Investigation of Lassa Fever outbreak in Grand Bassa County, Liberia, 2021

Phebe Jackson Thomas[1,2,3,&], Dora Dadzie[2], Irene Amedzro[2], Ernest Kenu[2], Janjay Hilary Glay[3]

[1]National Public Health Institute of Liberia, Monrovia, Liberia, [2]Ghana Field Epidemiology and Laboratory Training Program, Accra, Ghana, [3]Liberia Field Epidemiology Training Program, Monrovia, Liberia

KEYWORDS: Lassa Fever, Outbreak investigation, Ribavirin, Grand Bassa County, Liberia

ABSTRACT

Introduction: Lassa fever is an African viral haemorrhagic infection spread by contaminated rodent urine or feces. Every year, Lassa fever kills 5,000 individuals in West Africa. Three counties are known in Liberia to have Lassa fever. Cases are growing in previously disease-free areas, with a 56% fatality rate. Lassa fever was detected by a private health facility and reported to the Grand Bassa County Health Team through the district team on March 6, 2021. The County Surveillance Office organized a joint (District, County, and a resident of the Ghana Field Epidemiology and Laboratory Training Program (GFELTP)) rapid response team to investigate with aimed to confirm the outbreak, describe its magnitude and implement control and preventive measures. **Methods:** The investigation covered March to June 2021 in Grand Bassa County District. Stakeholders were consulted. Patients were interviewed, and their records checked. The standardized Lassa fever case definition was used to identify cases. Data was collected using the case investigation forms electronically by Kobo Collect and filling hard copy investigation forms. Data collected from cases were demographic data, date of onset of illness, signs and symptoms, travel history and exposure to animals or infected persons. A case search in the community and contact tracing revealed more cases. Cases were listed, and demographic and clinical data collected and summarized using proportions and frequencies. The communities were analyzed for environmental risk factors and blood samples were collected for Real-Time Polymerase Chain Reaction Testing (RT-PCR). **Results:** The index case was a 38-year-old female who was a resident of MIE Field camp located in Compound #3)with symptoms onset on the 1 March, 2021. She had a persistent high fever which did not resolve with anti-malarial and antibiotics. Three additional confirmed cases were detected through community case search. The district attack rate was 0.008 per 100,000, and the case fatality rate was 25% (1/4). The cases ages ranged from 24 to 55 years with a mean age of 45.5. Two (50%) were females. Overgrown weeds were seen close to residential areas, and the environmental hygiene was poor. **Conclusion:** An outbreak of Lassa fever in Grand Bassa County affected four residents in District #3, killing one. Community leaders were engaged and an organized cleanup exercises was conducted. Timely risk communication, rodent control, and environmental management helped control the outbreak. Healthcare workers should be periodically trained on the early detection of infectious diseases such as Lassa fever.

[&]CORRESPONDING AUTHOR
Phebe Jackson Thomas, Ghana Field Epidemiology and Laboratory Training Program, Accra, Ghana

phebensthomas@gmail.com

RECEIVED
21/03/2023

ACCEPTED
16/10/2024

PUBLISHED
23/10/2024

LINK

https://www.afenet-journal.net/content/article/7/50/full/

CITATION
Phebe Jackson Thomas et al. Investigation of Lassa Fever outbreak in Grand Bassa County, Liberia, 2021. Journal of Interventional Epidemiology and Public Health. 2024 Oct 23;7(4):5.
DOI:
https://www.doi.org/10.37432/jieph.2024.7.4.141

Introduction

Lassa fever is a highly contagious zoonotic disease that can affect humans after exposure to the urine or fecal matter of infected rodents that are peculiar to Africa. Clinical presentation includes fever, sore throat, headache, abdominal pain, diarrhoea, bleeding and shock in severe cases. The incubation period for Lassa fever ranges from 2 to 21 days. Lassa fever mode of spread is from rats to humans through two main methods: either humans hunt and prepare rats for their consumption, or infected rodents contaminate food with their urine or excrement [1].

Globally, an estimated 100,000 to 300,000 infections of Lassa fever occur, with approximately 5,000 deaths annually [2]. Lassa Fever virus is endemic in parts of West Africa including Liberia, due to the presence of a reservoir environment which is favorable for its survival [3,4]. In some parts of Sierra Leone and Liberia, the disease accounts for about 10-16% of hospitalizations [5] and has been reported by recent studies to be spreading to previously disease-free areas [3,6,7].

Early detection, close observation, and management of Lassa fever and other infectious diseases depend on efficient surveillance systems. Global initiatives entail collaboration across regional, national, and international health organizations, bolstered by a strong public health infrastructure and community involvement. The enhancement of global ability to manage and mitigate the effect of Lassa fever and other emerging infectious diseases is contingent upon the continual improvement of surveillance technologies, training, and international collaboration. At the sub-national level, there has been an improvement in case identification and reporting among surveillance actors thanks to the enhanced surveillance system that followed Liberia's update of its Integrated Disease Surveillance and Response plan from the second to the third edition and frequent training of health professionals. One of the diseases that must be reported right away under the Integrated Disease Surveillance and Response system in Liberia is Lassa fever. Community-based surveillance (CBS) in Liberia has been a critical component of the country's public health strategy, particularly in the aftermath of the Ebola outbreak. In order to identify, report, and address health threats as soon as possible, CBS entails involving the community and nearby healthcare professionals [8]. In Liberia, Lassa fever is endemic in three counties: Bong, Nimba, and Lofa. Even so, its magnitude is purported to be underestimated due to underreporting [1, 7]. According to the country' Integrated Disease Surveillance and Response guidelines [8], one confirmed case of Lassa fever constitutes an outbreak. For the past twelve years, Liberia has recorded at least one outbreak every other year in counties that are known to be endemic [7]. Outside endemic regions, about 16 cases have been confirmed since 2021, with a case fatality rate of 56% [7, 9].

