An Assessment of Rainfall and Temperature on Seasonal Outbreak of Lassa Fever in Nigeria for the Year 2020

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***Abstract* - The present study examined the impacts of rainfall and temperature on the seasonal outbreak of Lassa fever in Nigeria for the year 2020. The sample size was based on cluster sampling of the seven states with the highest number of cases in 2020. Three states from the south and four states from the north. Suspected and confirmed cases were gathered from the week by week epidemiological report of the NCDC website from December 30, 2019/week 52 to June 28, 2020/week 26. Average rainfall and temperature data for each state were gathered on a weekly average basis from the weather records of AccuWeather.com. The findings showed that there were no significant relationships between the climatic variables and the number of suspected and confirmed cases. However, there were weak significant relationships between the number of deaths and average low temperature (r = - 0.24) and average temperature difference (r = 0.19). In the southern states, for every one-degree (1°F) increase in temperature (f), there are an additional 12.1, 5.6 and 1.7 suspected cases in Edo, Ondo and Ebonyi states. Average high temperature alone could explain ~50% of the increase in cases. Relationships were less clear in the northern states. In contrast to previous research, the study found that there is a non-linear relationship between the climatic variables and Lassa fever outbreaks.**

***Keywords*— Rainfall, Temperature, Lassa Fever, Suspected cases, Confirmed cases, Seasonal Outbreaks**

I. INTRODUCTION

Lassa fever is one of the deadliest seasonal viral diseases plaguing the West African sub-region such as Sierra Leone, Liberia, Cote d'Ivoire, Togo, Senegal, Ghana, Mali, Guinea, and Nigeria [24]. Irregular imported cases have been accounted for in the United States of America, Europe, and Asia [4].

Past epidemiological data showed that West Africa has recorded about 300,000 to 500,000 cases of Lassa fever with 5,000 deaths each year [15]. The first Lassa fever case was identified at Lassa, a rural settlement in Borno state, North-eastern Nigeria after the death of two missionary nurses, Laura Wine and Charlotte Shaw in 1969 [24]. However, the Lassa virus was first discovered in the multimammate mouse, Mastomys natalensis in 1972 in Sierra Leone [14]. Today, Lassa fever is a growing public health issue in West Africa, where 59 million individuals are in danger, with 3 million cases and 67, 000 deaths may happen every year [21].

Lassa fever is a haemorrhagic fever caused by the Lassa virus. The virus is domicile in the Mastomys natalensis rodent found in the urine and faeces of the infected rat. Transmission

Tr. can be through direct contact with food or household items that have been contaminated with the urine or faeces of the infected rat. Rodent-to-human transmission occurs when humans inhale, ingest or have direct contact with the urine or the faeces as when killing and processing an infected rat for consumption. There is also human-to-human transmission via direct contact with the blood or bodily fluids of the infected patients [9]. This includes sneezing, coughing, sexual intercourse, kissing and breastfeeding. In hospital environments, it is transmitted through contaminated equipment. This is risky for health care workers taking care of patients [28]. A severe case of Lassa fever is experienced as a shock and multiorgan dysfunction can manifest leading to death [9]. Despite the high risk of this disease in West Africa, there is no approved vaccine for now. The main accessible pharmacologic treatment is the early intravenous treatment of the antiviral agent ribavirin, for these reasons, Lassa fever disease has been perceived by the World Health Organization (WHO) and the Coalition for Epidemic Preparedness Innovations as a significant danger to public health in dire need of attention in the area of research and innovative work [26]. Nigeria bears the most weight and case fatalities from this disease [10].

Nigeria has been experiencing Lassa fever outbreaks for over three decades and is still a major health concern today [18]. This zoonotic disease is not just a burden to the government but a serious threat to the communities [19]. Outbreaks of Lassa fever have been accounted for in different states of the federation especially Edo, Ebonyi, Bauchi, Plateau, Taraba, Gombe and Ondo states. Even though the sickness conveys an epidemic nature that draws in unexpected responses from the government, very little supported program is set up. The majority of the preventive measures in Nigeria focus on the clinical treatment of Lassa fever after an outbreak, carried out by the government through the Nigerian Centre for Disease Control (NCDC), the Nigerian Primary Health Care Development Agency, the Nigerian Red Cross Society (NRCS) and other Non-governmental Organizations (NGOs) [22], such as the World Health Organization (WHO), International Committee of Red Cross (ICRC), UNICEF etc. [17]. The moment an outbreak is over, the Federal Government and the States relax their efforts, forgetting that Lassa fever is a seasonal disease [29]. Critical aspects of managing the ongoing Lassa fever outbreak include surveillance, clinical case management, cross-border coordination, risk communications and support for affected communities, and implementation of standard infection prevention and control measures for health workers [32]. Most accessible reports concentrated for the most part on hospital outbreaks or more as of late on the laboratory analysis of blood specimens of suspected cases sent to reference lab [4].

