Beyond the Epidemic: Effective Public Health Strategies in Response to Nigeria's First Lassa Fever Outbreak in a Non-Endemic Region.

Samuel Terungwa Abaya, Dimie Ogoina, Jones Stow, Bio Belu Abaye, Chisom Emeka, Morufu Olalekan Raimi

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Beyond the Epidemic: Effective Public Health Strategies in Response to Nigeria's First Lassa Fever Outbreak in a Non-Endemic Region.

Samuel Terungwa Abaya[1*] PhD; Dimie Ogoina[2*] Prof Dr Med; Jones Stow[3] PhD; Bio Belu Abaye[4] PhD; Chisom Emeka[5*] PhD; Morufu Olalekan Raimi[6] PhD

[1]Nigeria Centre for Disease Control and Prevention (NCDC), Bayelsa State Office, Nigeria Yenagoa NG
[2]Niger Delta University Teaching Hospital (NDUTH) Chief Medical Director Okolobiri NG
[3]Ministry of Health, Bayelsa State Public Health Department Director of Public Health Yenagoa NG
[4]Ministry of Health, Bayelsa State Public Health Department Yenagoa NG
[5]World Health Organization National Professional Officer, Vaccine Prevention Diseases, Country Office, Abuja Abuja NG
[6]Federal University Otuoke, Bayelsa State, Faculty of Sciences, Otuoke NG
[*]these authors contributed equally

Corresponding Author:
Morufu Olalekan Raimi PhD
Federal University Otuoke, Bayelsa State,
Faculty of Sciences,
Department of Environmental Management and Toxicology
Otuoke
NG

Abstract

Background: Bayelsa State, located in Nigeria's Niger Delta region, had never reported a Lassa fever (LF) outbreak despite the country's 54-year history of such occurrences. This study examines the public health response components to the first-ever LF outbreak in Bayelsa State.

Objective: To describe the public health strategies and challenges encountered during the management of Bayelsa State's first Lassa fever outbreak

Methods: This descriptive observational study was conducted from February 8th to April 20th, 2023, employing both quantitative and qualitative methods. Sociodemographic, clinical, and public health data were collected from suspected and confirmed LF cases, including their contacts. Additionally, the study reviewed and documented the public health response plans, activities, and experiences during the outbreak

Results: A total of 37 suspected cases were reported, with two confirmed positive via PCR. The index case was laboratory-confirmed approximately nine weeks after symptom onset and tragically passed away five days after her third hospital admission, just a day after diagnosis. The second case, a contact of the index, fully recovered following a mild illness. Among 95 identified contacts, 70 were categorized as high-risk, and 15 exhibited symptoms. All 20 contacts who were tested returned negative results. The outbreak was managed using a multidisciplinary One Health approach aligned with Nigeria’s LF emergency preparedness and response framework. One death was recorded, and 21 contacts were tested. Challenges included low suspicion among healthcare workers, inadequate infection control practices, insufficient personal protective equipment (PPE), shortages of medical commodities, and lack of funding.

Conclusions: All communities within LF-endemic countries, regardless of prior outbreak status, must bolster their preparedness. Emphasis should be placed on preemptive sensitization and training of healthcare workers and investing in the sustainable availability of LF epidemic response commodities. Enhance preemptive healthcare worker sensitization and training in LF non-endemic regions, ensure sustainable availability of PPEs and other LF response commodities as well as strengthen infection control practices and outbreak response funding. This study highlights the importance of preparedness and rapid response, even in regions previously unaffected by LF outbreaks, to minimize the impact of emerging infectious diseases.

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[1]Samuel Terungwa Abaya, https://orcid.org/0009-0000-5559-2590
[1]Nigeria Centre for Disease Control and Prevention (NCDC), Bayelsa State Office, Nigeria.
samuelabaya79@gmail.com

[2]Dimie Ogoina, https://orcid.org/0000-0002-2098-6300
[2]Chief Medical Director, Niger Delta University Teaching Hospital (NDUTH) Okolobiri, Bayelsa State. Nigeria.
dimieogoina@gmail.com

[3]Jones Stow, https://orcid.org/0000-0002-7638-0391
[3]Director of Public Health, Public Health Department, Ministry of Health, Bayelsa State, Nigeria.
jystow@gmail.com

[4]Bio Belu Abaye, https://orcid.org/0009-0009-6561-9131
[4]Public Health Department, Ministry of Health, Bayelsa State, Nigeria.
beluabaye@yahoo.co.uk

[5]Chisom Emeka https://orcid.org/0000-0002-2927-9127
[5]National Professional Officer, Vaccine Prevention Diseases, World Health Organization, Country Office, Abuja, Nigeria. chisome80@gmail.com.

