Climatic-Determinants of Lassa Fever Cases in Ondo State Nigeria; A Retrospective Study (2018-2021)

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Abstract- Introduction: Lassa fever is a public health disease and it is zoonotic in nature which is widespread in West Africa countries, including Nigeria and usually spark seasonal outbreak in some States in Nigeria, especially Ondo State. There exists paucity of information regarding climatic determinants of Lassa fever in Ondo State.

Methods: Data on Lassa fever incidence and climatological variables in Ondo State within the period of January 2018 to June 2021 were obtained from the Department of Surveillance and Epidemiology, Nigerian Centre for Disease Control (NCDC) and National Centre for Environmental Prediction/ National Centre for Atmospheric Research (NCEP/NCAR) through the Nigeria Meteorological Agency (NIMET) respectively. Data collected were coded and entered into Microsoft excel spread sheet and analysed using R statistical software program and SPSS software program.

Result: In order to determine association between Lassa fever incidence and climatological variables,a negative binomial regression model was used at 5% level of significance. We observed a peak periods of Lassa fever from our monthly trend of confirmed cases of Lassa fever in Ondo State, these peak periods spanned from the first to third month around January to March and the last two months of the year around November and December. We also observed from our charts of monthly trend of climatological variable in Ondo State that the temperature was high and the rainfall pattern, cloud cover and relative humidity decreased especially during the peak periods around January/February and November/December.

Conclusion: The negative binomial model revealed that the relative humidity was significant associated ($p < 0.05$) with Lassa fever occurrence in Ondo State from 2018 to 2021. November through to March were peak periods for Lassa fever occurrence in Ondo State and monitoring the relative humidity, temperature and rainfall could serve as an early warning signs for the occurrence of Lassa fever in Ondo State.

Keywords: Lassa haemorrhagic fever, Nigeria, climate, negative binomial regression model, zoonoses

INTRODUCTION

Lassa fever is an acute haemorrhagic viral infection endemic in some countries in the West African sub-region including Nigeria [1]. Lassa fever is caused by an enveloped, single stranded RNA virus of the Arenaviridae family with a clear zoonotic origin [2][3]. The annual number of infections has been estimated at 100,000 to 300,000 with about 5000 dead [1]. Although the overall case fatality rate is 1-2%, during outbreaks it could be as high as 50% [4]. For these reasons, Lassa fever infection is recognized as a serious public health concern that necessitates future research on its transmission dynamics, prevention and possible eradication. The virus was first isolated in 1969 from a missionary nurse working in Lassa town of Borno State in North-eastern Nigeria [4] Since then, yearly outbreaks have been reported in several parts of the country including Adamawa, Ebonyi, Edo, Nasarawa, Gombe, Plateau and Taraba States, and more recently in some parts of Ondo State in south-west Nigeria [5]. Given the importance of the human–animal interface, we anticipate that environmental factors may be crucial driving forces contributing to the frequent re-occurrence of Lassa outbreaks in Ondo state. The viral hotspots are found in West African countries, namely, Nigeria, Liberia. Guinea, Sierra Leone and Benin i.e. it is endemic in these countries and usually sparks seasonal outbreak. In Nigeria, Lassa fever is one of the seven epidemic prone notifiable diseases reportable under the Integrated Disease Surveillance System (IDSR), a suspected case is considered an alert threshold and one confirmed case an epidemic threshold. Sporadic outbreaks occur annually, and have been reported in up to one-third of states in the country [6][7]. The animal reservoir of the virus is called Mastomys natalensis, also known as multimammate mouse, which is a rodent species that is widespread in the region. Although the main transmission route remains zoonotic, i.e. animal-to-human, contracting the virus through exposure to contaminated excreta or secretions from rodents [8], another frequently reported route is human-to-human transmission, via contact exposure to the virus from the blood or bodily fluids of an infected person. The latter contributes to approximately 19% of all reported cases and is usually observed during nosocomial outbreaks [9]. Therefore, the overall transmission pattern is primarily driven by environmental exposure to Lassa fever [3] rather than sustained human-to-human transmission chains, being different from Ebola virus disease [10]. The multimammate rat can quickly produce a large number of offspring, tends to colonize human settlements increasing the risk of rodent human contact, and is found throughout the west, central and eastern parts of the African continent [11][12][13]. In West Africa a study by Fichet-Calvet and Rogers [17] on the distribution of human Lassa fever outbreaks and cases in the period 1951–1989 revealed that areas of medium risk had an annual rainfall in the range of 1200–1500 mm, whereas rainfall in the range of 1500–3000 mm was associated with a high risk of disease. Regions with <1200 mm (or more than 3000 mm) of rainfall had no recorded occurrence of Lassa fever. Rainfall thus appears to be an associated factor in the incidence of Lassa fever. Above all, individuals who are at a higher risk of contracting the infection are those who live in rural areas where Mastomys are discovered, and where sanitation is not prevalent [14][15].