Little attention is paid to an increase and spread of rodents through the country, poor housing, environmental sanitation, waste disposal management and desertification. In the year 2020, Nigeria has its largest-ever Lassa fever outbreak classified by World Health Organization as a Grade 2 public health emergency, between 30 December 2019 and 28 June 2020 (See FIGURE 1), the outbreak spread across 129 local government areas in 27 states of the 36 states in Nigeria resulting in 5201 suspected cases, 1040 laboratory-confirmed cases and 218 deaths with a case fatality rate of 21.0% [23]. It is obscure which factors prompt these outbreaks yet on numerous occasions they happened following a time of heavy rain. To analyse how rainfall can impact the population numbers of rodents, it is important to research the connections between precipitation patterns and population processes like increase, growth, and survival of the rodents. Information on these connections will be valuable to comprehending population dynamics and, in the end, can assist with predicting changes in population density. It is on this premise that this research work is born. The researchers, therefore, address the impacts of rainfall and temperature and the rodent control strategies that have been investigated and which have been the most effective in reducing the transmission of Lassa fever infection.

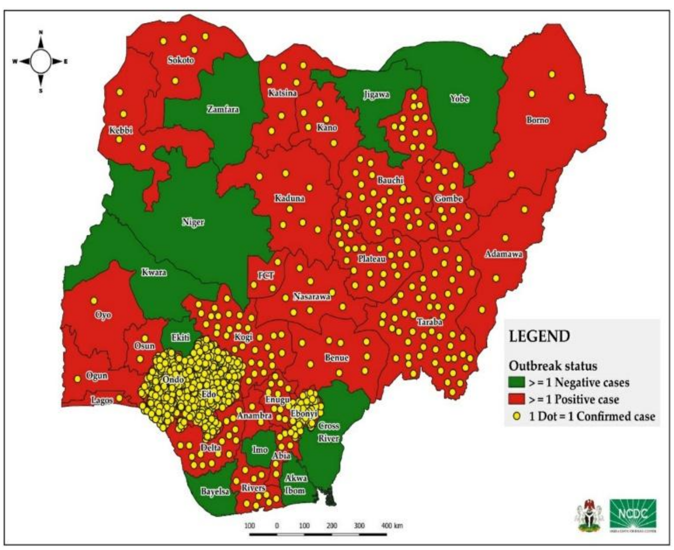

Fig 1: Map of Nigeria showing Lassa fever cases confirmed by states from week 01 – 26, 2020. (Source: NCDC Situational Report Epi. Week 26, 2020).

Lassa fever incidence and prevalence in Nigeria would be greatly reduced if there are community rodent controls, quality houses in the rural areas, good environmental health practices such as sanitation, good hygiene and food safety behaviours as a lifestyle. For this reason, there is an urgent need for individuals and collective community engagement and participation to maintain a hygienic and rodent-free environment for the good of all.

Research Objectives

i. To assess the impacts of rainfall and temperature on the re-emerging Lassa fever seasonal outbreaks in Nigeria.
ii. To determine the control measures that would minimize the contact points between the multimammate rats and the communities.
iii. To recommend effective control and prevention measures that could reduce contact between rodent populations and individuals.

Study Area

Nigeria consists of 36 states and the Federal Capital Territory (FCT). It extends from latitude 4°N to 14°N and from longitude 3°E to 15°E [11]. Nigeria lies on the inner corner of the Gulf of Guinea on the west coast of Africa. The country borders Benin to the west, Niger to the north and Chad and Cameroon to the east. Nigeria has a landmass of 923,768 square kilometres (km2) and includes 853 km of coastline [33]. The population of Nigeria is 206.14 million (2020) with an annual population growth rate of 2.5% [33]. It has two main relief regions: the high plateau, which is between 300 meters and 900 meters above sea level, and the lowland, which is generally less than 300 meters high. The high plateaus include the North Central Plateau, the Eastern and North Eastern Highlands, and the Western Uplands. The lowlands include the Sokoto Plains, the Niger-Benue Trough, the Chad Basin and the interior coastal lowlands of western Nigeria [33].

