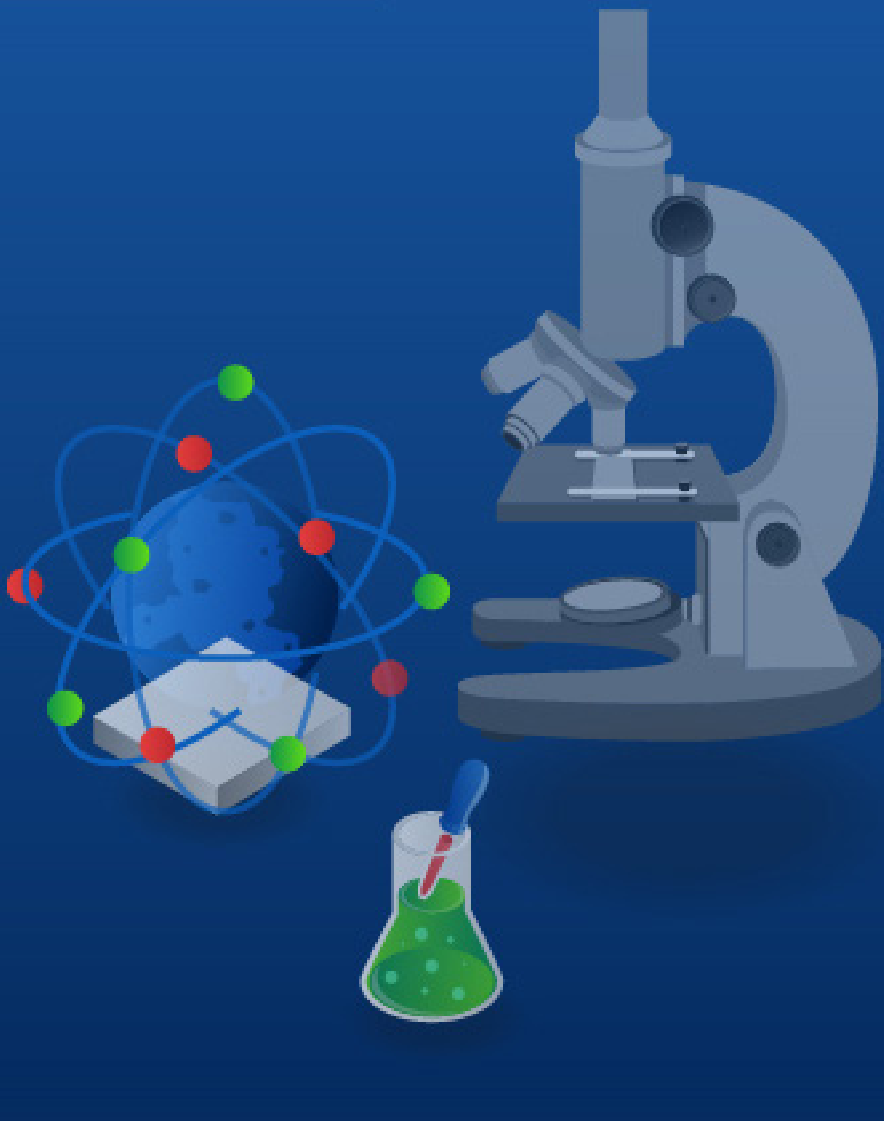
American Journal of Bioscience and Bioinformatics (AJBB)

ISSN: 2995-0481 (ONLINE)

VOLUME 5 ISSUE 1 (2026)



PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Biosciences and Bioinformatics (AJBB)

Volume 5 Issue 1, Year 2026
ISSN: 2995-0481 (Online)
DOI: https://doi.org/10.54536/ajbb.v5i1.8094
https://journals.e-palli.com/home/index.php/ajbb

Seasonal and Climatic Drivers of Lassa Fever Transmission in Nigeria: A Multi-Year Ecological Analysis (2020–2025)

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Article Information

Received: April 20, 2026
Accepted: June 28, 2026
Published: August 03, 2026

Keywords

Climate Variability, Epidemiology, Humidity, Lassa Fever, Negative Binomial Regression, Nigeria, Rainfall, Seasonality, Temperature

ABSTRACT

Lassa fever remains a major public health challenge in Nigeria, where recurrent outbreaks continue to impose substantial health and socioeconomic burdens. Although climatic variability has been implicated in disease transmission, the relative contributions of key environmental factors to outbreak occurrence remain insufficiently quantified. This study examined the influence of temperature, rainfall, humidity, and seasonality on Lassa fever epidemiology in Nigeria using national surveillance and meteorological data collected between 2020 and 2025. A total of 1,404 observations comprising confirmed cases and associated climatic variables were analysed using descriptive statistics, Pearson correlation analysis, and Negative Binomial Regression to account for overdispersion in disease counts. The findings revealed a pronounced seasonal pattern, with 77.1% of confirmed cases occurring during the dry season and peak transmission observed between January and March. Temperature was positively associated with disease incidence, whereas rainfall exhibited a significant inverse relationship. Negative Binomial Regression identified temperature (IRR = 1.024, $p < .001$), rainfall (IRR = 0.987, $p < .001$), humidity (IRR = 1.007, $p = .001$), and seasonality (IRR = 2.131, $p < .001$) as significant predictors of Lassa fever occurrence. After adjusting for climatic factors, disease incidence during the dry season was approximately 113% higher than during the wet season. These patterns suggest that climatic conditions influence transmission through their effects on environmental suitability, rodent ecology, and opportunities for human exposure. This study provides updated national-level evidence on the climatic determinants of Lassa fever transmission in Nigeria and demonstrates the dominant role of seasonality in shaping outbreak dynamics. By simultaneously quantifying the independent effects of multiple environmental drivers using a modelling framework appropriate for overdispersed disease count data, the study advances understanding of climate-sensitive Lassa fever epidemiology and provides an evidence base for climate-informed surveillance, early warning systems, and outbreak preparedness strategies.