[6]Morufu Olalekan Raimi
[6]Department of Environmental Management and Toxicology, Faculty of Sciences, Federal University Otuoke, Bayelsa State, Nigeria. raimimo@fuotuoke.edu.ng.

Abstract

Rationale: Bayelsa State, located in Nigeria's Niger Delta region, had never reported a Lassa fever (LF) outbreak despite the country's 54-year history of such occurrences. This study examines the public health response components to the first-ever LF outbreak in Bayelsa State. **Objective:** To describe the public health strategies and challenges encountered during the management of Bayelsa State's first Lassa fever outbreak. **Methods:** This descriptive observational study was conducted from February 8th to April 20th, 2023, employing both quantitative and qualitative methods. Sociodemographic, clinical, and public health data were collected from suspected and confirmed LF cases, including their contacts. Additionally, the study reviewed and documented the public health response plans, activities, and experiences during the outbreak. **Results:** A total of 37 suspected cases were reported, with two confirmed positive via PCR. The index case was laboratory-confirmed approximately nine weeks after symptom onset and tragically passed away five days after her third hospital admission, just a day after diagnosis. The second case, a contact of the index, fully recovered following a mild illness. Among 95 identified contacts, 70 were categorized as high-risk, and 15 exhibited symptoms. All 20 contacts who were tested returned negative results. The outbreak was managed using a multidisciplinary One Health approach aligned with Nigeria's LF emergency preparedness and response framework. One death was recorded, and 21 contacts were tested. Challenges included low suspicion among healthcare workers, inadequate infection control practices, insufficient personal protective equipment (PPE), shortages of medical commodities, and lack of funding. **Conclusions:** All communities within LF-endemic countries, regardless of prior outbreak status, must bolster their preparedness. Emphasis should be placed on preemptive sensitization and training of healthcare workers and investing in the sustainable availability of LF epidemic response commodities. **Recommendations:** Enhance preemptive healthcare worker sensitization and training in LF non-endemic regions, ensure sustainable availability of PPEs and other LF response commodities as well as strengthen infection control practices and outbreak response funding. **Significance Statement:** This study highlights the importance of preparedness and rapid response, even in regions previously unaffected by LF outbreaks, to minimize the impact of emerging infectious diseases.

Keywords
Lassa Fever, Public Health Response, Non-Endemic Region, Outbreak Preparedness, One Health Approach, Bayelsa State, Nigeria.

1. Introduction

Lassa fever (LF) is a significant viral hemorrhagic fever endemic to West Africa, caused by the Lassa virus, a member of the Arenaviridae family [1-3]. The virus is primarily transmitted to humans through contact with the excreta or bodily fluids of infected *Mastomys natalensis*, commonly known as the multimammate rat, which serves as the primary reservoir [1-8]. The discovery of the virus dates back to 1969, when it was first identified in a missionary nurse in the town of Lassa, Borno State, Nigeria [9-12]. Since then, LF has emerged as a persistent public health threat, particularly in regions with high rodent populations and poor sanitation, contributing to its spread and prevalence [13-25]. The importance of studying Lassa fever cannot be overstated, given its severe public health implications in West Africa. LF is responsible for an estimated 100,000 to 300,000 infections annually, with approximately 5,000 deaths [26-32]. These figures underscore the virus's potential to cause widespread morbidity and mortality, especially in countries with limited healthcare infrastructure [33-39]. Furthermore, the virus poses a significant risk to healthcare workers, who are often exposed to the virus through inadequate infection prevention and control (IPC) practices, highlighting the need for robust public health responses and healthcare system strengthening [39-48]. Research on Lassa fever has revealed several critical insights into the virus's transmission, clinical presentation, and epidemiology. Studies have shown that the virus has an incubation period of 6 to 21 days, with symptoms ranging from mild to severe, including fever, headache, and hemorrhaging [49-53]. LF outbreaks tend to peak during the dry season, from November to April, particularly in areas with poor housing and sanitation [9]. Despite these insights, there remain significant gaps in our understanding of the virus's behavior in non-endemic regions, where the population may lack immunity, and healthcare systems may be unprepared for outbreaks. The burden of Lassa fever is particularly heavy in rural and peri-urban areas of West Africa, where healthcare access is often limited, and environmental conditions favor the proliferation of the Mastomys