Nigeria is characterized by three distinct climate zones, a tropical monsoon climate in the south, a tropical savanna climate covering most of the central regions, and a hot and semi-arid Sahelian climate in the north of the country. This leads to a gradient of decreasing amounts of precipitation from the south to the north. In the southern regions, heavy precipitation events occur during the rainy season from March to October, with annual precipitation amounts mostly exceeding 2,000 mm, in the Niger Delta 4,000 mm and more can be reached [33]. The central regions are characterized by a well-defined rainy season (April to September) and a dry season (December to March). The dry season is influenced by the harmattan wind from the Sahara. The annual rainfall can be up to 1200 mm. In the north, rain falls in the range of 500 mm to 750 mm only from June to September. The rest of the year is hot and dry. Northern areas show a high degree of annual variation in their rainfall regime, leading to floods and droughts [33].

The highest temperature differences in Nigeria are between the coastal areas and the interior and between the plateau and the lowlands. On the plateau, mean annual temperatures vary between 21°C and 27°C, while temperatures in the interior lowlands are generally above 27°C. The coastal fringes have lower averages than the interior lowlands. Seasonal mean temperatures are consistently above 20℃ throughout the country, and diurnal variations are more pronounced than seasonal ones. The highest temperatures occur during the dry season and vary from coast to inland. Similar to precipitation, relative humidity in Nigeria decreases from south to north, with an annual mean of 88% around Lagos [33]. The average annual temperature for Nigeria is 26.9 °C, with monthly average temperatures ranging from 24 °C (December, January) to 30 °C (April). The mean annual precipitation is 1,165.0 mm. Rain falls in Nigeria throughout the year, with the heaviest rainfall occurring from April to October and the lightest from November to March [33].

II. METHODOLOGY

Research Design

The study employed a survey research design based on its ability to investigate and make inferences on the causal relationship between the current Lassa fever suspected and laboratory-confirmed cases, and rainfall and temperature. The rationale for choosing survey design was propelled by the vastness of the population. The sample size of the study was based on cluster sampling of the 27 affected states of the Lassa fever outbreak in Nigeria, in 2020. Seven (7) states were chosen as the most clustered of the 27 states (see FIGURE 2).

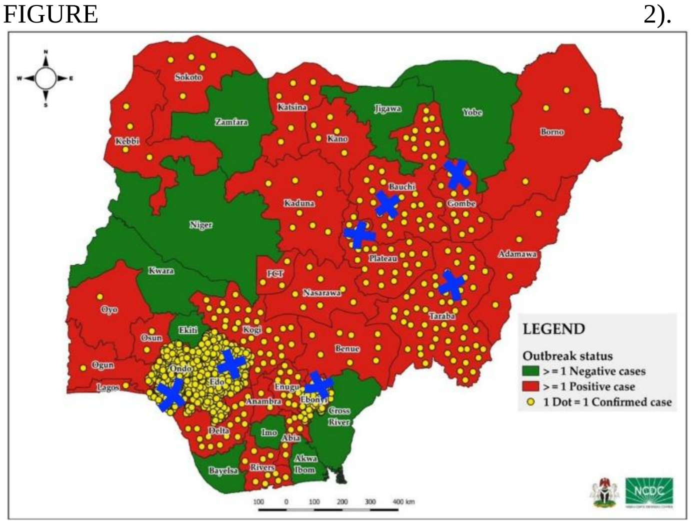

Figure 2: Map of Nigeria showing the study sites in blue stars, the prevalence of Lassa fever outbreak in Nigeria from week 01 – 26, 2020 (Source: NCDC Situational Report Epi. Week 26, 2020).

Sample Size Determination

The sample size was based on cluster sampling of the seven states with the highest number of cases in 2020. The cumulative suspected cases for the seven states were used which was 4088 [23]. Using an online sample size calculator [25], the sample size was determined by pre-specifying the margin of error as 0.05, confidence level 0.95 and the population size as 4088, giving the sample size of 352 suspected cases.

Data Collection

The surveillance-based incidence information of human Lassa fever cases in Nigeria was investigated. Data was routinely gathered from the week by week epidemiological report of the Nigerian Centre for Disease Control (NCDC) for the period from 2019/week 52 to 2020/week 26. The research looks at the significant outbreak that took place between December 30, 2019, and June 28, 2020, over the entire nation and the referenced seven states, are the hardest-hit states in the 2020 epidemics, such as Edo, Ondo, Ebonyi, Plateau, Bauchi, Taraba and Gombe. The extracted count included recently suspected, laboratory-confirmed and dead cases week after week. The corresponding week represents the weeks of rainfall and temperature (High and Low) respectively. The data of previous years was not used because of the inconsistent and irregular reporting and removal of data from the official website of the NCDC. However, the data used for 2020 are consistent, orderly and well captured. This is due to the present attention the government is giving to Lassa fever outbreaks through the NCDC. Climatological data (average rainfall and temperature) for each of the states were gathered on a weekly average basis from the historical weather records of AccuWeather.com Online website [1] for the corresponding weeks of Lassa fever suspected and confirmed cases in these states.*Data Analysis*

The Spearman correlation analysis was employed to ascertain the correlation between suspected and confirmed cases and death, and the impacts of rainfall and temperature. Linear regression was used to know the number of suspected cases and the impact of average high temperature on the southern and northern states.