On 6 March 2021, the Grand Bassa County Health Team was notified of one suspected Lassa fever case presenting with fever, red eyes, weakness, poor appetite, sore throat, vomiting and cough, and was treated with an anti-malarial and broad-spectrum antibiotic in a private hospital in District #3 through the District Health Team. This county was not known to be endemic for Lassa fever, although they had recently begun to record sporadic confirmed cases. Upon receipt of the information from the district, the County Surveillance Office - a resident of the Ghana Field Epidemiology and Laboratory Training Program (GFELTP) organized a joint district, county and national rapid response team to confirm the outbreak, identify the source, describe the magnitude and implement control and preventive measures.

Methods

Outbreak setting

Grand Bassa County is one of the 15 counties and most populous in Liberia, with a human population of 293,689 [10]. The outbreak investigation was conducted in District 3 from 6 March to 7 June 2021. The district is one of the health districts of Grand Bassa County, with an estimated population of 52,468. It is predominantly rural, with six clinics and one hospital, both private and public facilities. The district shares borders with Nimba County, Buchanan city, Bong County, and Rivercess County (**Figure 2**). The climate is tropical, hot and humid. The houses are 98% made of mud. The district is generally covered by green forest, with farming, mining, and rubber tapping as the major sources of income for its residents. The Liberia Agriculture Company (LAC) hospital, centrally located within the plantation areas or near major roads is more accessible. Over 42% of populations residing within 5km of health facilities have better access compared to those above 5km. Since LAC most likely houses its employees close to the plantation, this group can reasonably reach the medical facilities. The healthcare requirements of the staff members and their families are accommodated by the facilities. Cases of priority diseases including Lassa fever are detected from the community and health facility and are reported to district, county, and national levels. There are treatment facilities for Lassa fever in LAC Hospital (Grand Bassa County). Suspected case specimens are obtained from medical facilities and sent to the National Public Health Reference Laboratory, where the Real-Time Polymerase Chain Reaction Test (RT-PCR) is used for confirmation. These procedures are carefully followed in Liberia by the National Public Health Institute's Division of Infectious Disease and Epidemiology (DIDE). In cooperation with the WHO and other partners, they would conduct a comprehensive

analysis of the data and control measures after a time of no new confirmed cases, usually 42 days, before formally declaring the outbreak over. Health authorities should be sure that the announcement of the cessation of a Lassa fever outbreak is founded on a strong epidemiological evidence and successful public health actions by adhering to this standardized method.

Epidemiologic investigation

The team visited the health facility, interviewed patients, clinicians and reviewed medical records to verify the diagnosis. The patients´ registers were reviewed for potentially missed cases. The family of the index case was interviewed to gather information about the index case. Community volunteers were recruited, trained and deployed in the affected communities to conduct contact tracing and case search. An outbreak case definition was developed and used to search for additional cases. Contacts of confirmed cases were identified, line-listed and followed up for 21 days by a community volunteer. Contacts were categorized as high-risk or low-risk based on their association and exposure. Each contact was monitored daily for the onset of symptoms associated with Lassa fever, such as fever, headache, sore throat, muscle pain, chest pain, nausea, vomiting, diarrhoea, cough, and hemorrhagic manifestations. A key part of the monitoring process involved checking the contact´s body temperature daily to detect fever, one of the primary symptoms of Lassa fever. Health workers used digital thermometers to take accurate and consistent temperature readings. These thermometers are preferred due to their ease of use and quick readings. In some settings, non-contact infrared thermometers were used to reduce the exposure of disease transmission. These devices allowed health workers to measure temperature from a short distance without physical contact. Health workers maintained detailed logs of each contact´s daily health status, including recorded temperatures and any reported symptoms. This information was crucial for identifying early signs of infection. If a contact developed symptoms or had a fever, the health worker reported this immediately to a central health authority or outbreak response team for further evaluation and potential isolation. Contacts who developed symptoms were promptly isolated to prevent further transmission; a blood sample was collected and sent to the National reference laboratory for Lassa fever confirmation. Symptomatic contacts received appropriate medical care based on their condition and the confirmation of the disease. Controlling the disease's spread required closely observing the contacts of Lassa fever cases.

Case definition

Suspected: Any person with fever (≥38 °C) and two or more of the following signs: malaise, headache, sore throat, cough, nausea, vomiting, diarrhea, myalgia, chest pain, hearing loss, bleeding, swollen neck or face, and absence of a response after 48 hours of anti-malarial treatment and/or broad-spectrum antibiotic, history of contact with rodents or with cases of Lassa fever confirmed within a period of 21 days of onset of symptoms from the 27 February- 14 July 2021, in Grand Bassa County.