METHODS

Study design: A retrospective study involving secondary data analysis. This study involved the obtaining of data on Lassa fever incidence and climatological variables in Ondo State within the period of January 2018 to June 2021

Study locations: The study area was carried out in Ondo State, Nigeria where Lassa fever has been reported. Ondo State has 18 local government area. The climate of the state highly favours the agrarian activities and crops such as cocoa, kola nut, oil palm and arable crops like maize and tubers such as yam and cassava which are grown annually.

Data collection: Data were obtained from the weekly epidemiological report of the Department of Surveillance and Epidemiology, Nigerian Centre for Disease Control (NCDC) for the period from 2018/week 1 to 2021/week 24 for Ondo State. The extracted variables included newly suspected weekly, confirmed cases and the date of onset of symptoms. To access monthly data on climatological variables (i.e. rainfall, relative humidity and cloud cover), we used publicly available data from the National Centre for Environmental Prediction/ National Centre for Atmospheric Research (NCEP/NCAR) through the Nigeria Meteorological Agency (NIMET) and temperature variables were obtained from the Agro climatological and Ecological Monitoring Unit, Akure, Ondo State.

Data analysis: Data from the field were coded and entered into Microsoft excel spread sheet and analysed using R statistical software program and SPSS software program. In order to test for the significance of a relationship between seasonal Lassa fever dynamics and climatological variables , we employed a Negative Binomial Regression Models on R software program. Data were presented as charts and in frequency distribution tables. We used a confidence level set at $P < 0.05$ to ascertain associations between seasonal Lassa fever incidence and climatological variables.

Ethical consideration: Approval was received from the Department of Surveillance and Epidemiology, Nigerian Centre for Disease Control (NCDC). This study involved secondary data analysis and there was no contact with the patients. Access was granted to the secondary data after all forms of identifiers that could reveal the patient's identity were removed.

RESULTS

Trend and peak period of Lassa fever cases in Ondo State, 2018-2021: in weekly confirmed cases of Lassa fever in 2018, we observed a peak period of Lassa fever from week 1 and above in 2018, while the highest number of occurrences was observed in week 7 and 52.Highest number of Lassa fever cases was observed in week 6. Also the highest occurrence of Lassa fever was observed in the third week and the number of confirmed cases, was observed till week 24. Whereas the highest number of cases, was observed in week 11. In (Figure 1), weekly trend of Lassa fever from 2018-2021, we observed that 2020 has the highest number of confirmed cases. Now, examining the number of occurrences across the year, it was observed that the occurrences of Lassa fever was obvious in year 2020 than any other year in Ondo state, Nigeria. Also across the weeks in each year, (Figure 1) reveals that in all the weeks of the years considered in this research, the earlier weeks of 2020 (namely week 2 through 11) has the highest peak in the occurrence of the fever. In (Figure 2) through monthly confirmed cases of Lassa fever from 2018-2021, we observed a peak period in January and February of the years under review. In (Figure 2) monthly trend of confirmed Lassa fever cases in Ondo State, 2018-2021 in a data table. Now, considering the monthly occurrence of the fever across the year, the firth three months of year 2020 witness more cases of Lassa fever than any other cases in other years. In January of 2020, there were more than 117 cases of Lassa fever occurrences, 134 cases in February, 37 in March. The next year that witness high occurrence of Lassa fever cases was 2019 with 80 reported cases in January, 38 in February and 27 cases in March. There is consistent reported cases of Lassa fever in the months of January and February of every year .