III. RESULTS

The potential impacts of rainfall and temperature on the re-emerging Lassa fever seasonal outbreaks in Nigeria

Climatic Relationship

Table 1 shows the linear correlation statistics between the climatic factors (rainfall and temperature) and suspected cases, confirmed cases, and deaths in every one of the seven states. Linear correlation indicated that there were no significant relationships between the climatic factors and the quantity of suspected and confirmed cases. In any case, there were weak significant relationships between the number of deaths and average low temperature (r = - 0.24) and average temperature difference (r = 0.19). The number of suspected cases rather than confirmed or deaths cases is used for showing relationships between the variables due to the completeness of the data set.

Table 1: Spearman's r and p values for the correlation between suspected and confirmed cases and deaths with the climatic variable

	Average Rainfall (inches)		Average High Temperature (°f)		Average Low Temperature (°f)		Average Temperature Difference (°f)	
	r	p	r	p	r	p	r	p
Suspected Cases	0.13	0.099	-0.13	0.096	-0.06	0.465	-0.13	0.098
Confirmed Cases	0.03	0.703	-0.01	0.944	-0.12	0.121	0.06	0.421
Deaths	0.00	0.991	0.01	0.915	**-0.24**	**0.003**	**0.19**	**0.018**

Rainfall Relationship

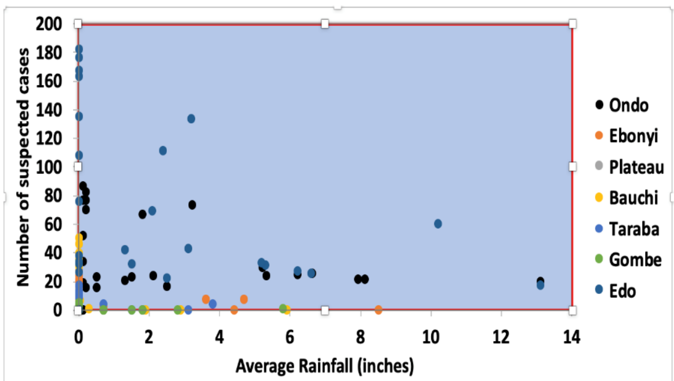

Figure 3: Shows the relationships between the number of suspected cases and average rainfall in the seven states.

There is a non-linear relationship between the number of suspected cases and rainfall amount with higher cases prevalent during the periods of low rainfall. The relationships between the number of suspected cases and rainfall differ between states located in the south (Ondo, Ebonyi and Edo) and states in the north (Plateau, Bauchi, Taraba and Gombe). Even though rainfall amount is similar between the states in the north and south, suspected cases are much higher in the south than in the north.

Temperature Relationship

There is a non-linear relationship between the number of suspected cases and average high temperature with little or no cases prevalent during the periods of high temperature. In the south, Edo has the highest number of cases followed by Ondo and Ebonyi despite similar temperature profiles. Linear regression models for the relationship between suspected cases and temperature by the states are given in Tables 2 and 3. Table 2 for the southern states shows that for every one-degree (1°F) increase in temperature (f), there are an additional 12.1 suspected cases in Edo state. This is compared with 5.6 and 1.7 cases in Ondo and Ebonyi respectively. Average high temperature alone could explain ~50% of the increase in cases in all three states as shown by the high r^2 values (TABLE 2). Relationships were less clear in the northern states. In Plateau, an increase in one degree (1°F) Fahrenheit resulted in less than one additional suspected case of Lassa fever (TABLE 3) with an average high temperature explaining only 15% of the increase in cases. In the other three states, there was no relationship between temperature and suspected cases.