natalensis rat [17-25]. Countries such as Nigeria, Sierra Leone, Liberia, Guinea, and Mali have reported recurrent LF outbreaks, with Nigeria experiencing some of the most severe outbreaks in recent history. The largest outbreak in Nigeria occurred in 2017, with a progressive increase in cases and fatalities over the years [10, 54-56]. In 2022 alone, Nigeria reported 8,202 suspected cases, with 1,067 confirmed cases and 189 deaths across 27 states [1-8]. These figures illustrate the significant and growing public health challenge posed by LF in Nigeria and neighboring countries.

Bayelsa State, located in the Niger Delta region of Nigeria, presents a unique case in the epidemiology of Lassa fever. Despite the state's proximity to regions with frequent LF outbreaks, it had not reported any confirmed cases of LF since its creation in 1996. This anomaly positioned Bayelsa as a non-endemic region, raising questions about the factors that may have protected the state from outbreaks until recently. However, the first confirmed outbreak of LF in Bayelsa State in 2023 marks a significant shift, challenging the state's previous non-endemic status and highlighting the need for a comprehensive public health response. The first LF outbreak in Bayelsa State underscores the need for preparedness in regions previously considered non-endemic. This outbreak, which resulted in 37 suspected cases and two confirmed cases, including one fatality, revealed several challenges in the public health response, such as poor infection control practices, inadequate personal protective equipment (PPE), and insufficient funding [1-8]. The multidisciplinary One Health approach used to manage the outbreak aligns with Nigeria's LF emergency preparedness and response framework, but the challenges faced suggest a need for further strengthening of these systems, especially in non-endemic regions. Different groups are impacted by Lassa fever in various ways, with healthcare workers being particularly vulnerable due to their close contact with infected patients. Additionally, individuals living in rural and peri-urban areas with poor housing and sanitation are at a higher risk of infection [1-5, 46-48]. The

socioeconomic impact of LF is also significant, as the cost of managing outbreaks, including hospitalization, treatment, and public health interventions, can strain already limited resources in affected countries. Moreover, the long-term health consequences for survivors, who may suffer from hearing loss and other complications, add to the disease's burden. Despite the progress made in understanding and managing Lassa fever, there remain critical gaps in our knowledge, particularly regarding the virus's dynamics in non-endemic regions like Bayelsa State. These gaps include understanding the factors that contributed to the state's protection from LF for many years and the potential changes in environmental or social conditions that may have triggered the recent outbreak. Addressing these gaps is crucial for developing effective public health strategies that can be adapted to different epidemiological contexts.

The present study aims to fill these gaps by providing a detailed analysis of the public health response to the first LF outbreak in Bayelsa State. By documenting the plans, activities, and challenges faced during the outbreak, this study seeks to offer valuable lessons for managing LF in non-endemic regions. These insights could inform future public health interventions and contribute to the broader goal of reducing the burden of LF in West Africa and beyond. Conclusively, the study of Lassa fever, particularly in regions previously considered non-endemic, is essential for enhancing global health security. The findings from this study in Bayelsa State will not only contribute to the scientific understanding of LF but also provide practical recommendations for strengthening public health responses in similar contexts. As LF continues to pose a significant threat in West Africa, the lessons learned from this study could play a critical role in improving preparedness and response efforts, ultimately reducing the disease's impact on affected populations.

2. Method

2.1 Study Area

This study was conducted in Bayelsa State, located in the Niger Delta region of Nigeria. Bayelsa is bordered to the east and northeast by Rivers State, to the west and northwest by Delta State, and to the south by the Atlantic Ocean. The state covers a total area of 10,773 square kilometers and has an estimated population of 2,704,515 (Bayelsa State Government, 2023). Bayelsa is divided into eight Local Government Areas (LGAs): Southern Ijaw, Kolokuma Opokuma, Yenagoa, Nembe, Ogbia, and Sagbama [57-60]. The state is characterized by a predominantly riverine and estuarine environment, with a significant portion of the population living in rural communities with limited access to healthcare services [61]. The unique geographical and socio-economic conditions of Bayelsa State, coupled with its prior non-endemic status for Lassa fever, made it a critical area of focus for this study.