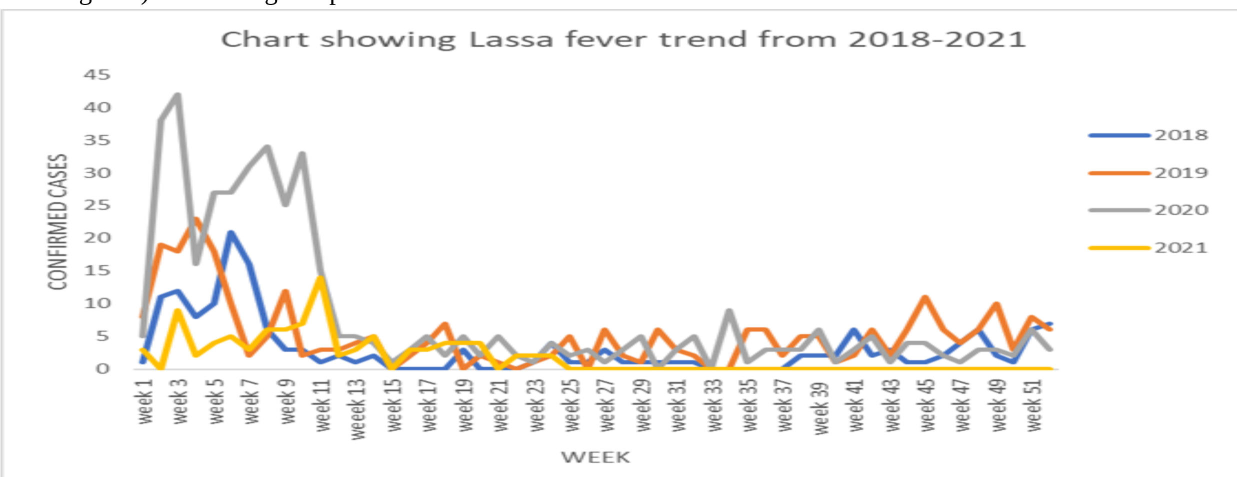
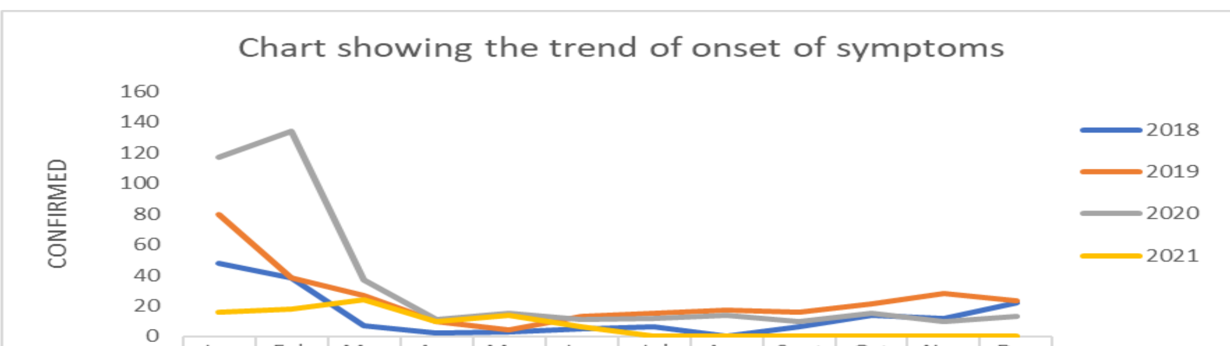


Figure 1. : weekly trend of confirmed Lassa fever cases in Ondo State, 2018-2021



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2018	48	38	7	2	3	5	6	0	6	14	12	22
2019	80	38	27	10	4	13	15	17	16	21	28	23
2020	117	134	37	11	15	11	12	14	10	15	10	13
2021	16	18	24	10	14	6	0	0	0	0	0	0