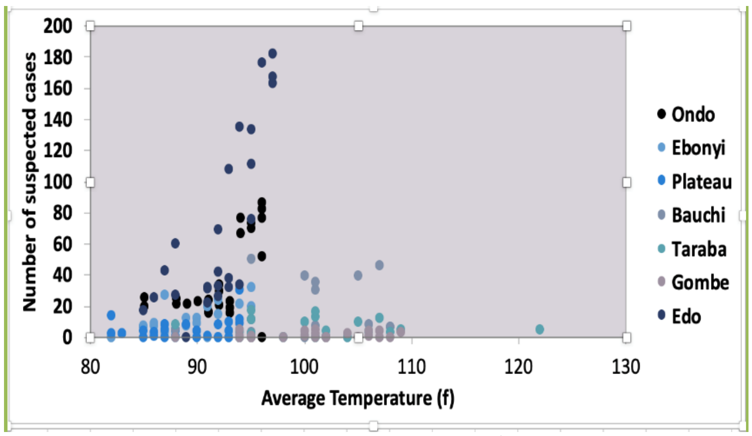

Fig. 4: Shows the relationships between the number of suspected cases and the average high temperature in the seven states.

There is a non-linear relationship between the number of suspected cases and average high temperature with little or no cases prevalent during periods of high temperature.

Table 2: Results of linear regression of the number of suspected cases and average high temperature by the state in the South.

	Edo	Ondo	Ebonyi
Estimate	12.108	5.629	1.725
Std. error	2.304	1.176	0.365
F	27.62	22.91	22.36
p	<0.001	<0.001	<0.001
r2	0.53	0.49	0.482

Table 3: Results of linear regression of the number of suspected cases and average high temperature by the state in the North.

	Plateau	Bauchi	Taraba	Gombe
Estimate	0.755	0.519	-0.048	0.062
Std. error	0.342	0.664	0.171	0.083
F	4.885	0.610	0.080	0.559
p	**0.038**	0.443	0.780	0.464
r2	0.150	-0.017	-0.042	-0.022

The appropriate risk control measures would minimize the contact point between multimammate rats and the communities

Effective Control Measures

Since no human vaccine exists nor effective medication for the treatment of Lassa fever disease, the best option available to prevent Lassa fever infection is household and community rodent control. The appropriate risk control measures that would reduce the contact points between the multimammate rats and the communities are grouped below. Based on the clear distinction of rainfall amount and temperature between the north and south, the implementation of rodent control measures is also classified by north and south to account for the potential differences in driving variables.

Table 4: Shows the categorization of rodent control strategies for the southern states with the highest Lassa fever cases in 2020.

IMPLEMENTATION OF RODENT CONTROL STRATEGIES FOR SOUTHERN STATES (High Infection States)			
S/N	**States**	**Interventions**	**Control measures**
1 2 3	Edo Ondo Ebonyi	Door-to-door health education and awareness on the transmissions, signs, symptoms and preventive measures of Lassa fever disease using outreach groups, interactive mobile cinema shows, radio jingles, TV shows, social media and the distributions of printed materials	- Individual and environmental hygiene promotions through household cleanliness, clearing of dirt and vegetations around the houses, - Proper solid wastes management and provisions of solid wastes disposal facilities - Disinfection of households and fumigation of the environment - Behavior change in storing harvested crops and food handling - Policy to prevent side of the roads drying of foods and rats' consumption - Sealing all rat holes and hideouts - Pest control activities such as rat traps and rat glues - Keeping of cats and dogs

Table 4 displays the interventions and control measures for the southern states. The three states recorded the highest numbers of suspected, confirmed and death cases in the 2020 Lassa fever outbreak. The control measures are designed according to Lassa fever prevalence in these three states to realize the objective stated.

Table 5: Shows the categorization of control strategies for implementation in the northern states with low Lassa fever infection rates.

IMPLEMENTATION OF RODENT CONTROL STRATEGIES FOR NORTHERN STATES (Low Infection States)		
States	Intervention	Control Measures
Plateau Bauchi Taraba Gombe	Mass campaigns and enlightenment on the modes of contacts, dangers of rat consumptions, ancestral and religious beliefs and key preventive measures on Lassa fever infection through TV shows, radios, social media and distribution of leaflets	- Individual and community hygiene activities for example, weekly environmental sanitation - Rats control at household and community levels - Proper wastes management by clearing solid wastes disposed near houses - Avoidance of contacts with rats through hunting for consumption - Store foods in airtight containers - Keeping of cats and dogs - Rodenticides - Normal traps and rat glues - Blockages of rats' hideouts - Keeping cats and dogs - Fill little gaps with steel wool, rough cloths, or close with concrete

Table 5 displays the interventions and control measures for the northern states. The four states recorded average numbers of suspected, confirmed and death cases in the 2020 Lassa fever outbreak. The control measures are designed according to the impacts of cases in these states to prevent contact with Lassa fever infection.