Probable: Any suspected case exhibiting one or more of the following symptoms: seizures, restlessness, confusion, facial or neck oedema, hearing loss and fever ≥38°C or bleeding.

Confirmed: A suspected case that is laboratory confirmed (positive IgM antibody, PCR or virus isolation) or epidemiological linkage to a confirmed case.

Contact: is defined as a person who has close, frequent contact with the infected person or to an infected person´s secretions, excretions, or tissues within three weeks of the last contact with a confirmed or probable case of Lassa fever.

Data collected from cases were demographic data, date of onset of illness, signs and symptoms, travel history and exposure to animals or infected persons. Cases were listed in a line list.

Data Collection process and tools

Outbreak case definitions were developed and used to search for additional cases. We collected data using the case investigation forms electronically by Kobo Collect and filling hard copy investigation forms. Data collected from cases were demographic data, date of onset of illness, signs and symptoms, travel history and exposure to animals or infected persons. Cases were listed in a line list. We interviewed the cases, caregivers, family members and contacts.

Laboratory investigation

Collected samples of venous blood from suspected cases and transported it using triple packaging in Ethylene Diamine Tetra-acetic Acid tubes at 2°C to 8°C with ice packs to the National Reference Laboratory for Real-Time Reverse Transcriptase Polymerase Chain Reaction (RT-PCR) testing.

Environmental and behavioural exposure assessment

Affected communities were assessed for environmental and behavioural exposure factors. The factors inspected were sanitation, vegetation, waste disposal methods, management of cooking utensils, environmental hygiene, and hunting rodents for food consumption purpose. The health facilities were also assessed for adherence to Infection prevention and control (IPC) guidelines [11].

Data analysis

The line list was imported into Epi Info™7. Demographic and clinical characteristics of cases were described using frequencies and proportions. We calculated overall and category-specific attack rates and case-fatality rates. An epidemic curve was constructed to show the time trend, and a spot map was drawn in ArcGIS (ArcMap10.7) to show the geographical distribution of cases. Suspected, probable, and confirmed cases were included in the analysis. Results were presented in tables, graph, and map.

Ethical considerations

Ethical approval was obtained from the Division of Infectious Disease and Epidemiology Department within the National Public Health Institute of Liberia and the County Health Officer of Grand Bassa County Health Team. In addition, consent was obtained from study participants before interviews. Data confidentiality was assured by the use of codes in place of personal identifiers.

Results

Distribution of the Lassa Fever outbreak by person

Overall, four cases were confirmed from March to July 2021, with an overall attack rate of 8 per 100,000. The case fatality rate was 25% (1/4). Two cases (50%) were females. The mean age is 45.5 years ranging from 24 - 55 years). (Table 1). The index case was a 38-year-old female who was a resident of MIE Field camp located Compound 3 in District 3, with symptoms onset on the 1 March 2021. She was admitted to the Liberia Agriculture Company (LAC) hospital on 4 March 2021 with fever, red eyes, weakness, poor appetite, sore throat, vomiting and cough, and was treated with anti-malarial and broad-spectrum antibiotics. The sample was collected on 6 March 2021 for Lassa fever Laboratory investigation and tested positive on 8 March 2021. The case patient was isolated and treated with ribavirin. She died on 7 March 2021 while awaiting the lab result. Three additional cases were identified on 8, 13, and 27 April through a community case search using the case definition and was diagnosed at the health facility. These cases had dates of onset on 2, 10, and 23 of April respectively. Their blood samples were collected on 12, 13 and 27 of the same month. The District 3 A&B attack rate was 0.008 per 100,000.

Identification of contacts of confirmed cases

A total of 39 contacts were identified, 30.8% (12/39) of the contacts were males. Slightly over a quarter, 25.6% (10/39) of the contacts identified were classified as high-exposure contacts (Table 2).

Distribution of the Lassa Fever outbreak by time

The outbreak began on the 1 March 2021 and ended on the 10 July 2021. It was declared over on the 31 July 2021 (Figure 1).

Distribution of the Lassa Fever outbreak by place

The Lassa fever outbreak affected only District #3 of Grand Bassa County. All four case-patients resided in the MIE field, Baboon camp, B-four Camp, and Estate four camp communities (Figure 2).

Clinical characteristics of cases

At least two cases presented with myalgia, swollen neck, malaise, headache, sore throat and nausea (Figure 3).

Laboratory findings

Samples were collected from four suspected cases. All were positive for the Lassa virus. Other routine laboratory tests such as malaria parasite test using microscopy diagnostic tests and urinalysis diagnostic tests (which involved examining the physical, chemical, and microscopic properties of urine) were all negative.

Case management

Cases were isolated in the isolation unit located in the hospital premises, and management was done with intravenous Ribavirin. Supportive treatments such as intravenous fluids, antipyretics, antibiotics, and multivitamins were used. IPC measures were strictly adhered to. A safe and dignified burial was conducted for the deceased. All contacts were quarantined in their homes and monitored daily by contact tracers. The investigation did not identify the source of the outbreak.

Environmental findings

A garbage disposal site was observed in an open area close to the community. Rodent traps were commonly used by residents to hunt for food consumption purposes. Overgrown weeds were seen close to residential areas, and the environmental hygiene was poor. The majority of residents lived in thatch houses with holes large enough to be accessed by rodents. Their cooking environment was untidy, with utensils exposed to the physical environment.