Figure 2: monthly trend of confirmed lassa Fever cases in Ondo State, 2018-2021

Trend of climatological variables (rainfall pattern, temperature, relative humidity and cloud cover) in Ondo State: in (Figure 3), monthly trend of climatological variable in Ondo State, 2018. It was evident that relative humidity is prevalent in January only while rainfall becomes prevalent from February to October while relative humidity becomes prevalent from November to December and temperature do not change significantly across the months in the year. While cloud cover fairly change over the months in the year. However, in (Figure 4), rainfall and relative humidity were both prevalent in January while rainfall becomes prevalent from February to November. Relative humidity becomes prevalent in December and temperature do not change significantly across the months in the year, while cloud cover fairly change over the months in the year. In (Figure 5), monthly trend of climatological variable in Ondo State, in 2020, which experience high peak in the cases of Lassa fever, relative humidity is prevalent in January/February while rainfall becomes prevalent from march to October while relative humidity becomes prevalent from November to December and temperature do not change significantly across the months in the year. While cloud cover fairly change over the months in the year. Again in (Figure 6), it is evident from the above plot that relative humidity is predominant in January and February while rainfall is predominant from March to May. Thus, based on the foregoing chart for climatological variables, it is evident that relative humidity and rainfall is predominant in some weeks/months of the year (especially January and February, which usually witness high peak in Lassa fever cases).