IV. DISCUSSION

Past preventive measures executed to battle Lassa fever outbreaks in Nigeria concentrated on clinical treatment after an outbreak occurs. The researchers looked at the issue on a very basic level by deciding the components that empower the rodents to move in and out of human settlements and why the outbreak follows a seasonal pattern annually. When the data were combined for the seven states as shown in (TABLE 1), the linear correlation indicated that there were no significant relationships between the climatic factors and the number of suspected with the confirmed cases. However, there were weak significant relationships between the number of deaths and average low temperature (r = - 0.24) and average temperature difference (r = 0.19). The climatic variables (rainfall and temperature) show a non-linear relationship existed between the suspected cases and the variables in both the north and the south. This research paper fills the knowledge gap of the lack of focus by the Nigerian government on rodent control measures instead of depending heavily on the fire brigade approach to eradicate seasonal Lassa fever outbreaks.

Rainfall Relationship

A non-linear relationship (FIGURE 3) existed between the number of suspected cases and rainfall amount in the seven states with higher cases prevalent during the periods of low rainfall. The relationships between the number of suspected cases and rainfall differ between states located in the south (Ondo, Ebonyi and Edo) and states in the north (Plateau, Bauchi, Taraba and Gombe). Even though rainfall amount is similar between the states in the south and the north, suspected cases were much higher in the south than in the north. In the south, as rainfall increases, suspected cases were still been recorded with higher cases prevalent during the period of low rainfall. Whereas, in the north, as rainfall increases, suspected cases dropped to zero with one or two cases recorded. Higher cases are prevalent during the period of no rainfall.

Temperature Relationship

Also, a non-linear relationship existed between the number of suspected cases and average temperature (FIGURE 4) in the seven states with little or no cases prevalent during the periods of high temperature. When data were split, Linear regression models for the relationship between suspected cases and temperature for the southern states (TABLE 2) show that for every one-degree (1°F) increase in temperature (f), there are an additional 12.1 suspected cases in the Edo state. This is compared with 5.6 and 1.7 cases in Ondo and Ebonyi respectively. Average high temperature alone could explain ~50% of the increase in cases in all three states as shown by the high r^2 values. Relationships were less clear in the northern states (TABLE 3). In the Plateau state, an increase in one degree (1°F) Fahrenheit resulted in less than one additional suspected case of Lassa fever with an average high temperature explaining only 15% of the increase in cases. In the other three states, there was no relationship between temperature and suspected cases. The temperature difference between the south and the north are in line with the study that climatic condition, for example, temperature have very much recorded effects on infectious diseases.

For both the findings of rainfall and temperature above, it is significant to note that precipitation and temperature do not directly impact the transmissibility of the Lassa fever infection to people. Studies showed that precipitation pattern impacts rodents' breeding and movement in and out of human settlements. Rodents migrate inside or close to human settlements to breed and hibernate during the dry season and are dispersed to the fields or farms during the rainy season. This, therefore, generate an increase in the contact rate of individuals with rodents during the dry season, and thus, a higher probability of acquiring Lassa fever disease [3].

Effective Control Measures

It ought to be noticed that rat control is the key measure in any program to mitigate Lassa fever infection. This is because experts in the Lassa fever endemic areas, including most third-world countries, don't have a great reputation for mounting successful healthcare and disease prevention programs [7]. The key difficulties in the crisis procedure on Lassa fever as illustrated in the NCDC Situational report for Epidemiological Week 4 of 2020 outbreak are poor environmental sanitation conditions seen in communities with higher infection rates and poor infection prevention and control measures in the health facilities [17]. Since the climatic variables serve as proxies for the breeding of new offspring (population increase) and the movement of the rodents, the control measures are basically on how to control the rat ecology that would minimize contact points with humans. Therefore, the control measures to be implemented in the north and the south are the same. The difference lies in the intensity of reported cases between the two regions. As can be seen in Figure 2, Edo, Ondo and Ebonyi (south) states reported higher cases of Lassa fever than Plateau, Bauchi, Taraba and Gombe (north) in the 2020 outbreak. Therefore, the rodent control program designed must focus more on the south than on the north. This is differentiated and suggested in Tables 5 and 6.

Limitation

In this study 'An assessment of rainfall and temperature on seasonal outbreak Lassa fever in Nigeria for the year 2020', the authors researched the relationships between rainfall/temperature and the seasonal outbreaks of Lassa fever. The impacts of these variables were observed on the seasonal patterns of Lassa fever outbreaks and focused on community rodent control and prevention as a possible solution to prevent a future outbreak. This was carried out for six months. The impacts of these variables on rat ecology were investigated to a certain extent but there are additional things we wished to uncover, for example, the breeding seasons and the dynamics of movements of these rats in and out of human settlements. Also, while the research was going on, these questions kept coming to mind: why do some states in Nigeria report cases of Lassa fever and some do not? Why do states have higher cases than others even under similar rainfall and temperature conditions? These are knowledge gaps that opened up as a result of this study and the researchers wished they have the time to consider them. However, these are not possible because of the scope of the work, the time frame involved and the present Covid 19 restrictions. Therefore, these areas are in dire need of research.