INTRODUCTION

Lassa Fever is a zoonotic viral haemorrhagic disease that remains a significant public health challenge in Nigeria and several countries across West Africa. The disease is caused by the Lassa virus and is primarily transmitted to humans through exposure to food, household items, or environmental surfaces contaminated by infected *Mastomys* rodents, which serve as the principal reservoir hosts. Human-to-human transmission may also occur, particularly in healthcare settings where infection prevention and control measures are inadequate (WHO, 2024; Grace *et al.,* 2021; Eneh *et al.,* 2025; Adeyeni *et al.*, 2025). Despite sustained surveillance and response efforts, Nigeria continues to experience recurrent outbreaks, with substantial morbidity and mortality reported annually. Recent surveillance data indicate that states such as Ondo, Edo, Bauchi, and Taraba consistently contribute a significant proportion of the national disease burden, highlighting the endemic nature of Lassa fever in the country (Redding *et al.,* 2021; NCDC, 2025; Cadmus *et al.,* 2025).

The public health significance of Lassa fever extends beyond its recurrent outbreaks to the severe clinical outcomes associated with infection. The disease commonly presents with non-specific symptoms, including fever, headache, weakness, vomiting, and chest pain, which can progress to haemorrhage, multi-organ dysfunction, and death in severe cases. Early diagnosis remains challenging due to symptom overlap with other endemic febrile illnesses, while limited healthcare access in some affected communities further increases disease severity and fatality rates (Dan-Nwafor *et al.,* 2022; Al-Mustapha *et al.,* 2024; WHO, 2024). In addition to clinical factors, environmental and socio-economic conditions such as poor sanitation, inadequate housing, unsafe food storage practices, and increased rodent infestation have been identified as important drivers of disease transmission in endemic areas (Cadmus *et al.,* 2023; Oyeyiola *et al.,* 2025).

A notable feature of Lassa fever epidemiology in Nigeria is its pronounced seasonal behaviour. Outbreaks typically peak during the dry season, particularly between November and March, and decline during the rainy season. This recurring pattern suggests that climatic conditions play a critical role in shaping transmission dynamics (Grace *et al.,* 2021; Redding *et al.,* 2021; Fuwape *et al.,* 2026). Environmental variables such as temperature, rainfall, and relative humidity influence rodent ecology,

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breeding cycles, habitat suitability, food availability, and virus survival, thereby affecting the likelihood of human exposure. During dry periods, rodents frequently move into human dwellings and food storage facilities in search of food and shelter, increasing opportunities for virus transmission.

Previous studies have consistently demonstrated that climatic variability plays a fundamental role in shaping the transmission dynamics of Lassa fever across Nigeria and other endemic regions of West Africa. Temperature influences the survival, breeding success, dispersal, and foraging behaviour of *Mastomys natalensis*, the principal reservoir host of the Lassa virus, while simultaneously affecting viral persistence under different environmental conditions. Rainfall regulates vegetation cover, food availability, and habitat suitability, thereby influencing rodent population density and seasonal movement into human settlements. Relative humidity also contributes to disease transmission by affecting environmental moisture, virus survival, and ecological conditions that facilitate human exposure. Increasing evidence further suggests that climatic variables interact with land-use change, agricultural activities, urbanisation, housing quality, and socioeconomic conditions to determine the spatial and temporal distribution of Lassa fever rather than acting independently (Redding *et al.,* 2021; Cadmus *et al.,* 2023; Arotolu *et al.,* 2025; Fuwape *et al.,* 2026; Ezenwa-Ahanene *et al.,* 2024). Recent epidemiological investigations have likewise confirmed that Lassa fever outbreaks exhibit strong seasonal characteristics, with transmission intensifying during the dry season when ecological conditions promote increased human–rodent contact (John *et al.,* 2026; Ezenwa-Ahanene *et al.,* 2024; Grace *et al.,* 2021). Nevertheless, the magnitude and direction of these climatic relationships vary across ecological zones, geographical locations, and surveillance periods because of differences in environmental conditions, rodent ecology, human behaviour, and surveillance capacity. These inconsistencies highlight the need for continued investigation using recent epidemiological and meteorological data to improve understanding of climate-sensitive transmission pathways and to support the development of more reliable early warning and outbreak prediction systems.

The distribution of Lassa fever in Nigeria also exhibits considerable spatial heterogeneity. Although cases have been reported across multiple states, the burden remains disproportionately concentrated in specific endemic regions, including Ondo, Edo, Bauchi, Taraba, Benue, and Kogi States (Al-Mustapha *et al.,* 2024; NCDC, 2025). Such variations indicate that local ecological conditions, population characteristics, socio-economic activities, and healthcare accessibility may interact with climatic factors to influence disease occurrence. Understanding these spatial and seasonal dynamics is essential for improving surveillance systems, targeting interventions, and strengthening outbreak preparedness.

Despite increasing research attention, important knowledge gaps remain regarding the role of seasonal variability in Lassa fever transmission. Much of the existing literature has focused on outbreak descriptions, surveillance reports, and case-fatality trends, with relatively limited emphasis on quantifying the influence of climatic factors on disease occurrence at the national scale (Ilori *et al.,* 2020; Dan-Nwafor *et al.,* 2022). Furthermore, many studies have been restricted to specific states or localized outbreaks, limiting broader understanding of seasonal transmission patterns across Nigeria's diverse ecological zones.

