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Analysing the Relationship between Weather Factors and Lassa Fever Incidence in Owo, Nigeria

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ABSTRACT: *The occurrence of Lassa fever in Nigeria is closely linked with weather factors. Lassa fever increases at the end of the rainy season many places in Nigeria.This study investigates the relationship between Lassa fever incidence and weather factors, specifically temperature and relative humidity, in Owo Local Government, Nigeria. Using Pearson Correlation analysis on a four-year Lassa fever incidence and weather dataset from 2017 to 2020, the results reveal a weak negative correlation between Lassa fever and relative humidity, and a significant positive correlation with temperature. These findings underscore the potential for weather-based forecasting models to predict outbreaks, offering critical insights for public health planning and intervention.*

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I. INTRODUCTION

Lassa fever is a zoonotic viral haemorrhagic illness caused by the Lassa virus, a member of the *Arenaviridae* family. First identified in 1969 in a missionary nurse in Lassa town, Nigeria, the disease has since become a significant public health concern in West Africa[1]. Lassa fever is endemic in several countries, including Nigeria, Sierra Leone, Liberia, and Guinea, affecting approximately 100,000–300,000 individuals annually and causing about 5,000 deaths [2]. In Nigeria, the disease is considered a persistent threat due to its recurring outbreaks and high fatality rate. The primary host and reservoir of the Lassa virus is the multimammate rat (*Mastomys natalensis*), a rodent species widely distributed across sub-Saharan Africa. These rats are well-adapted to human environments, thriving in farmlands and residential areas. Infection in humans occurs primarily through exposure to food or household items contaminated with the urine, faeces, or saliva of infected rodents. Human-to-human transmission is also possible via contact with the bodily fluids of an infected person, particularly in healthcare settings where infection control measures are inadequate [3]. This dual transmission pathway contributes to the disease's persistence and its potential for outbreaks.Symptoms of Lassa fever vary widely, ranging from mild flu-like symptoms to severe haemorrhagic manifestations, making early diagnosis challenging. In some cases, Lassa fever leads to long-term complications, including hearing loss, which occurs in up to 25% of survivors. The disease has a fatality rate of about 1% among the general population but can rise to 15% among hospitalized patients, underscoring its severity [4].

In Nigeria, Lassa fever has been reported in several states, with Ondo State consistently ranking among the hardest-hit regions. Within Ondo State, Owo Local Government stands out as a hotspot for the disease. The prominence of Lassa fever in Owo can be attributed to a combination of ecological, climatic, and socioeconomic factors. The area's warm temperatures and low humidity during the dry season create conditions favourable for the survival and spread of the Lassa virus. Additionally, agricultural practices and poor housing conditions in the region often facilitate close contact between humans and rodents.Lassa fever outbreaks in Owo follow a seasonal pattern, with the highest incidence typically recorded between November and April[5]. This corresponds with the dry season, when food scarcity forces *Mastomys natalensis* into homes in search of sustenance. This seasonal migration significantly increases human exposure to the virus, making Owo a critical location for studying the epidemiological and environmental drivers of Lassa fever.The survival and transmission of the Lassa virus are closely linked to environmental factors such as temperature, humidity, and rainfall. Several studies have highlighted the role of these variables in shaping the dynamics of Lassa fever outbreaks. For instance, Zhao *et al*. [5] demonstrated that reduced rainfall is associated with higher reproduction rates of the Lassa virus, while Osagiede *et al*. [6] reported that a decrease in rainfall correlates with increased Lassa fever incidence in Edo State. Mohammed*et al*. [7] expanded on these findings by showing that temperature, rainfall, and relative humidity collectively explain up to 70% of Lassa fever cases across 13 northern Nigerian states. The virus's sensitivity to temperature and humidity is particularly relevant to outbreak forecasting. High temperatures can enhance virus viability and rodent activity, while low humidity has been associated with increased transmission. Understanding these relationships is crucial for developing predictive models that can inform public health responses and mitigate the impact of outbreaks.