Outbreak prevention and control measures

From our visits to the health facility, we observed that health care workers used appropriate personal protective equipment (PPE), hand hygiene practices, and waste

management procedures. Training on the early detection, treatment and management of Lassa fever for health care workers was conducted including the proper use of personnel protective equipment (PPE).

Health care workers were sensitized on the disease in making differential diagnosis. We also conducted an IPC assessment among community dwellers and found that IPC measures were not in place. We encouraged health care workers to continue following IPC practices and proper waste management measures reinforced. The team also created awareness, strengthened surveillance in case detection in affected communities and encouraged community dwellers to avoid hunting or contact with rodents. The team and community dwellers carried out a clean-up campaign in affected districts on the 1 July 2021. Community dwellers were encouraged to keep their homes and cooking utensils clean, to reduce the possibility of rodents nesting in the rooms. Residents of affected as well as neighboring communities were educated to avoid contact with rodents, weed their surroundings and clean their utensils. Community health volunteers (gCHVs) conducted case searches and were encouraged to continue community awareness in affected and surrounding communities. Lassa fever jingle was aired on the local radio station (Radio Gorgblee) for three months after the outbreak. We ensured that burials were supervised and appropriate infection prevention measures were followed. Community meeting with the existing local leadership were organized to spread awareness using information, education, and communication (IEC) materials such as posters, flyers, radio talk show and encourages preventive practices. A community rodent trapping and baiting campaign focused on home and area with high human activity was initiated and also reducing the rodent populations by maintaining clean environments, properly storing food, and sealing entry points to homes. The outbreak was controlled but the investigation did not identify the source of the outbreak.

Discussion

The study confirmed a Lassa fever outbreak in District 3, Grand Bassa County Liberia. It also described the epidemiological characteristics and clinical aspects of the outbreak among the population living in an environment close to district 3 with multiple Lassa fever exposure factors from March to July 2021. Our investigation revealed a case fatality rate that is similar to a study conducted in Nigeria [9]. However, in a study conducted across Nigeria and Makurdi, North Central Nigeria the case fatality rates were less than. The fact that Lassa fever has no specific clinical presentation usually makes differentiating disease diagnosis difficult in the absence of laboratory confirmation leading to late diagnosis and increased fatality. This outcome is in line with a Nigerian study on expectant mothers that discovered patients who postponed seeking medical attention had a greater fatality exposure due to misdiagnosis or failure to recognize Lassa fever[12]. The severity of the illness and late administration of the ribavirin in July may have also contributed to high fatality rate; unlike other study in Nigeria found that the case fatality was properly due to shortage of ribavirin [13, 14].

This investigation revealed that the index case death was linked to the Lassa fever virus. The non-specific clinical presentation of Lassa fever makes early detection difficult in the absence of laboratory confirmation. Usually, it is only suspected when conventional treatment has failed, delaying detection. In this outbreak, Lassa fever was suspected within 21 days after anti-malarial treatment failed, which delayed detection and led to death. Similar delay episodes have been reported in Guinea (21 days), Ghana (12 days) and some parts of Liberia (8 days) [7, 15, 16]. Also, this could be because Lassa fever presents numerous symptoms that make it difficult for physicians to make accurate diagnosis, particularly those who are not familiar with the disease in non-endemic areas. In most LF-endemic areas, the early symptoms are comparable to other fever infections, including malaria which coincide with a study conducted by WHO that revealed Lassa fever is endemic in Liberia [17].The cause of death of the LF case might be due to delayed healthcare seeking or untimely detection of the case. In a study in Bauchi State, Nigeria, delay in seeking care by case patients after symptom onset was a predictor of death from Lassa fever [15].

A low attack rate was recorded; which could be attributed findings from this study showed a low attack rate for this outbreak. This could be attributed to campaigns conducted in the county to increase Lassa fever awareness among residents, better equipment at the treatment center or earlier diagnosis of cases besides the index case. This is similar to findings from another study conducted in Bong county in Liberia in 2016 that reported a low attack rate [16].

The study findings showed all cases occurred in district 3A & B, Grand Bassa County. This could be due to the fact that this district is rural area and bordering part of the Lassa fever belt in Liberia. Houses in the rural areas or villages are sometimes close to forest, commercial areas or with a higher human density harboring domestic rats, thereby increasing the exposure of humans to the virus. Furthermore, this could likely be due to one of the endemic counties which is Bong being adjacent to district 3A & B rurally, where the locals practice farming, occasionally go hunting, eat rats, and disregard environmental hygiene. As a result, they come into contact with blood, urine, faces, and other bodily fluids such as saliva or semen of an infected human while preparing, which exposes them to the Lassa virus. Additionally, it is also likely that residents of this district

are involved in hunting and consuming rats, as well as not observing environmental sanitation, thereby exposing themselves to the Lassa virus. This finding are similar to a study in Guinea which showed that Lassa fever is a disease of rural areas influenced by the composition of the rodent population [18].