2.2 Study Design

A descriptive observational study was conducted between February 8 and April 20, 2023. The study employed a mixed-methods design, incorporating both qualitative and quantitative approaches to assess the effectiveness of the public health response to the first Lassa fever outbreak in Bayelsa State. This approach is consistent with methodologies recommended for evaluating complex public health interventions [62]. The study focused on seven key components of the public health response, as outlined in the Nigerian Centre for Disease Control (NCDC) guidelines for viral hemorrhagic fever (VHF) response: Coordination, Case Management, Infection Prevention and Control/Safe Burial, Laboratory Pillar, Logistics Pillar, Risk Communication Pillar, and Surveillance [8, 63].

2.3 Study Population

The study population included healthcare workers (HCWs) who had direct or indirect contact with Lassa fever cases, community members from the affected areas, and key stakeholders involved in public health in Bayelsa State. The selection of participants was based on their

involvement in or exposure to the public health response to the Lassa fever outbreak. Participants were drawn from health facilities that reported suspected and confirmed Lassa fever cases and from the communities where these cases originated [64].

2.4 Study Duration

The study was conducted over a period of approximately 10 weeks, from February 8 to April 20, 2023. This period was chosen to encompass the entirety of the outbreak response activities, allowing for a comprehensive evaluation of the public health interventions implemented during the outbreak [10].

2.5 Sample Size Calculation

Given the descriptive nature of the study, a purposive sampling method was employed, targeting individuals and groups most directly involved in the public health response to the outbreak. The sample size was determined based on the need to capture a wide range of experiences and perspectives, ensuring the inclusion of key informants from various sectors, including healthcare workers, community leaders, and public health officials [65]. Quantitative data were collected from all confirmed and suspected cases of Lassa fever reported during the study period, as well as their contacts.

2.6 Sampling Techniques

Purposive sampling was utilized to select participants who were directly involved in the outbreak response or who had significant exposure to the outbreak, either as HCWs, community members, or public health stakeholders. This non-probability sampling method is particularly effective in exploratory studies where the focus is on obtaining in-depth information from a specific group [66].

2.7 Study Instrument

The study employed a combination of semi-structured interviews, focus group discussions,

and structured questionnaires to collect qualitative and quantitative data. The semi-structured interviews were designed to elicit detailed information about the experiences, challenges, and perceptions of the public health response among participants. Focus group discussions provided additional insights into community-level responses and perceptions. The structured questionnaires were used to gather quantitative data on clinical management, exposure types, and contact tracing [67].

2.8 Study Procedure

The study began with a review of operational plans, documented activities, and periodic situational reports produced by the Bayelsa State Ministry of Health's Lassa fever response team. Key informant interviews were conducted with healthcare workers, community leaders, and public health officials to gather qualitative data on their experiences and the challenges they faced during the outbreak. Interviews were conducted in person or via telephone, depending on the feasibility and availability of participants. Interviews were recorded, transcribed, and thematically analyzed to identify common themes related to the public health response. Quantitative data were obtained from health facility records and the Surveillance Outbreak Response Management and Analysis System (SORMAS) database. Contact investigation forms were completed for each contact, and follow-up calls and visits were conducted as necessary [9].

2.9 Outcomes

2.9.1 Primary Outcome

The primary outcome of the study was to evaluate the effectiveness of the public health response to the first Lassa fever outbreak in Bayelsa State, focusing on the seven components of the NCDC's VHF response framework. This included assessing the coordination of the response, the effectiveness of case management, the adequacy of infection prevention and control measures, the functionality of the laboratory and logistics pillars, the effectiveness of

risk communication strategies, and the robustness of surveillance activities [3-8, 68].

2.9.2 Secondary Outcome

The secondary outcome was to identify the key challenges and gaps in the public health response that could be addressed in future outbreaks. This included evaluating the availability and adequacy of personal protective equipment (PPE), the level of healthcare worker preparedness, and the overall readiness of the state's healthcare system to manage viral hemorrhagic fever outbreaks [64].