The prevalence of Lassa fever in Owo underscores the need for localised research to understand the disease's drivers and develop effective interventions. This study focuses on analysing the relationship between Lassa fever incidence and two critical weather variables—temperature and relative humidity—in Owo Local Government. By examining a four-year dataset (2017–2020), the research seeks to determine whether weather factors can be effectively integrated into predictive models to improve outbreak forecasting and inform targeted interventions. Given the high disease burden in Owo, Ondo State, Nigeria, this localized analysis offers valuable insights into the environmental and epidemiological drivers of Lassa fever.

II. METHODOLOGY

Dataset Description

This study used two primary datasets to investigate the relationship between Lassa fever cases and weather factors. These include Lassa fever incidence data and weather data from 2017 to 2020. Both datasets were synchronized by week to assist in the analysis. Each week in the period under study contained corresponding Lassa fever case counts and weather variables (temperature and relative humidity), enabling a paired analysis of the variables.

i. **Lassa Fever Incidence Data**

Weekly epidemiological reports (WER) of Lassa fever confirmed and suspected cases were obtained from the Nigeria Centre for Disease Control (NCDC). This dataset provides comprehensive data for all 774 local government areas (LGAs) in Nigeria. For this study, the data was filtered to focus exclusively on Owo Local Government in Ondo State, where Lassa fever is particularly prevalent. The selected dataset covered the period from 2017 to 2020 and included weekly case counts. Preprocessing steps were carried out to ensure data quality, such as removing duplicate entries and handling missing values where necessary.

ii. **Weather Data**

Weather data for Owo Local Government was sourced from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 dataset, a reliable global atmospheric reanalysis dataset. The variables considered were the weekly average temperature (in degrees Celsius) and relative humidity (as a percentage). The same time frame (2017–2020) was used to align weather data with the Lassa fever case data. Preprocessing involved aggregating daily weather data into weekly averages and addressing any missing entries using interpolation techniques to ensure temporal consistency with the case data.

The procedure involved in performing the analysis is summarised in the three steps highlighted below:

a) Calculate weekly correlations between Lassa fever cases and each weather variable (temperature and relative humidity).

b) Use a significance level of $\alpha = 0.05$ to test the statistical significance of the correlations. A p-value less than 0.05indicates a statistically significant relationship.

c) Visualise the trends using scatterplots and time-series graphs to provide further insights into relationships.

Correlation Analysis

To determine the relationship between Lassa fever incidence and weather variables, Pearson correlation analysis was employed. This statistical method quantifies the strength and direction of the linear relationship between two variables. Pearson correlation was chosen due to its effectiveness in identifying linear associations, which are critical for understanding how weather variables influence Lassa fever cases. Despite its simplicity, the method is well-suited for preliminary analysis in this context, serving as a foundation for more complex modelling in future studies[8],[9].

Mathematically, Pearson's correlation coefficient, often denoted as *r*, is given by the formula in equation (1)

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2 \quad \sum_{i=1}^{n}(Y_i - \bar{Y})^2}} \qquad (1)$$

where n represents the number of data points, X_i and Y_i are the individual data points of datasets X and Y respectively, $\bar{X}$ and $\bar{Y}$ represents the means (average) of datasets $\bar{X}$ and Y respectively.

Hypothesis Testing

A significance test was conducted at a 95% confidence level (α=0.05) to determine if the correlation was statistically significant:

- Null Hypothesis (H_0): No significant relationship exists between Lassa fever cases and the weather variable ($r = 0$).
- Alternative Hypothesis (H_1): A significant relationship exists ($r \neq 0$).

The values of r, along with the corresponding p-values, were analysed to determine the nature and significance of the relationships:

- $p < 0.05$: RejectH_0: indicating a significant relationship.
- $p \geq 0.05$: Fail to reject H_0: indicating no significant relationship.