The growing impacts of climate variability further underscore the need for comprehensive investigations of climate-sensitive infectious diseases. Changes in temperature regimes, rainfall patterns, and environmental conditions may alter rodent habitats, affect pathogen survival, and modify human exposure risks, potentially influencing the timing, intensity, and geographic spread of Lassa fever outbreaks (WHO, 2024; Redding *et al.,* 2021; Fayomi *et al.,* 2025). Understanding these relationships is increasingly important for developing climate-informed surveillance systems and evidence-based public health interventions.

Against this background, this study examines the influence of seasonal variations on the epidemiology of Lassa fever in Nigeria using integrated epidemiological and climatic data from 2020 to 2025. Specifically, the study evaluates seasonal trends in disease occurrence and assesses the effects of temperature, rainfall, humidity, and seasonal conditions on confirmed Lassa fever cases. The findings are expected to provide evidence for strengthening outbreak prediction, early warning systems, and targeted disease control strategies in endemic regions of Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted in Nigeria, a West African country characterized by diverse climatic and ecological conditions that influence the transmission dynamics of infectious diseases. Nigeria experiences two major seasons: the rainy season, which usually occurs between April and October, and the dry season, which spans from November to March. Variations in rainfall, temperature, and relative humidity across these seasons may contribute significantly to the occurrence and spread of Lassa Fever. Nigeria consists of different ecological zones ranging from the mangrove swamps and rainforest regions in the south to the Guinea savannah and Sahel savannah regions in the north. These environmental differences affect human activities, rodent ecology, and disease transmission patterns. The study focused on states with recurrent reports of Lassa fever outbreaks, particularly in endemic regions where the disease burden is consistently high.

Study Design

This study adopted a retrospective ecological and epidemiological research design to examine the impact of seasonal variations on the epidemiology of Lassa fever in Nigeria. The design enabled the analysis of historical disease records alongside environmental and meteorological variables over a specified study period. The study investigated the temporal relationship between seasonal climatic factors and reported Lassa fever cases, mortality rates, and outbreak patterns across affected regions in Nigeria.

Sources of Data

Secondary data were used for this study. Epidemiological data on confirmed Lassa fever cases, suspected cases, and deaths were obtained from official surveillance reports published by the Nigeria Centre for Disease Control and Prevention (NCDC). Meteorological data including rainfall, temperature, and relative humidity were obtained from the Nigerian Meteorological Agency (NiMet). These variables were selected because of their possible influence on rodent behavior, virus survival, and human exposure patterns.

Study Period

The study covered a period of multiple years (2020 to 2025) to allow for adequate assessment of seasonal and temporal trends in Lassa fever occurrence. The selected time frame provided sufficient epidemiological and climatic data for identifying seasonal patterns and variations in disease transmission.

Variables Considered

The study considered both dependent and independent variables in assessing the impact of seasonal variations on the epidemiology of Lassa Fever in Nigeria. The dependent variable for the study was the number of confirmed Lassa fever cases reported during the study period. This variable was used to measure the occurrence and distribution of the disease across different seasons. The independent variables comprised selected climatic and seasonal factors that may influence the transmission dynamics of Lassa fever. These included rainfall, temperature, relative humidity, and seasonal classification categorised into rainy and dry seasons. These variables were selected because environmental and climatic conditions are known to affect rodent population activities, virus survival, and the level of human exposure, thereby influencing the incidence of Lassa fever outbreaks.

Methodology

This study adopted a retrospective ecological research design using confirmed Lassa fever surveillance data and corresponding climatic data (temperature, rainfall, and relative humidity) collected across Nigeria from 2020 to 2025. Descriptive statistics and seasonal trend analyses were employed to characterise the temporal distribution of Lassa fever cases and identify seasonal patterns. Pearson correlation analysis was conducted to examine the relationships between climatic variables and confirmed cases. Furthermore, a Negative Binomial Regression model was applied to quantify the independent effects of temperature, rainfall, humidity, and seasonality on Lassa fever incidence while accounting for overdispersion in the count data. All analyses were performed to evaluate the influence of climatic and seasonal variability on the epidemiology of Lassa fever in Nigeria.

Data Analysis

Data were cleaned and organized before analysis. Descriptive statistics were used to summarize the epidemiological and climatic characteristics of the study variables, while time-series analysis was performed to examine temporal and seasonal patterns of Lassa fever incidence. Pearson correlation analysis was conducted to assess associations between climatic factors and disease occurrence. To quantify the effects of temperature, rainfall, and relative humidity on Lassa fever incidence, a Negative Binomial Regression (NBR) model was fitted. The NBR approach was adopted due to the count nature of the response variable and the presence of overdispersion in the data. Model performance and adequacy were assessed through Pearson residual diagnostics and Q–Q plots. Results were presented using tables and figures, and all analyses were conducted using Python.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 presents the descriptive statistics of confirmed Lassa Fever cases and selected climatic variables observed during the study period in Nigeria. A total of 1,404 observations were analysed for all variables. The findings showed that the average number of confirmed Lassa fever cases was 4.6, with a standard deviation of 6.2, indicating noticeable variation in the number of reported cases across different periods. The number of confirmed cases ranged from 0 to 51, suggesting that some periods recorded no cases while others experienced relatively high outbreaks. Temperature had a mean of 34.8°C and a standard deviation of 3.4°C, indicating moderate variation throughout the study period. Rainfall showed substantial variability, with an average of

Table 1: Descriptive Statistics of Confirmed Lassa Fever Cases and Climatic Variables