V. CONCLUSION AND RECOMMENDATION

Conclusion

As stated above, Lassa fever outbreaks have been happening in Nigeria since 1969. The researchers investigated the potential impacts of rainfall and temperature on the recent outbreak and came up with the following conclusions: there were no significant relationships between the climatic variables and the number of suspected cases and confirmed cases in the seven states. However, there were weak significant relationships between the number of deaths and low temperature. There is a non-linear relationship between the number of suspected cases and the amount of rainfall with higher cases prevalent during periods of low rainfall. More so, there is a non-linear relationship between the number of suspected cases and average temperature with little or no cases prevalent during the periods of high temperature. Average higher temperature alone explains ~50% of the cases in the southern states and 15% in Plateau state with no relationship between temperature and suspected cases in the other three states in the north. It should be noted that the rainfall and temperature do not directly cause the outbreak of Lassa fever but serve as a proxy for other factors, for examples rodents' breeding and movement in and out of human settlements; therefore, effective community rodent control was provided to prevent the seasonal Lassa fever outbreaks in Nigeria.

Recommendation

i. Strong political will

The Nigerian government must wake up to its constitutional responsibility for the welfare of its people. She ought to return to and harmonize the strategic plans to implement best practices in the control of Lassa fever outbreaks. The public health plans previously started must be continued and fortified. It is additionally essential to scale up the clinical response to the outbreaks. One of the lessons gained from Ebola virus disease control in Nigeria was the eagerness of the Government towards ending the plague. The Government gave strong authority and coordinated control commitments. The continuous seasonal Lassa fever outbreaks in Nigeria ask for similar political responsibility as the Ebola virus disease in the year 2014 [30].

ii. Public health enlightenment campaigns

Lassa fever is a very important zoonotic disease of poverty and compromised environmental hygiene ordinarily found in households and which can contaminate grains and other food materials without much of a stretch. It remains a public health burden on vulnerable populations in Nigeria. Proactive measures to control this menace should target public health enlightenment campaigns and advocacy on Lassa fever rodent control measures. Creating better enlightenment sessions would encourage behaviour change that would prompt effective control [2].

iii. Individual and community hygiene

Reducing the frequency and closeness of contact between Mastomys. natalensis and people remain the main preventive measure against Lassa fever disease. As opposed to erratic control, persistent rodent control would be a promising strategy, the improvement of a coordinated control system by combining different individual and environmental hygiene measures such as disinfecting households and clearing vegetation near houses, good solid wastes management, proper storing of crops harvested and food handling, stopping the side of the roads drying of foods, maintaining distances from bushes, avoiding touching and eating rats and proper handwashing and cleaning of utensils. This is because one of the key difficulties in the crisis procedure on Lassa fever as illustrated in the Situational report for Epidemiological Week 4 of 2020 is poor environmental sanitation conditions seen in communities with higher infection rates [17].

iv. The use of normal trapping, rat glues and natural predators

This control should incorporate a combination of poisoning with continuous trapping and rat glues. Poison should be done in the dry season, and trapping/rat glues would take over for the. rest of the year, with resulting training on application and safe control of dead rodents. Use normal predators such as cats and dogs. A recent report on scenes of fear made by natural predators in Swaziland indicated that only the combination of cats and dogs successfully drove away rodents [20]. The extra examination is expected to better comprehend the limit of cats to drive away rodents, the connection between individuals and cats and dogs, and general medical issues identified with cat and dog possession.

v. Sealing all rodent holes and closing doors and windows

Adequate and proper rat control measures in rural areas require a high level of responsibility from the local dwellers. Rural residents must seal up gaps inside and outside the home to forestall passage by rodents. A rat can get through a hole the size of a nickel. Keep rodents from entering the home by checking inside and outside the house for holes or gaps, filling the holes with steel wool, rough cloths or the use of concrete to block holes completely. By extension, urban dwellers should shut their doors as well as windows at whatever point they are inside or outside, as the need may be. This training will lessen the odds of rodents sneaking into families and subsequently decline the danger of Lassa fever transmission.