Findings from this study showed that all of the cases were detected at health facility level. However, there was delayed detection and diagnosis of index patient. This could be likely due to poor health seeking behavior among the population, resulting seeking care from a health facility late when the disease has advanced. Moreover, this could likely be due to the sometimes-asymptomatic nature or nonspecific early signs and symptoms of Lassa fever, which sometimes delay identification or diagnosis, poor resident adherence to the health protocol and result in worse outcomes when the infection is severe. This findings are similar to the study conducted in Nigeria among pregnant women which reported late care seeking attitude and delay in identification or diagnosis of Lassa fever among patients [7, 12].

The inability of the investigation to identify the source of the outbreak was the limitation of the study. The inability to employ phylogenetic sequencing to identify the virus's source and how it relates to other viruses that have spread to other countries and to Liberia.

The team however identified conditions that possibly facilitated exposure of the community members to rodents. This finding is similar to another the study conducted in Liberia on the lesson learned from the investigation and response of Lassa fever outbreak, which showed that the source need to be identified through conducting environmental assessment[7]

Conclusion

An outbreak of Lassa fever in Grand Bassa County affected four residents in district 3A&B, killing one. The actual source of the outbreak could not be identified. The case fatality highlight the severity of the outbreak and the need for prompt public health interventions. Cases were detected at both health facilities and through active case searches. They were all isolated, and contacts followed up for 21 days through monitoring. Timely exposure communication, rodent control and environmental management helped control the outbreak. The Ministry of Health and the Grand Bassa County Health Team should ensure that the Lassa fever jingle is aired in the local vernacular on all local radio stations.

Public Health Actions

The health facilities and case home were disinfected to prevent further spread to other patients and staff. Community leaders were engaged and an organized clean-up exercise was carried out among communities dwellers. Residents of affected as well as neighbouring communities were educated to avoid contact with rodents, weed their surroundings and clean their utensils. Radio jingles were continually played for three months to educate residents on Lassa fever and preventive measures. Community Health Volunteers (CHVs) were encouraged to continue community awareness in affected and surrounding communities. IPC and proper waste management measures were reinforced at health facilities.

What is known about this topic

- Lassa is an African viral haemorrhagic infection spread by contaminated rodent urine or feces
- Every year, Lassa fever kills 5,000 individuals in West Africa

What this study adds

- Timely exposure communication, rodent control and environmental management helped control the outbreak.

Competing interests

The authors declare no competing interests.

Authors´ contributions

The first author, P. Thomas, is primarily responsible for the overall outbreak process from the investigation, data collection, data analysis, and apprehended this manuscript. The second author, J. Glay contributed to the Investigation, data collection and manuscript preparation. The other author, D. Dadzie, D. Bandoh, AG Mohammed, I. Amedzro , and E. Kenu also reviewed and edited the manuscript. All author analysed critically and approved the final version of the manuscript.

Acknowledgements

The author want to extend special heartfelt thanks and appreciation to the following: Division of Infectious Disease and Epidemiology, National Public Health Institute of Liberia (NPHIL), County Surveillance for Grand Bassa County Health Team, Ghana Field

Epidemiology & Laboratory Training Program(GFELTP) and Mentors who supported this process. Special thanks to Delia Akosua Bandoh for her endless support in drafting and reviewing various versions of this manuscript.

Table and figures

Table 1: Distribution of Confirmed Lassa fever cases in District 3A &B, Grand Bassa, Liberia, 2021
Table 2: Distribution of Lassa fever contacts in District 3A &B, Grand Bassa, Liberia, 2021
Figure 1: Epidemiological curve of Lassa Fever outbreak, Grand Bassa, Liberia, 2021
Figure 2: Spot map of confirmed Lassa fever cases in District #3, Grand Bassa County, Liberia, 2021
Figure 3: Lassa fever cases by signs & symptoms, District 3A & B, Grand Bassa County, Liberia, 2021

References

1. Africa Centers for Disease Control and Prevention. **Lassa Fever** [Internet]. Addis Ababa (Ethiopia): Africa Centers for Disease Control and Prevention; 2019 Sep [cited 2024 Oct 8].

2. Centers for Disease Control and Prevention. **About Lassa Fever** [Internet]. Atlanta (GA): Centers for Disease Control and Prevention; 2024 Apr 19 [cited 2024 Oct 8].

3. World Health Organization. **Lassa fever** [Internet]. Geneva (Switzerland): World Health Organization; c2024. Overview; c2019 [cited 2024 Oct 8];[about 2 screens].

4. Arruda LB, Haider N, Olayemi A, Simons D, Ehichioya D, Yinka-Ogunleye A, Ansumana R, Thomason MJ, Asogun D, Ihekweazu C, Fichet-Calvet E, Kock RA. **The niche of One Health approaches in Lassa fever surveillance and control**. Ann Clin Microbiol Antimicrob [Internet]. 2021 Apr 24 [cited 2024 Oct 8];20(1):29. **https://doi.org/10.1186/s12941-021-00431-0 PubMed** | **Google Scholar**

5. Leach M, Bett B, Said M, Bukachi S, Sang R, Anderson N, Machila N, Kuleszo J, Schaten K, Dzingirai V, Mangwanya L, Ntiamoa-Baidu Y, Lawson E, Amponsah-Mensah K, Moses LM, Wilkinson A, Grant DS, Koninga J. **Local disease-ecosystem-livelihood dynamics: reflections from comparative case studies in Africa**. Phil Trans R Soc B [Internet]. 2017 Jun 5 [cited 2024 Oct 8];372(1725):20160163. **https://doi.org/10.1098/rstb.2016.0163 PubMed** | **Google Scholar**