Variable	N	Mean	SD	Minimum	25th Percentile	Median	75th Percentile	Maximum
Confirmed Cases	1404	4.6	6.2	0.0	1.0	2.0	5.0	51.0
Temperature (°C)	1404	34.8	3.4	25.5	32.6	35.5	37.0	45.6
Rainfall (mm)	1404	92.2	115.9	0.0	0.4	25.1	190.6	370.9
Humidity (%)	1404	54.9	22.2	1.7	37.5	55.0	74.0	90.8

92.2 mm and a high standard deviation of 115.9 mm, reflecting considerable differences in rainfall intensity across seasons. Similarly, humidity had a mean value of 54.9% with a standard deviation of 22.2%, suggesting fluctuations in atmospheric moisture levels during the study period. Overall, the descriptive statistics indicate that both climatic conditions and Lassa fever occurrence varied considerably over time, highlighting the possible influence of seasonal factors on the epidemiology of the disease.

Seasonal Distribution of Lassa Fever Cases

Figure 1 provides the seasonal distribution of confirmed Lassa Fever cases in Nigeria from 2020 to 2025. The results show a clear seasonal pattern in the occurrence of the disease across the study period. In all years considered, the dry season consistently recorded more confirmed Lassa fever cases than the wet season. The highest number of dry season cases was observed in 2024 with 1,040 confirmed cases, followed closely by 2020 and 2023 with 1,030 and 982 cases, respectively. In contrast, the wet season recorded substantially lower cases across all years, with values ranging from 165 to 303 cases. The findings suggest that Lassa fever transmission is more intense during the dry season in Nigeria. This pattern may be associated with increased human contact with rodents during the dry months, as food scarcity and environmental conditions may force rodents to move closer to human settlements in search of food and shelter. In Nigeria, the dry season usually occurs between November and March, while the rainy season spans from April to October. The peak in Lassa fever cases during the dry season aligns with the period when outbreaks are commonly reported in many endemic states across the country. The relatively lower number of cases during the rainy season may be linked to environmental conditions that reduce rodent-human interaction and influence virus survival.

Figure 2 shows that the dry season accounted for the majority of confirmed Lassa Fever cases in Nigeria, contributing 77.1% of the total reported cases, while the wet season accounted for only 22.9%. This indicates that Lassa fever occurrence is significantly higher during the dry season compared to the rainy season. The finding further suggests that seasonal conditions during Nigeria's dry months may favour increased rodent-human interaction and enhance the transmission of the disease.