III. RESULTS AND DISCUSSION

Lassa Fever and Temperature

After conducting the experiments, the results revealed distinct patterns in Lassa fever cases and their relationships with weather variables. Findings from the experiments show that Lassa fever cases tend to increase towards the end of the year, starting around the 50th week, while relative humidity decreases, as illustrated in **Figure 1**. This period corresponds to Nigeria's dry season, which typically spans December to April. The correlation analysis yielded a value of **r = -0.0037** at a confidence level of 0.05 (see **Table 1**), indicating a weak negative correlation between relative humidity and Lassa fever cases.The significance test further revealed that this relationship is statistically non-significant with a **p-value of 0.96**. These findings suggest that while lower relative humidity may coincide with increased Lassa fever incidence, the relationship is weak and not statistically significant. However, it is worth noting that the environmental conditions during the dry seasonwhen relative humidity is lowmay indirectly create favourable conditions for Lassa fever outbreaks, such as increased human exposure to rodent hosts.

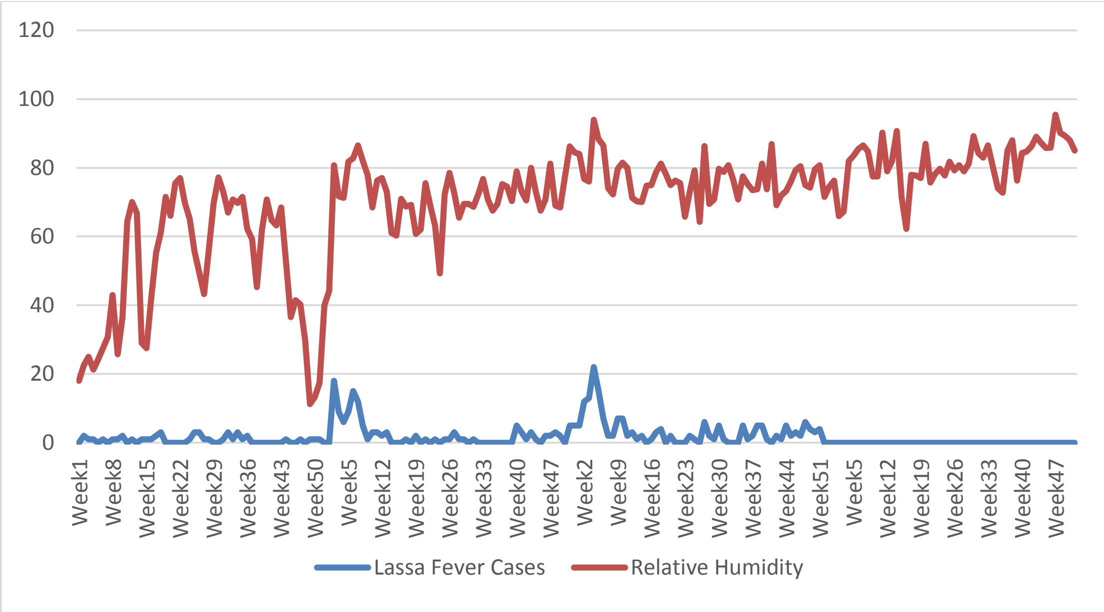

Figure 1: Five-year Trend Analysis of Lassa Fever Cases and Relative Humidity in Owo, Nigeria.

Table 1: Correlation Analysis Result for Lassa Fever Cases and Relative Humidity in Owo Local Government, Ondo State, Nigeria

Regression Statistics	
Multiple R	**0.004**
R Square	1.379E-05
Adjusted R Square	-0.005
Standard Error (SE)	16.441
Observations	208

	Coeff.	*SE*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	68.36	1.29	52.87	8.3E-122	65.81	70.91	65.81	70.91
Lassa Fever Cases	-0.02	0.36	-0.05	**0.96**	-0.73	0.69	-0.73	0.69

Lassa Fever and Temperature

In contrast, a positive relationship was observed between temperature and Lassa fever cases. As depicted in **Figure 2**, Lassa fever cases also increased towards the end of the year, starting around the 50th week, coinciding with rising temperatures. The correlation analysis provided a value of **r = 0.14** at a confidence level of 0.05 (see **Table 2**), suggesting a weak positive correlation.The significance test showed that this relationship is statistically significant with a **p-value of 0.03**, indicating that higher temperatures are more likely to favour Lassa fever outbreaks. These results align with prior studies that suggest warm and dry conditions can enhance the transmission dynamics of the disease, likely due to behavioural changes in rodent populations or their increased interaction with humans during this period.