6. Kyei NNA, Abilba MM, Kwawu FK, Agbenohevi PG, Bonney JHK, Agbemaple TK, Nimo-Paintsil SC, Ampofo W, Ohene SA, Nyarko EO. **Imported Lassa Fever: A report of 2 cases in Ghana**. BMC Infect Dis [Internet]. 2015 May 29 [cited 2024 Oct 8];15(1):217. **https://doi.org/10.1186/s12879-015-0956-2 PubMed** | **Google Scholar**

7. Woyessa AB, Maximore L, Keller D, Dogba J, Pajibo M, Johnson K, Saydee E, Monday J, Tuopileyi R, Mahmoud N. **Lesson learned from the investigation and response of Lassa fever outbreak, Margibi County, Liberia, 2018: case report**. BMC Infect Dis [Internet]. 2019 Jul 11 [cited 2024 Oct 8];19(1):610. **https://doi.org/10.1186/s12879-019-4257-z PubMed** | **Google Scholar**

8. Ministry of Health (Liberia), National Public Health Institute of Liberia. **National Technical Guidelines for Integrated Disease Surveillance & Response** [Internet]. 3rd ed. Monrovia (Liberia): Ministry of Health, National Public Health Institute of Liberia ;2021 Jun [Adapted 2019 Nov; cited 2024 Oct 8]. 520 p. Download Final_IDSR Technical Guidelines_Final Version signed by Hon. DG and Hon. Minister.pdf.

9. Akpede GO, Asogun DA, Okogbenin SA, Dawodu SO, Momoh MO, Dongo AE, Ike C, Tobin E, Akpede N, Ogbaini-Emovon E, Adewale AE, Ochei O, Onyeke F, Okonofua MO, Atafo RO, Odia I, Adomeh DI, Odigie G, Ogbeifun C, Muoebonam E, Ihekweazu C, Ramharter M, Colubri A, Sabeti PC, Happi CT, Günther S, Agbonlahor DE. **Caseload and Case Fatality of Lassa Fever in Nigeria, 2001-2018: A Specialist Center's Experience and Its Implications**. Front Public Health [Internet]. 2019 Jun 25 [cited 2024 Oct 8]; 7:170. **https://doi.org/10.3389/fpubh.2019.00170** Erratum in: **Corrigendum: Caseload and Case Fatality of Lassa Fever in Nigeria, 2001–2018: A Specialist Center's Experience and Its Implications**. Front Public Health [Internet]. 2019 Sep 13 [cited 2024 Oct 8];7:251. **https://doi.org/10.3389/fpubh.2019.00251 PubMed** | **Google Scholar**

10. Liberia Institute of Statistics and Geo-Information Service. **Liberia Population and Housing Census: Final Results** [Internet]. Monrovia (Liberia): Liberia Institute of Statistics and Geo-Information Service; 2023 June [cited 2024 Oct 8]. 90 p. Download LiberiaCensus2022Report.pdf.

11. Ministry of Health (Singapore). **NATIONAL INFECTION PREVENTION AND CONTROL GUIDELINES FOR PRIMARY CARE 2022** [Internet]. Singapore (Singapore): Ministry of Health; [cited 2024 Oct 8]. 89 p. Download national-ipc-guidelines-for-primary-care_on-moh-website_finalcfeeec720d8e48c88e26b91118c6736f.pdf.

12. Okogbenin S, Okoeguale J, Akpede G, Colubri A, Barnes KG, Mehta S, Eifediyi R, Okogbo F, Eigbefoh J, Momoh M, Rafiu M, Adomeh D, Odia I, Aire C, Atafo R, Okonofua M, Pahlman M, Becker-Ziaja B, Asogun D, Okokhere P, Happi C, Günther S, Sabeti PC, Ogbaini-Emovon E. **Retrospective Cohort Study of Lassa Fever in Pregnancy, Southern Nigeria** . Emerg Infect Dis [Internet]. 2019 Aug [cited 2024 Oct 8];25(8):1494-500. **https://doi.org/10.3201/eid2508.181299 PubMed** | **Google Scholar**

13. Bagcchi S. **Lassa fever outbreak continues across Nigeria** . Lancet Infect Dis [Internet]. 2020 May [cited 2024 Oct 8];20(5):543. **https://doi.org/10.1016/s1473-3099(20)30299-1 PubMed** | **Google Scholar**

14. Achinge GI, Kur JT, Gyoh SK. **Lassa fever Outbreak In Makurdi, North Central Nigeria: What You Need To Know** . IOSR J Dent Med Sci [Internet]. 2013 [cited 2024 Oct 8]; 7 (5): 42-6. **https://doi.org/10.9790/0853-0754246 Google Scholar**

15. Abdulkarim MA, Babale SM, Umeokonkwo CD, Bamgboye EA, Bashorun AT, Usman AA, Balogun MS. **Epidemiology of Lassa Fever and Factors Associated with Deaths, Bauchi State, Nigeria, 2015-2018** . Emerg Infect Dis [Internet]. 2020 Mar 2[cited 2024 Oct 8];26(4):799-801. **https://doi.org/10.3201/eid2604.190678 PubMed** | **Google Scholar**

16. Hamblion EL, Raftery P, Wendland A, Dweh E, Williams GS, George RNC, Soro L, Katawera V, Clement P, Gasasira AN, Musa E, Nagbe TK. **The challenges of detecting and responding to a Lassa fever outbreak in an Ebola-affected setting**. Int J Infect Dis [Internet]. 2017 Nov 11 [cited 2024 Oct 8]; 66:65-73. **https://doi.org/10.1016/j.ijid.2017.11.007 Google Scholar**

17. World Health Organization. **Lassa Fever - Liberia** [Internet]. Geneva (Switzerland): World Health Organization; 2018 Feb 22 [cited 2024 Oct 8].