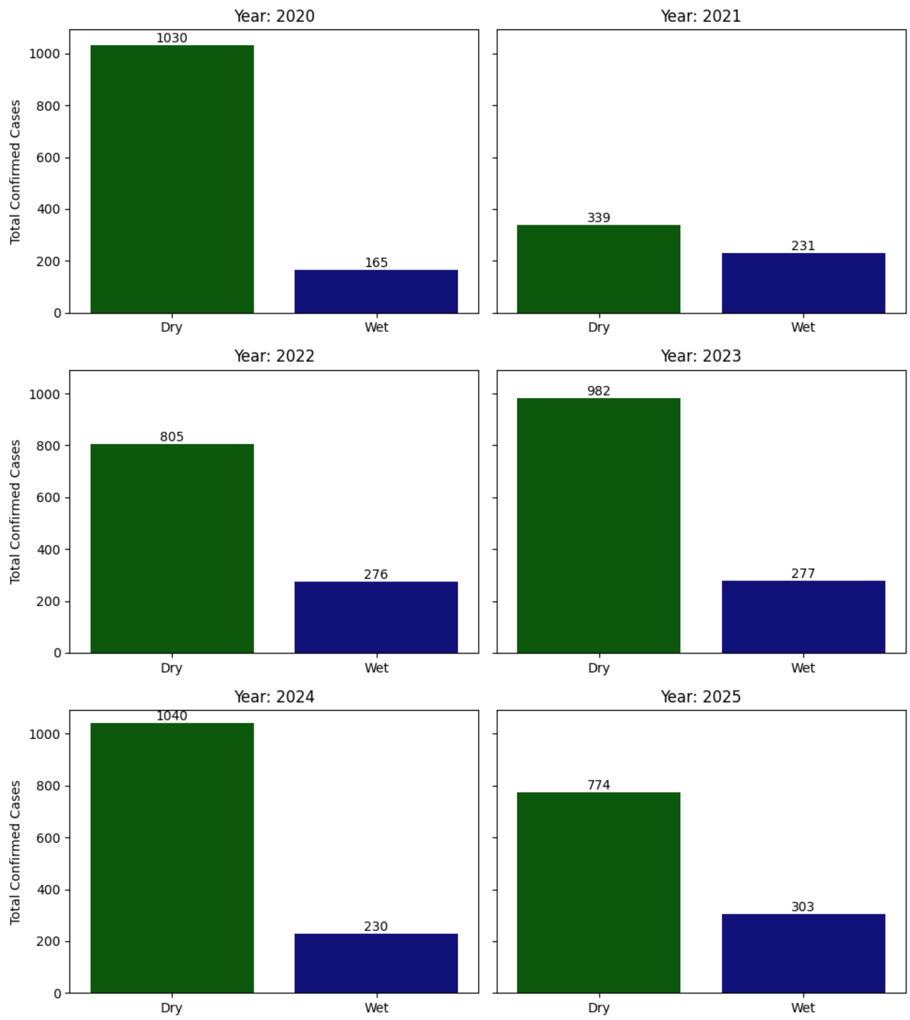

Figure 1: Seasonal Distribution of Lassa Fever Confirmed Cases

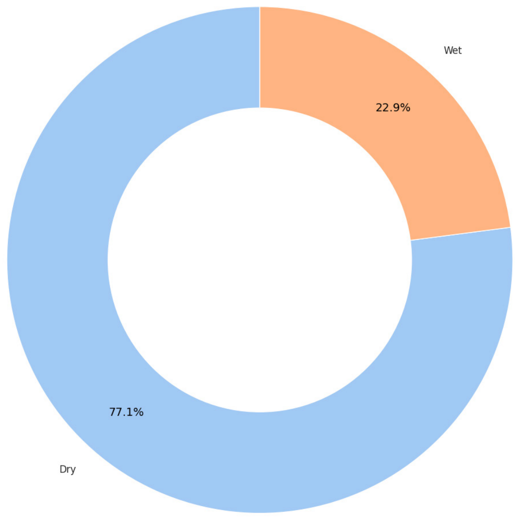

Figure 2: Percentage of Total Lassa Fever Confirmed Cases by Season

Monthly Trend Analysis of Lassa Fever Incidence

Figure 3 presents the monthly distribution of confirmed Lassa Fever cases in Nigeria across all study years. The results show that the highest number of confirmed cases occurred in February (1,534 cases), followed closely by January (1,513 cases) and March (1,125 cases). After March, the number of cases declined sharply, reaching lower levels between May and October, before rising again in November and December. The observed pattern indicates a strong seasonal trend in the occurrence of Lassa fever in Nigeria. The peak transmission period falls within the dry season, particularly between December and March, when environmental conditions may favour increased rodent activities and closer contact between rodents and humans. This period also corresponds with the Harmattan season in Nigeria, which is often characterised by dry and dusty weather conditions. In contrast, the rainy season, which usually spans from April to October in most states, recorded comparatively lower numbers of confirmed cases. The reduction in cases during these months may be linked to changes in environmental conditions, food availability, and reduced rodent-human interaction. The result highlights the significant influence of seasonal variations on the epidemiology and transmission dynamics of Lassa fever in Nigeria.

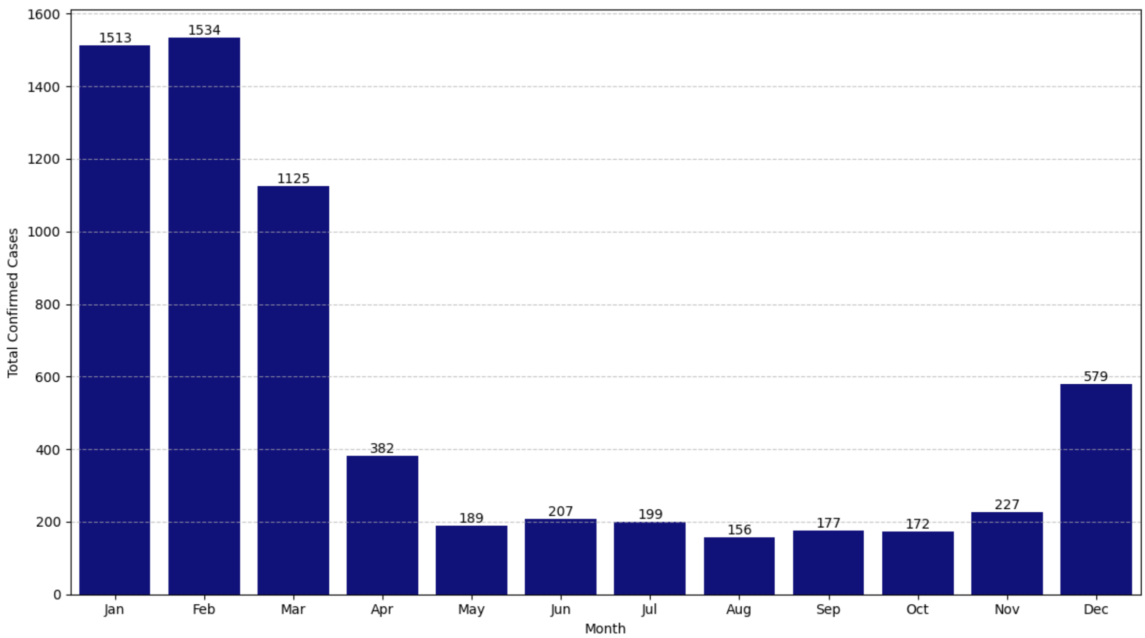

Figure 3: Monthly Distribution of Total Lassa Fever Cases

Relationship Between Climatic Variables and Lassa Fever Incidence

Figures 4 and 5 jointly showed that temperature had the strongest relationship with confirmed Lassa fever cases ($r = 0.57$, $p < 0.001$), indicating that higher temperatures are associated with increased disease incidence. This finding supports the observed concentration of outbreaks during the dry season, when temperatures are generally higher. Rainfall exhibited a weak but significant negative correlation with confirmed cases ($r = -0.19$, $p < 0.001$), suggesting that Lassa fever occurrence tends to decrease as rainfall increases. In contrast, humidity showed a weak positive association with confirmed cases ($r = 0.13$, $p < 0.001$), indicating a modest contribution to disease transmission.

The analysis also revealed strong interrelationships among the climatic variables. Temperature was strongly and negatively correlated with both rainfall and humidity, while rainfall and humidity showed a very strong positive correlation. The findings suggest that climatic conditions, particularly temperature, play an important role in influencing Lassa fever transmission dynamics in Nigeria and contribute to the marked seasonal pattern of outbreaks observed across the country.