2.10 Inclusion Criteria

Participants were included in the study if they met any of the following criteria: (1) healthcare workers who had direct or indirect contact with Lassa fever cases; (2) community members who had contact with confirmed or suspected cases; (3) public health stakeholders involved in the outbreak response. Exclusion criteria included individuals who were not involved in the outbreak response or had no contact with Lassa fever cases [65].

2.11 Data Collection

Qualitative data were collected through key informant interviews and focus group discussions with healthcare workers, community members, and public health stakeholders. These interviews were designed to capture the participants' experiences, challenges, and perceptions of the public health response to the outbreak. Quantitative data were collected from health facility records, including clinical management data, exposure types, and contact tracing information. Data from the SORMAS database were also utilized to track and analyze the outbreak's progression [9].

2.12 Data Analysis

Quantitative data were analyzed using descriptive statistics, with variables represented as percentages and proportions. Microsoft Excel was used to organize and present the data. Qualitative data were analyzed thematically, with transcripts coded to identify key themes

and patterns related to the public health response. The thematic analysis provided a comprehensive understanding of the strengths and weaknesses of the outbreak response in Bayelsa State [67].

2.13 Ethical Considerations and Approval

Ethical approval for the study was obtained from the Bayelsa State Ministry of Health Ethical Review Committee. All study participants provided informed consent before participating in the study. Participants were assured of the confidentiality of their responses, and all data were anonymized to protect their identities. The study adhered to the ethical principles of respect for persons, beneficence, and justice, as outlined in the Declaration of Helsinki [68].

3 Results

3.1 Clinical and Epidemiological History of the Index Case

On February 8th, 2023, a 37-year-old Nigerian woman presented at the Niger Delta University Teaching Hospital (NDUTH) in Yenagoa, Bayelsa, with an eight-week history of recurrent symptoms. These symptoms included fever, fatigue, joint pains, and hematuria. Upon admission, she was conscious but exhibited signs of severe illness, including lethargy, pallor, jaundice, and breathlessness even at rest. As her condition deteriorated, she lapsed into a coma and developed oliguria, which was also associated with hematuria. It is important to note that prior to her presentation at NDUTH, she had sought medical attention at two different private hospitals. She was admitted to one of these hospitals for 10 days before being referred to NDUTH (Figure 1). After five days of admission at NDUTH, the healthcare team suspected Lassa fever (LF), prompting them to take a blood sample for laboratory testing on February 13th, 2023. Tragically, the patient passed away the following day on February 14th, 2023 (Figure 1). The laboratory results, confirming a positive diagnosis for LF

through polymerase chain reaction (PCR), were not received until February 18th, 2023, five days after the sample was collected (Figure 1). This delay underscores the critical need for rapid diagnostic capabilities, especially in managing viral hemorrhagic fevers like LF.

3.2 Establishment of LF Response Team

The confirmation of LF in the state led to the immediate establishment of an LF emergency response team and the activation of the State's Public Health Emergency Operation Centre (PHEOC). The response team promptly initiated surveillance, case finding, contact tracing, and risk communication activities. A comprehensive line list was developed, documenting all contacts of the patient, including family members, healthcare workers, and others who had close physical contact with the index case from the onset of her illness through her presentations at various private hospitals and eventually at NDUTH. The response team meticulously documented a total of 84 exposed healthcare workers, 29 from the private hospitals and 55 from NDUTH. These individuals were closely monitored, and samples were collected from those who exhibited symptoms. The collected samples were then sent to the National Reference Laboratory (NRL) in Gaduwa, Abuja, for PCR testing to confirm LF. Healthcare workers identified as high-risk contacts due to their level of exposure were isolated and closely observed for any symptoms. Those who developed symptoms were promptly treated while awaiting the results of their PCR tests. In parallel, to prevent the potential spread of the virus, the hospital initiated thorough disinfection procedures for the beds and other equipment used by the confirmed LF case prior to her death. The mortuary staff was also strictly instructed to adhere to appropriate infection prevention and control measures while handling the deceased's body. Additionally, steps were taken to prevent family members from coming into direct contact with the deceased’s body, further minimizing the risk of transmission.