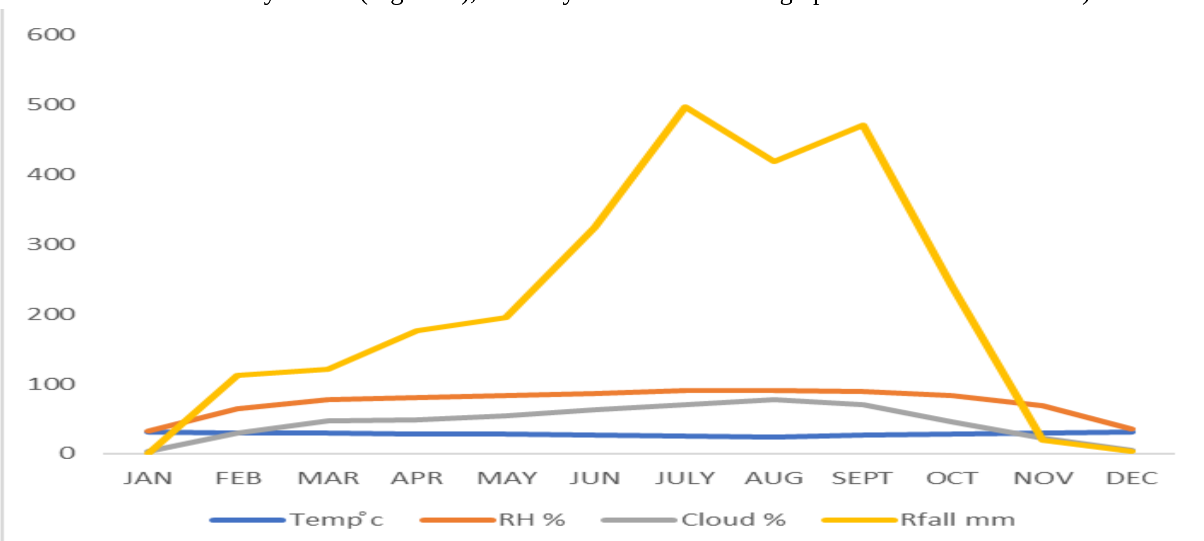


Figure 3: monthly trend of climatological variable in Ondo State, 2018

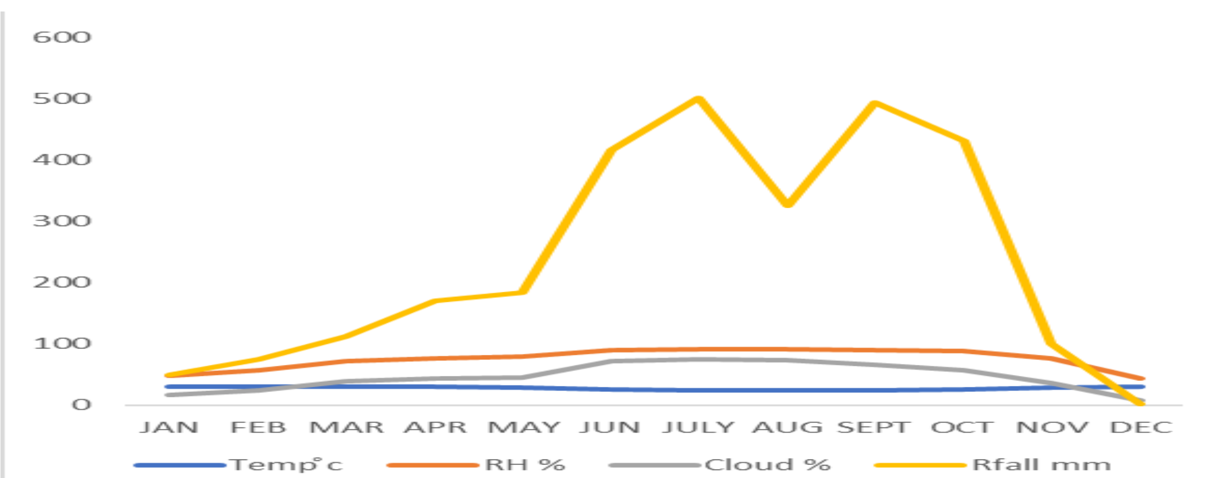


Figure 4: Monthly trend of climatological variable in Ondo State, 2019

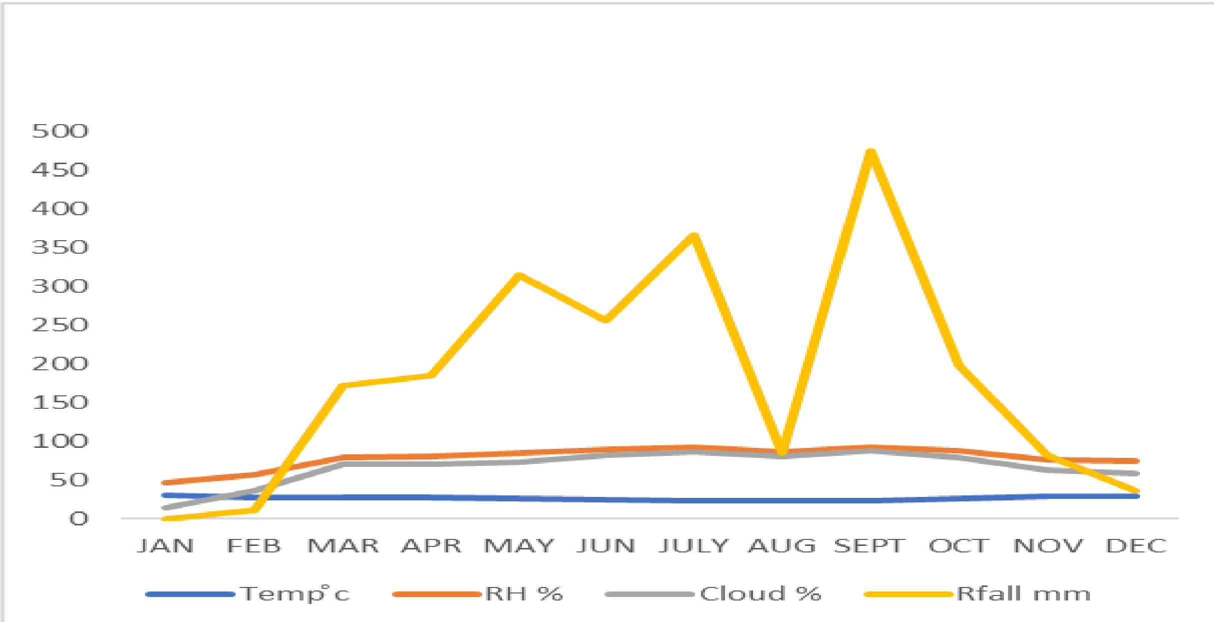


Figure 5: monthly trend of climatological variable in Ondo State, 2020

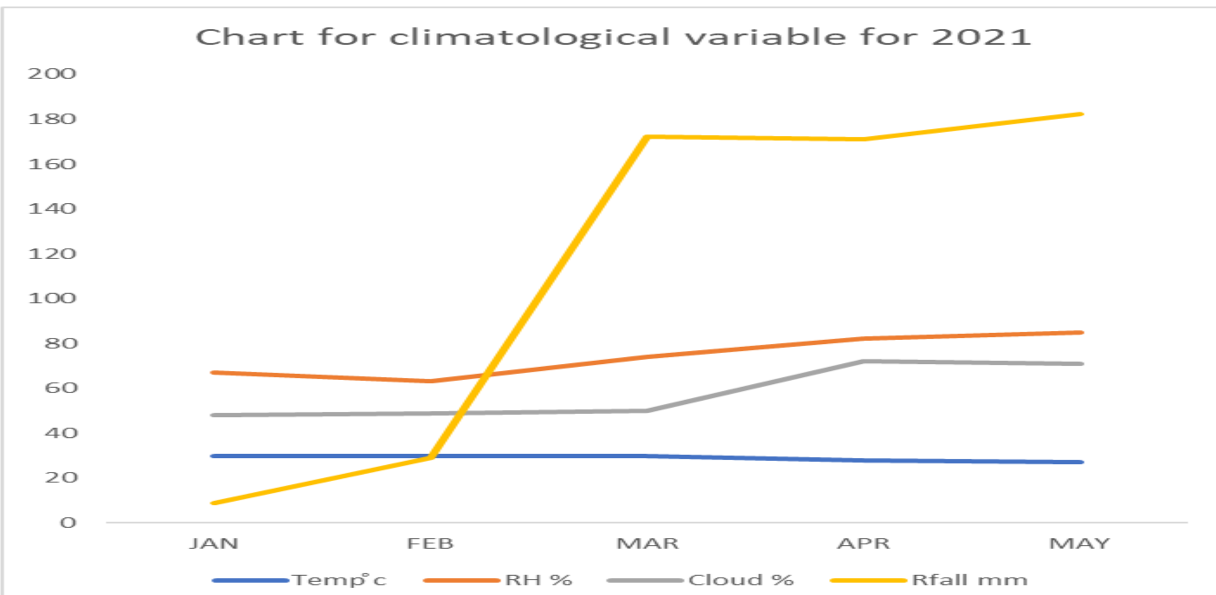


Figure 6: monthly trend of climatological variable in Ondo State, 2021

Climatological variables (rainfall pattern, temperature, relative humidity and cloud cover) associated with the occurrence of Lassa fever in Ondo State : using a negative binomial regression model of climatological variable vis-à-vis Lassa fever incidence for our prediction and analysis, in (Table 2) temperature is not significant to the occurrence of Lassa fever (p. >0.05), also cloud cover is not significant to the cases of Lassa fever ($p > 0.05$) and rainfall is not significant to the cases of (p.> 0.05) while relative humidity is also not significant ($p > 0.05$). In (Table) 1, temperature and rainfall are significant to the occurrence of Lassa fever ($p < 0.05$), while cloud cover and relative humidity are not significant to the cases of Lassa fever (p.