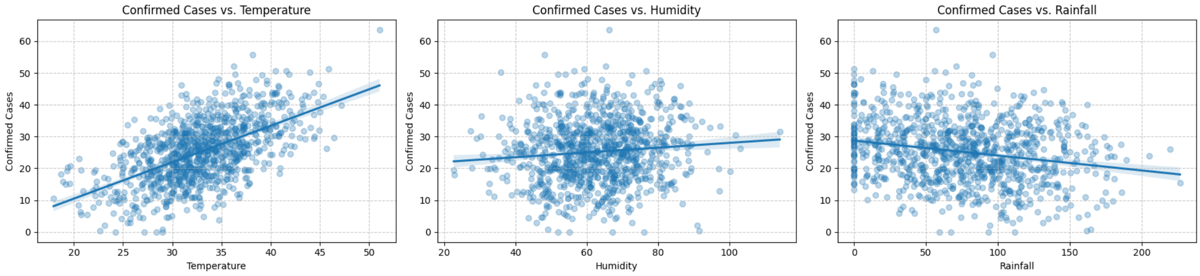

Figure 4: Relationship between Confirmed Lassa Fever Cases and Environmental Factors

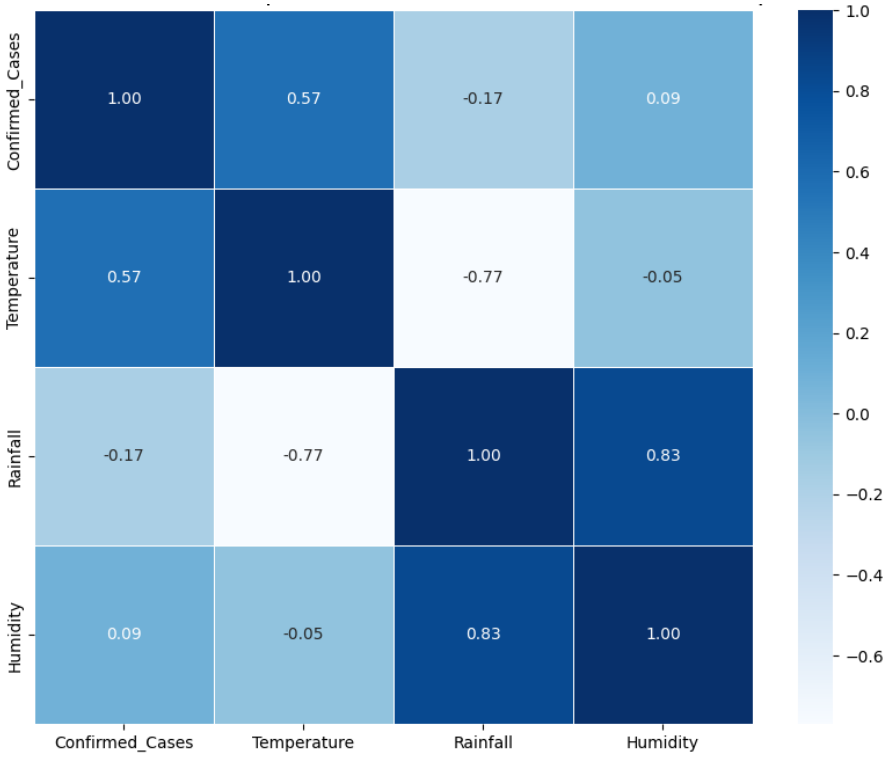

Figure 5: Correlation Heat Map of Environmental factors and Lassa Fever Confirmed cases

Negative Binomial Regression Analysis

To quantify the effects of climatic and seasonal factors on Lassa fever incidence, a Negative Binomial Regression (NBR) model was employed. The model is appropriate because the response variable (confirmed Lassa fever cases) is count data and exhibits overdispersion, where the variance exceeds the mean. Under such conditions, the Negative Binomial model provides more reliable parameter estimates than the Poisson regression model.

The probability distribution of the Negative Binomial model is expressed as:

$Y_i = NB(\mu_i, \alpha)$, where Y_i is the number of confirmed Lassa fever cases, μ_i is the expected number of cases, and α is the dispersion parameter accounting for overdispersion.

Using a log-link function, the model is specified as

$\log(\mu_i) = \beta_0 + \beta_1 T_i + \beta_2 R\_i + \beta_3 H_i + \beta_4 S_i$, where T_i is temperature, R_i is rainfall, H_i is humidity, S_i is seasonal classification (dry = 1, wet = 0), β_0 is intercept, β_1, β_2, β_3, β_4 are regression coefficients.

The Negative Binomial Regression analysis in Table 2 revealed that temperature, rainfall, humidity, and seasonality were significant predictors of Lassa fever incidence in Nigeria ($p < .05$). Temperature had a positive effect on disease occurrence, with each unit increase associated with a 2.4% increase in expected cases (IRR = 1.024). In contrast, rainfall showed a significant negative effect, indicating that each unit increase in rainfall reduced the expected number of cases by approximately 1.3% (IRR = 0.987). Humidity was positively associated with Lassa fever incidence, although its effect size was relatively small (IRR = 1.007). Seasonality emerged as the strongest predictor, with the risk of Lassa fever during the dry season being approximately 113% higher than during the wet season (IRR = 2.131). The findings demonstrate that climatic and seasonal factors play a crucial role in shaping Lassa fever transmission dynamics in Nigeria, highlighting the importance of incorporating environmental indicators into surveillance and outbreak preparedness strategies.