3.3 Subsequent Case Identification and Response

As the investigation continued, a new LF case was identified within the same family. The brother of the index case, who had close physical contact with her on the day of her death, February 14th, was later found to be infected. His samples were collected on March 4th, 2023, and he was confirmed positive for LF on March 8th, 2023. Unlike the index case, he only presented with mild symptoms such as fever, headache, and malaise. Fortunately, after receiving appropriate care, he tested negative for LF on March 23rd, 2023 (Figure 1 and Appendix 1). These events highlight the critical role of timely response and rigorous contact tracing in managing LF outbreaks. The swift establishment of an LF emergency response team, coupled with thorough disinfection procedures and strict adherence to infection prevention and control measures, played a vital role in containing the outbreak and preventing further spread of the virus.

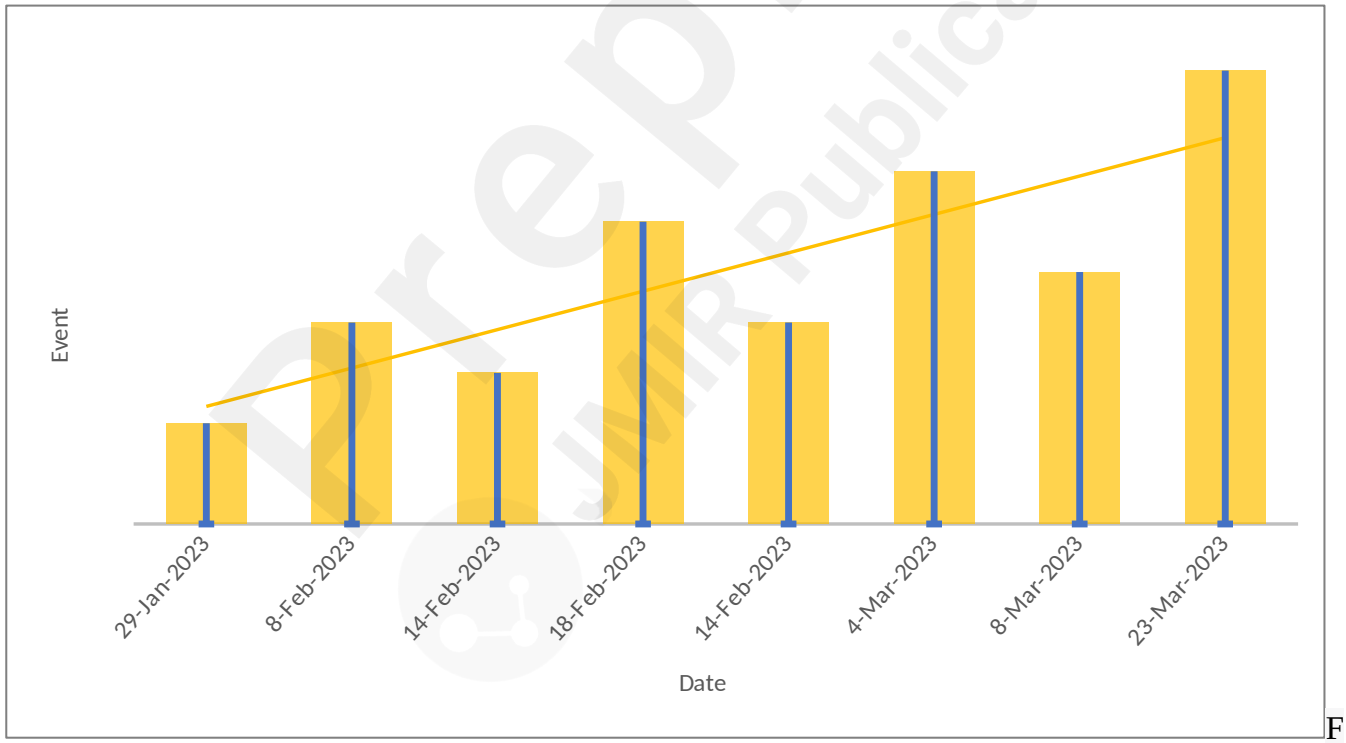

Figure 1: Case event and timeline of the first Lassa fever outbreak in Bayelsa State.