vi. *Establish an Effective Disease Reporting and Response System*

Timely and accurate reporting is an important part of efforts to combat communicable diseases. With the establishment of the Epidemic Preparedness Task Force, they must identify factors affecting the changing epidemiology of Lassa fever and forecast any possible escalating factors of the disease to make recommendations at the state or regional level giving, including taking action. In 2003, to demonstrate poor surveillance practices by health workers, Bawa, Olumide, and Umar surveyed 144 health workers from 88 health care facilities, with only fifty-five (38.2%) of the respondents being aware of the National Disease Surveillance and Notification (DSN) system [5].

vii. *Community surveillance - contact tracing, active case finding and referrals:*

Mastomys rats are the main reservoir for the Lassa virus and are so common in endemic areas of West Africa that it is not possible to eliminate them from the environment. Care should be taken when handling Mastomys rats. Health care workers caring for people with suspected or confirmed Lassa fever should take additional infection control measures to prevent contact with the person's blood, body fluids, and contaminated surfaces or materials, such as clothing and bedding. They should use standard infection prevention and control (IPC) measures when caring for individuals, regardless of their suspected diagnosis. These include basic hand hygiene, respiratory hygiene, the use of personal protective equipment (to prevent splashing or another contact with infected materials), and safe injection practices. Also, there should be active case searches using community case definitions of Lassa fever and also work closely with state and LGA Disease Surveillance Notification Officers (DSNOs) and other stakeholders to trace the individuals who have been in contact with the confirmed cases and link them to designated isolation and referral centres for supportive care [34].

viii. *Strengthening Lassa fever epidemiological risk surveillance and laboratory early detection*

Strengthening local and regional robust and sustainable implementation of integrated disease surveillance and response (ISDR) in routine laboratory diagnostics and epidemiological surveillance services and surge resource capacities are essential. Leveraging on decentralized African Centers for Disease Control and Prevention and a regional public laboratory network is critical to promoting WHO recommendations on global outbreak threats and crisis response, promoting the International Health Regulations (IHR) of 2005 and global health security. In addition, investing in more sensitive and reliable Lassa fever virus point-of-care and field diagnostic tools for early detection (e.g. rapid diagnostic kit) and rapid molecular case confirmation, safe and effective drugs and vaccines in remote rural areas where vulnerable communities live in central rodent reservoirs. Funding for programs to build key operational coordination, epidemiology and surveillance capacities would ensure effective and simultaneous transdisciplinary outbreak response measures and clinical case management guidelines for Lassa fever. Therefore, strengthening community health centres and laboratory capacity, data exchange access and operational logistics to demonstrate operational research priorities and decision-making guidelines, supply chain and timely risk communication, and common livelihoods [13].

ix. *Establishment of regional; and Country Epidemic Preparedness Team*

Epidemics can spread quickly across borders, and rapid information sharing from one country to another can increase the timeliness and effectiveness of interventions. A sub-regional organization specialized in epidemic preparedness and response could also facilitate information sharing within regions. In the case of Nigeria, a geopolitical or governmental preparedness team could provide an emergency preparedness response, ensure rapid protection of life and reduction of vulnerability, and save lives if an outbreak occurs. The author is not aware that there is a Sustainable Epidemic Preparedness Team in Nigeria charged with the role and responsibility of preparing for and responding to epidemic alerts [2].

x. *Accelerating research and development (R&D) for novel diagnostic tools, drugs and safe vaccines*

The research area of Lassa fever needs more detailed and recent studies on disease incidence, geographic distribution and virus seroprevalence [31]. Ribavirin is currently the recommended drug for Lassa fever [6]. The intravenous form is more effective than the oral form [8]. As the race to develop a Lassa fever vaccine continues, the WHO has put forward its thoughts on the vaccine regimen of choice against an emergency reactive response in an outbreak [31]. Diagnosis serves as the first step in the early detection, monitoring and response of disease, so there is a need for more reliable and effective diagnostic test assays that can detect the five strains of Lassa fever virus. This is handy when considering the choices for primers of geographic-region specific Lassa fever virus strains. Likewise, continued collective partnership and engagement in medical and veterinary best practices in human and animal care are required [12]. For example, the consensus on the experimental use of Ebola vaccines during the 2013/2014 Ebola virus outbreak in West Africa is supported by all parties in most affected countries [12]. However, Nigeria showed a strong and effective resilience that gave the country a head start and was the first African country to contain the scourge during this period. Investing in the development and implementation of local and regional Lassa fever vaccination programs and interventions to disrupt Lassa virus transmission dynamics, supported by an effective cold chain and traceability system, contextual communications to build trust and confidence in vulnerable communities are all important value-added approaches and strategies in containing the prevailing Lassa eruptions, Scourge and eventual elimination [27] [16].

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