Table 2: Multivariable Regression Analysis of Climatic and Seasonal Predictors of Confirmed Lassa Fever Incidence in Nigeria (2020–2025)

Predictor	β	SE	Z	p	95% CI for β	IRR	95% CI for IRR
Intercept	1.606	0.543	2.958	.003	0.542, 2.670	4.983	1.719, 14.439
Temperature	0.024	0.006	4.000	< .001	0.012, 0.036	1.024	1.012, 1.037
Rainfall	-0.013	0.001	-13.000	< .001	-0.015, -0.011	0.987	0.985, 0.989
Humidity	0.007	0.002	3.300	.001	0.003, 0.011	1.007	1.003, 1.011
Season Code	0.757	0.102	7.406	< .001	0.557, 0.957	2.131	1.744, 2.603

Model Diagnosis

Diagnostic evaluation of the Negative Binomial Regression model demonstrated satisfactory model performance. Pearson residuals were centred around zero and exhibited no pronounced systematic patterns across fitted values, indicating an appropriate specification of the mean structure. The Q–Q plot showed reasonable conformity to theoretical expectations, with only minor deviations in the upper tail attributable to a small number of extreme observations.The diagnostics suggest that the model adequately accounted for overdispersion and provided a reliable framework for examining the association between climatic factors and Lassa fever incidence.

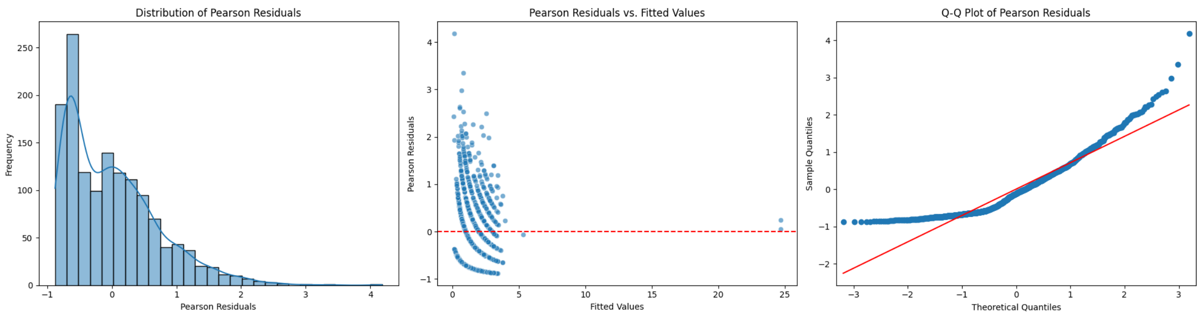

Figure 6: Residual Analysis of Negative Binomial Model

Discussion

This study investigated the influence of seasonal and climatic variability on Lassa fever epidemiology in Nigeria using national surveillance and meteorological data spanning 2020–2025. The findings revealed a pronounced seasonal pattern in disease occurrence, with the majority of confirmed cases reported during the dry season and peak transmission occurring between January and March. Furthermore, both correlation and Negative Binomial Regression analyses demonstrated that temperature, rainfall, humidity, and seasonality significantly influenced Lassa fever incidence. These findings reinforce growing evidence that climatic and environmental conditions play a fundamental role in shaping the ecological and epidemiological processes that drive Lassa fever transmission in Nigeria and other endemic regions of West Africa.

The seasonal analysis showed that more than three-quarters of confirmed cases occurred during the dry season, confirming the well-documented seasonal nature of Lassa fever outbreaks in Nigeria. This finding is consistent with previous studies that reported increased disease incidence between November and March, when environmental conditions favour greater interaction between humans and rodent reservoirs (Grace *et al.,* 2021; Dan-Nwafor *et al.,* 2022; John *et al.,* 2026). Similar observations were reported by Akhmetzhanov *et al.* (2019), who demonstrated that seasonal variability is a major determinant of Lassa fever transmission dynamics across Nigeria. The dry-season predominance observed in this study is likely linked to ecological changes in *Mastomys natalensis*, the primary reservoir host of the Lassa virus. During periods of reduced rainfall and declining natural food resources, rodents frequently shift from outdoor habitats into human settlements in search of food, water, and shelter (Bonwitt *et al.,* 2017; Oyeyiola *et al.,* 2025). This seasonal habitat transition increases the frequency of contact between rodents and humans through contamination of food supplies, household surfaces, and stored agricultural products. In many rural communities, post-harvest crop storage practices and inadequate rodent-proof food storage facilities may further increase opportunities for exposure to infected rodent excreta. Consequently, the observed seasonal pattern reflects a complex interaction between environmental conditions, rodent behavioural adaptation, and human activities that collectively enhance transmission risk during the dry season.

Temperature emerged as the climatic variable most strongly associated with Lassa fever incidence. Both the correlation and Negative Binomial Regression analyses identified temperature as a significant positive predictor of disease occurrence, with a one-unit increase in temperature corresponding to an estimated 2.4%

increase in expected confirmed cases. This finding is consistent with the work of Redding *et al.* (2021), who identified temperature as a key environmental driver of Lassa fever dynamics in Nigeria, and with Fuwape *et al.* (2026), who reported a significant association between elevated temperatures and increased disease occurrence in high-risk states. From an ecological perspective, higher temperatures may influence rodent population dynamics by altering breeding activity, foraging behaviour, and movement patterns. Elevated temperatures can also increase the tendency of rodents to seek cooler and more stable microenvironments within human dwellings, thereby increasing opportunities for human–rodent interaction. Furthermore, warmer conditions often coincide with the dry season, a period characterised by increased agricultural activities, crop harvesting, food storage, and household exposure to rodent-contaminated environments. Arotolu *et al.* (2025) similarly demonstrated that temperature is among the most influential climatic factors affecting the geographical distribution of Lassa fever in Nigeria. The positive association observed in this study therefore, suggests that increasing temperatures may indirectly elevate disease risk by modifying both rodent ecology and patterns of human exposure.