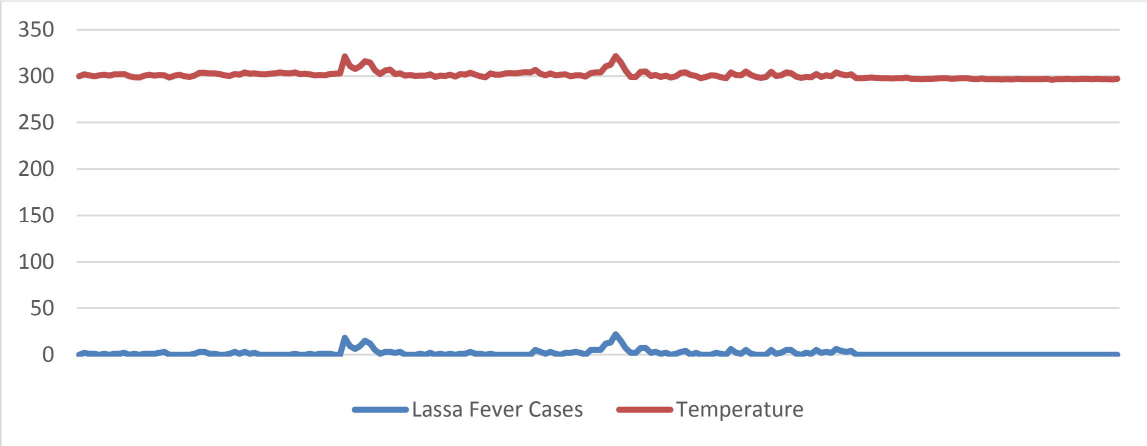

Figure 2: Five-year Trend Analysis of Lassa Fever Cases & Temperature in Owo, Nigeria.

Table 2: Pearson Correlation Analysis Result for Lassa Fever Cases and Temperature in Owo Local Government, Ondo State, Nigeria

Regression Statistics	
Multiple R	**0.144**
R Square	0.021
Adjusted R Square	0.016
Standard Error (SE)	1.967
Observations	208

	Coeff.	*SE*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	299.29	0.16	1935.24	0	298.98	299.59	298.98	299.59
Lassa Fever Cases	0.09	0.04	2.09	**0.038**	0.005	0.17	0.005	0.17

IV. CONCLUSION

This study has demonstrated a distinct relationship between Lassa fever incidence and key weather variables. The analysis revealed a weak negative correlation between Lassa fever cases and relative humidity, suggesting that lower levels of relative humidity may create favourable conditions for the disease's transmission. On the other hand, a statistically significant positive correlation was observed between Lassa fever cases and temperature, indicating that rising temperatures may contribute to an increase in Lassa fever outbreaks. These findings highlight the influence of weather patterns, particularly during Nigeria's dry season (December to April), on the spread of Lassa fever. Future work currently underway focuses on leveraging these insights to forecast Lassa fever cases by integrating historical case data with temperature trends using machine learning and advanced deep learning models. Furthermore, the scope of the analysis will be expanded to include data from additional Local Government Areas in Nigeria with reported Lassa fever cases. This broader dataset will allow for a more comprehensive understanding of the relationship between weather variables and Lassa fever dynamics across diverse regions, providing deeper insights for public health interventions and outbreak preparedness strategies. Ultimately, these efforts aim to refine forecasting methodologies and contribute to real-time automated surveillance systems for Lassa fever in Nigeria, enabling more effective resource allocation and disease management to mitigate the impact of future outbreaks.

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