA and the wider Sahel. Future studies should adopt spatial and multivariate approaches to better resolve causal pathways.

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