Rainfall exhibited a significant inverse relationship with Lassa fever incidence in both the correlation and regression analyses. The Negative Binomial Regression results indicated that each unit increase in rainfall was associated with an approximately 1.3% reduction in expected disease incidence. This finding supports previous studies that identified rainfall variability as an important determinant of Lassa fever transmission dynamics (Zhao *et al.,* 2020; Redding *et al.,* 2021; Akhmetzhanov *et al.,* 2019). Rainfall influences the structure and availability of rodent habitats, food resources, and breeding conditions, thereby affecting rodent abundance and movement patterns. During periods of low rainfall, natural vegetation and food sources become limited, encouraging rodents to migrate into residential areas where food and shelter are more readily available. Such habitat shifts increase the likelihood of contamination of food items, cooking utensils, and household environments with rodent urine and faeces containing the virus. Conversely, higher rainfall may enhance the availability of natural resources within rodent habitats, reducing the need for rodents to enter human settlements. Recent studies by Arotolu *et al.* (2025), Cadmus *et al.* (2025), and Oyeyiola *et al.* (2025) similarly reported that rainfall variability significantly influences rodent ecology and habitat utilisation, with important implications for Lassa fever transmission. The inverse relationship observed in this study, therefore, highlights the role of rainfall as a critical environmental regulator of disease risk through its influence on rodent population behaviour and habitat dynamics.

Humidity was also positively associated with confirmed Lassa fever cases, although its effect was less pronounced than that of temperature and seasonality. The regression analysis indicated that a one-unit increase in relative humidity was associated with an approximately 0.7% increase in expected disease incidence. This finding suggests that humidity contributes to environmental conditions that may support viral persistence and influence rodent survival and reproductive success. Similar observations were reported by Fuwape *et al.* (2026), who identified humidity as a significant climatic determinant of Lassa fever incidence in several Nigerian states. While humidity alone may not directly drive outbreaks, its interaction with temperature and rainfall likely contributes to ecological conditions that influence both reservoir host populations and environmental suitability for viral survival. Consequently, humidity may function as a complementary environmental factor that amplifies the effects of other climatic variables on disease transmission.

Among all predictors examined, seasonality emerged as the strongest determinant of Lassa fever incidence. The Negative Binomial Regression results indicated that disease occurrence during the dry season was more than twice that observed during the wet season, even after controlling for temperature, rainfall, and humidity. This finding is consistent with reports by Grace *et al.* (2021), Dan-Nwafor *et al.* (2022), and John *et al.* (2026), which identified the dry season as the period of greatest outbreak risk in Nigeria. The strong seasonal effect likely reflects the cumulative influence of several interconnected ecological and behavioural mechanisms, including seasonal fluctuations in rodent abundance, habitat displacement, changes in food availability, environmental conditions affecting viral persistence, and increased human exposure to contaminated environments. Human behavioural practices such as crop harvesting, food storage, waste disposal, and increased indoor activities during the dry season may further amplify exposure risks. These findings highlight the importance of implementing seasonal risk-based surveillance, community education programmes, rodent control measures, and targeted public health interventions before and during periods of elevated transmission risk.

The significant correlations observed among climatic variables further highlight the complexity of Lassa fever epidemiology. Temperature was strongly and negatively correlated with rainfall and humidity, whereas rainfall and humidity exhibited a strong positive relationship. These findings indicate that climatic variables interact synergistically rather than operating independently to influence disease transmission. Similar climatic interactions have been documented by Redding *et al.* (2021) and Fuwape *et al.* (2026), who emphasised the importance of considering multiple environmental drivers simultaneously when investigating Lassa fever dynamics. The observed relationships suggest that climatic conditions shape transmission risk through interconnected effects on rodent ecology, habitat suitability, food availability, viral persistence, and human exposure pathways. Consequently, integrated climate–disease approaches are essential for understanding outbreak behaviour, improving risk prediction, and strengthening climate-informed public health preparedness strategies in endemic regions.

CONCLUSION

This study investigated the influence of seasonal and climatic variability on the epidemiology of Lassa fever in Nigeria using integrated surveillance and meteorological data collected between 2020 and 2025. The findings showed that Lassa fever transmission is strongly seasonal, with most confirmed cases occurring during the dry season and outbreaks consistently peaking between January and March. Temperature, rainfall, humidity, and seasonality were all identified as significant predictors of disease incidence, with seasonality exerting the greatest influence. Specifically, higher temperatures and lower rainfall were associated with increased Lassa fever cases, while humidity showed a smaller but significant positive effect. These results suggest that climatic conditions shape disease transmission by influencing rodent ecology, habitat suitability, and the frequency of human–rodent contact.

A key contribution of this study is the use of a Negative Binomial Regression framework to quantify the independent effects of multiple climatic variables on Lassa fever incidence while accounting for the overdispersed nature of disease count data. This provides stronger statistical evidence than descriptive analyses alone and improves understanding of the environmental processes that sustain recurrent outbreaks in Nigeria. The findings highlight the need to integrate climate information into national disease surveillance and early warning systems to improve outbreak prediction and preparedness. Strengthening rodent control measures, improving environmental sanitation, enhancing community awareness, and prioritising public health interventions during the high-risk dry season could substantially reduce disease transmission. Future studies should incorporate additional environmental and socioeconomic factors and evaluate predictive models capable of supporting real-time outbreak forecasting.

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