> 0.05). In table 3, temperature and relative humidity are significant to the occurrence of Lassa fever ($p < 0.05$), while cloud cover and rainfall are also significant to the cases of Lassa fever (p.> 0.05). In table 4, the temperature and rainfall are marginally significant to the occurrence of Lassa fever ($p <0.05$).

	ESTIMATE	STD.ERROR	z- Value	P value
Intercept	-30.452782	10.406940	-2.926	0.00343
Temperature	1.073346	0.330710	3.246	0.00117
Relative humidity	0.028984	0.022116	1.311	0.19002
Cloud cover	-0.058819	0.032949	-1.785	0.07424
Rainfall (mm)	0.013572	0.003385	4.009	6.09e-05

Table 1: negative binomial regression model for climatological variables vis-à-vis lassa fever incidence For 2018

	ESTIMATE	STD.ERROR	z- Value	P value
Intercept	8.8493934	4.9687658	1.781	0.0749
Temperature	-0.1034814	0.1552929	-0.666	0.5052
Relative humidity	-0.0106323	0.0344600	-0.309	0.7577
Cloud cover	0.0326994	-0.0343768	0.951	0.3415
Rainfall	0.000478	0.0024416	00.167	0.8673

Table 2: negative binomial regression model for climatological variables vis-à-vis lassa fever incidence for 2019

	ESTIMATE	STD.ERROR	z- Value	P value
Intercept	20.8902476	1.7404508	12.003	2e-16
Temperature	-0.1010268	0.0520998	-1.939	0.0525
Relative humidity	-0.3253572	0.0477180	-6.818	9.21e-12
Cloud cover	0.1533870	0.0303628	5.052	4.38e-07
Rainfall (mm)	0.0016954	0.0008629	1.965	0.0495