18. Magassouba N, Koivogui E, Conde S, Kone M, Koropogui M, Soropogui B, Kekoura I, Hinzmann J, Günther S, Keita S, Duraffour S, Fichet-Calvet E. **A Sporadic and Lethal Lassa Fever Case in Forest Guinea, 2019** . Viruses [Internet]. 2020 Sep 23 [cited 2024 Oct 8];12(10):1062. **https://doi.org/10.3390/v12101062 PubMed** | **Google Scholar**

Table 1: Characteristics of Confirmed Lassa fever cases in District 3A &B, Grand Bassa, Liberia, 2021	
Characteristics of cases	**N=4 (%)**
Place of detection	
Facility	4 (100)
Community	0 (0)
Sex	
Male	2 (50.0)
Female	2 (50.0)
Age (Year)	45.5 (24-55)
Outcome	
Alive	3 (75.00)
Dead	1(25.00)

Table 2: Distribution of Lassa fever contacts in District 3A &B, Grand Bassa, Liberia, 2021	
Characteristics of contacts	N=39 (%)
Sex of contacts	
Male	12(30.77)
Female	27(69.23)
Contact's relation to cases	
Family members	4(10.25)
Community member	12(30.77)
Health workers	23(58.97)
Exposure classification	
High exposure	10(25.64)
Low exposure	29(74.36)

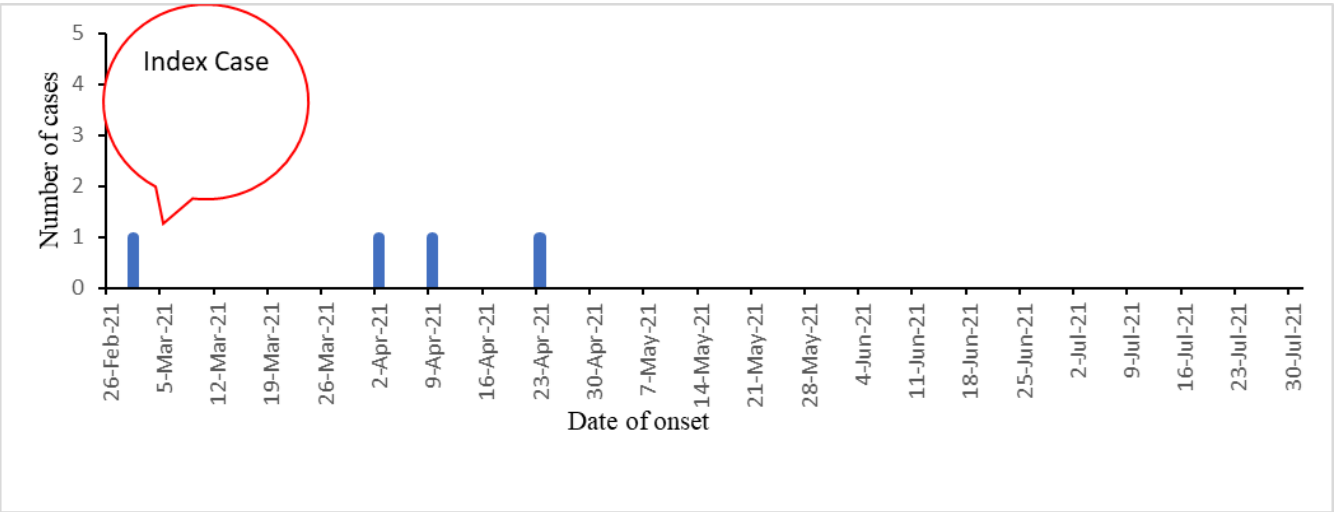

Figure 1: Epidemiological curve of Lassa Fever outbreak, Grand Bassa, Liberia, 2021