Table 3 : negative binomial regression model for climatological variables vis-à-vis lassa fever incidence For 2020

	ESTIMATE	STD.ERROR	z- Value	P value
Intercept	11.121292	17.003383	0.654	0.513
Temperature	-0.151530	0.431937	-0.351	0.726
Relative humidity	-0.020787	0.065376	-0.318	0.751
Cloud cover	-0.050957	0.048158	-1.058	0.290
Rainfall (mm)	0.00409	0.004139	0.988	0.323

Table 4: negative binomial regression model for climatological variables vis-à-vis Lassa fever incidence for 2021

DISCUSSION

The study analysed the surveillance- based incidence data of Lassa fever in Ondo state from 2018/January to 2021/June. Lassa fever incidence in Ondo State peaked in the first three and the last two months of the year consistently. Monthly trend of climatological variable in Ondo State revealed that temperature was high, while the rainfall pattern, cloud cover and relative humidity were low especially during the peak periods. The association between climatic variables and Lassa fever occurrence were not consistent across the years considered. However, the temperature and rainfall was significantly associated overall negative binomial analysis. Lassa fever incidence in Ondo State peaked in the first three and the last two months of the year consistently and this support the findings by [5] that the highest number of cases recorded is usually during January to February yearly and also compare to the findings by [19] that cases of Lassa fever used to be highest during the dry season (January to March) and lowest during the wet season (May to November). However, data from Kenema, Sierra Leone showed that admissions were highest during the change from the dry to the wet season [18]. The high cases of Lassa fever could be attributed to scarcity of food during the dry season forcing the rodents into the human settlement for food and could also be attributed to practices of bush burning among communities which causes the vectors responsible for the transmission of Lassa fever to migrate to households in search of food items for survival [5]. It was observed that the temperature was high, while the cloud cover, rainfall pattern and relative humidity were low or decreased consistently during the peak periods of Lassa fever cases in Ondo State. The high temperature, low cloud cover, rainfall pattern and relative humidity observed are attributed to dry season which is normally the breeding season for must rodents and due to the scarcity of food during this period this forces this rodents into human settlement in search of food and also to breed and this may lead to the rise in the contact frequency between humans and infected rodents. Previous studies have linked breeding patterns of Mastomys. natalensis with climate [16]. Annual breeding patterns of Mastomys. natalensis are linked to rainfall patterns Mulungu [20]. The variation observed across the years under consideration could be due to climate change. A report by [17] of the distribution of human Lassa fever outbreaks and cases in the period 1951–1989 revealed that areas of medium risk had an annual rainfall in the range of 1200–1500 mm, whereas rainfall in the range of 1500–3000 mm was associated with a high risk of disease. Regions with transmission in Nigeria, also showed that rainfall was the only climatological variable that was significant to the occurrence of Lassa fever in Nigeria. This disparity in the finding may be due to the peculiarities of the climatic condition in Ondo State that favours agrarian activities and it may have clearly shown the impact of climate change on the occurrence of Lassa fever in Ondo State. Although, we don't expect that relative humidity, temperature and rainfall will directly affect the transmissibility of Lassa fever in Ondo State, it could be a pointer to the fact that they could be a seasonal migration of rodents (Mastomys natalensis) which is influenced by climate to human settlement in search of food, to hibernate and breed during the dry season and in turn increasing the contact rate i.e. Human-Rodents.

CONCLUSION

This study has establish that the peak periods of Lassa fever in Ondo State is around January and February and also around November and December. We also establish that relative humidity from our overall analysis is significantly associated with Lassa fever occurrence using a negative binomial regression model. Therefore, preventive measure should be heightened during the peak periods and the relative humidity can serve as early warning signs for Lassa fever occurrence in Ondo State.

What is already Known on this topic:
Lassa fever is a viral haemorrhagic fever and usually spark seasonal outbreak in Nigeria especially in Ondo State.

What this study add:
This study was able to highlight the peak period of lassa fever cases in Ondo State which could be attributed to climatological variables such as rainfall, temperature and relative humidity

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Competing interests: we declare that there was no competing interest

Authors' contribution: All authors contributed equally to the writing of this paper and have read and agreed to the final manuscript.

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