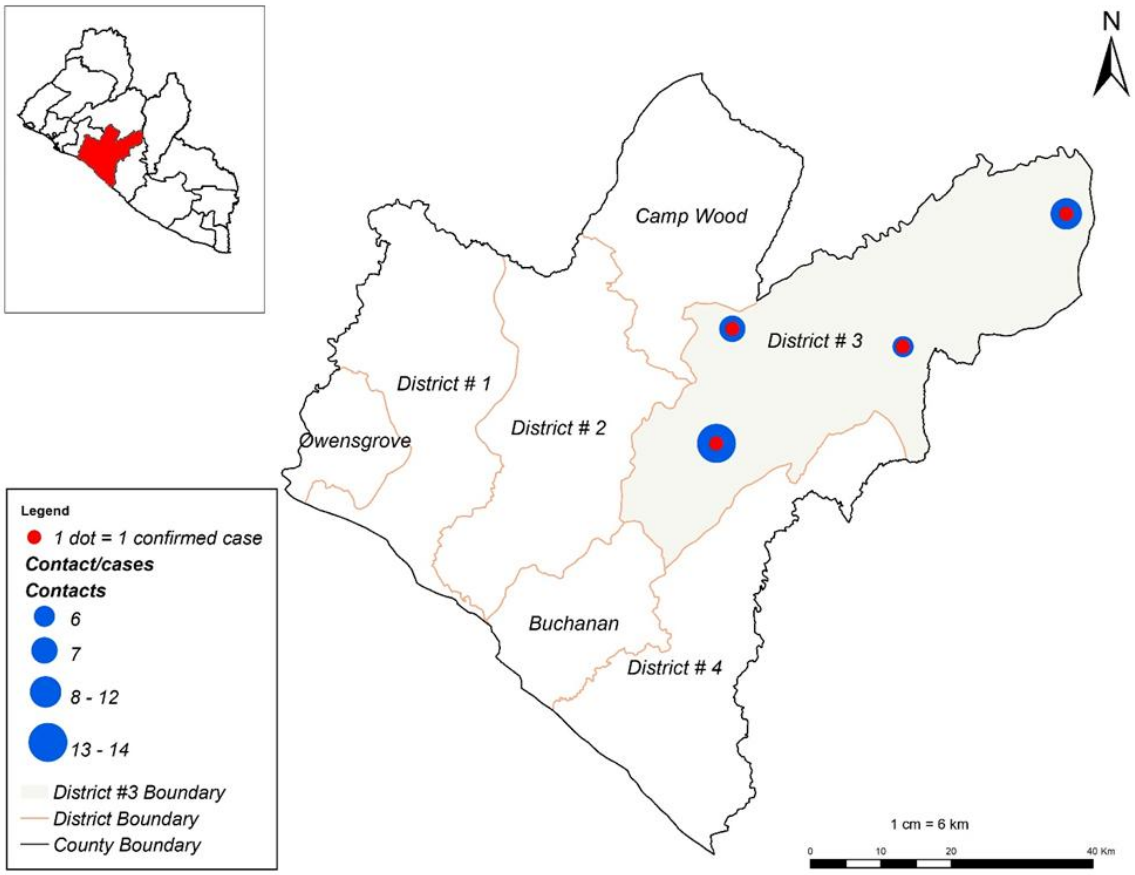

Figure 2: Spot map of confirmed Lassa fever cases in District #3, Grand Bassa County, Liberia, 2021

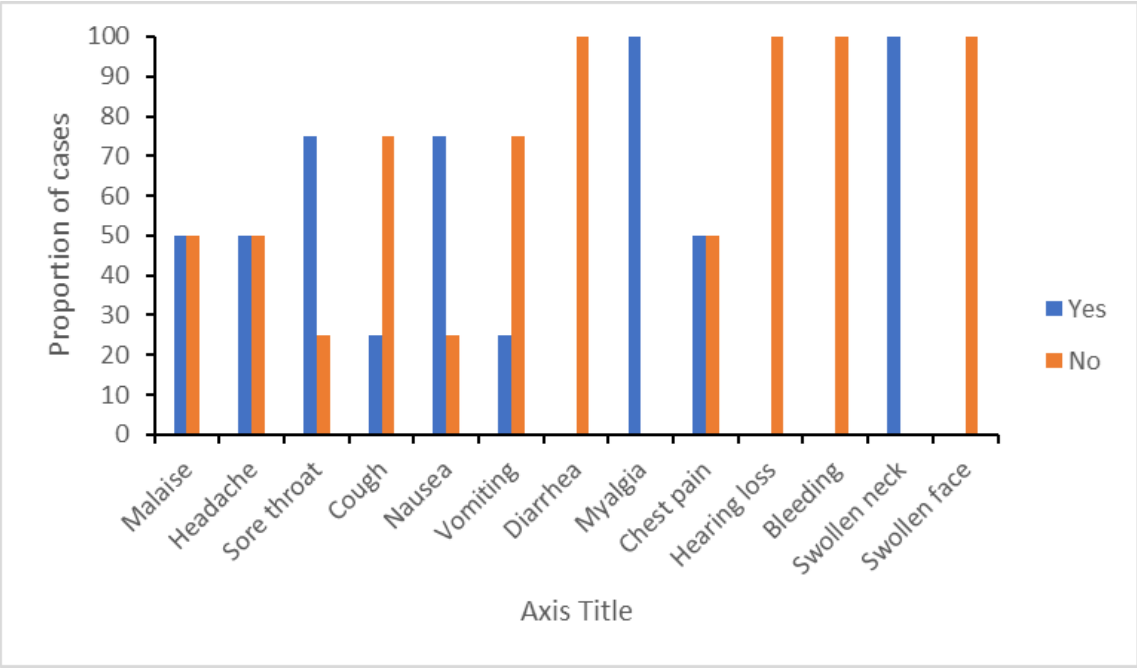

Figure 3: Lassa fever cases by signs & symptoms, District 3A & B, Grand Bassa County, Liberia