3.4 Activities of the State Public Health Emergency Operations Centre (PHEOC)

Following the confirmation of the Lassa fever (LF) outbreak, the State Public Health Emergency Operations Centre (PHEOC) promptly activated its Incident Management System

(IMS) to coordinate the response. The Commissioner of Health appointed an Incident Manager to lead the operations, ensuring that all efforts were effectively streamlined across the response pillars. The PHEOC's operations were systematically organized into seven critical pillars, each focused on a specific aspect of the outbreak response: Coordination, Case Management, Infection Prevention and Control/Safe Burial, Laboratory Services, Logistics, Risk Communication, and Surveillance.

Coordination: This pillar was responsible for the overall strategic management and coordination of the outbreak response. The Incident Manager led daily briefings and debriefings with all stakeholders, ensuring that there was a clear understanding of the evolving situation and that response activities were aligned with the state's public health goals. Coordination also involved liaising with national and international partners, securing resources, and facilitating inter-agency collaboration to strengthen the response efforts.

Case Management: The Case Management team focused on the clinical care of confirmed and suspected LF patients. This included establishing treatment protocols, ensuring that healthcare workers were adequately trained in LF management, and setting up isolation wards in designated healthcare facilities. The team also provided support to healthcare workers in managing complications and ensuring that patients received timely and appropriate care, ultimately aiming to reduce mortality rates associated with LF.

Infection Prevention and Control/Safe Burial: To prevent further transmission of the virus, the Infection Prevention and Control (IPC) team implemented strict protocols in healthcare settings and in the community. This included training healthcare workers on IPC measures, ensuring the availability and proper use of personal protective equipment (PPE), and overseeing the safe burial of deceased LF patients. The team worked closely with the Case Management team to maintain high standards of hygiene and minimize the risk of healthcare-associated infections.

Laboratory Services: The Laboratory pillar was essential for the accurate diagnosis of LF. This team facilitated the collection, transportation, and testing of samples from suspected cases. They ensured that samples were promptly sent to the National Reference Laboratory (NRL) for PCR testing and that results were communicated swiftly to inform clinical management and public health actions. The team also provided guidance on sample collection and handling to minimize the risk of contamination and false results.

Logistics: The logistics team ensured the smooth flow of supplies and resources necessary for the response. This included the procurement and distribution of PPE, medical supplies, and other essential items required by the healthcare facilities and response teams. The team also managed the logistics of transporting samples to the laboratory and coordinated the movement of personnel involved in the outbreak response.

Risk Communication: The Risk Communication team played a pivotal role in disseminating accurate and timely information to the public, healthcare workers, and other stakeholders. They developed and distributed educational materials on LF, conducted community engagement activities, and worked with the media to raise awareness about the outbreak and the measures being taken to control it. The team also addressed rumors and misinformation, ensuring that the public remained informed and engaged in preventive measures.

Surveillance: Surveillance activities were critical for tracking the spread of the outbreak and identifying new cases. The Surveillance team conducted contact tracing, monitored the health status of contacts, and ensured that suspected cases were quickly identified and tested. They also maintained a comprehensive line list of cases and contacts, which was regularly updated and used to guide public health interventions. Thus, the table 1 below summarizes the specific activities conducted by each pillar of the PHEOC during the LF outbreak response, highlighting the comprehensive and coordinated approach taken to manage and contain the outbreak.

Table 1: Specific activities conducted by each pillar of the PHEOC during the LF outbreak response

S/N	Pillar	Activities Conducted	Challenges	Remarks
1	Coordination	The incident management system was quickly activated at response level one following the confirmation of the first Lassa fever case. Official announcement and press briefing by the state government to notify the public about the outbreak. Inauguration of the state Public Health Emergency Operations Centre Lassa fever One Health Rapid Response Team by the commissioner of health. Meeting with stakeholders in the ministry of health, environment, and agriculture to discuss ways to contain the outbreak. Development of Incident Action Plan and engagement with partners for support and funding.	Lack of timely communication among stakeholders.	Effective coordination led to a swift response and mobilization of resources.
2	Case Management	Activation of the isolation centres in the two tertiary hospitals in the state (Federal Medical Centre Yenagoa and Niger Delta University Teaching Hospital Okolobiri). Dissemination of reviewed case management guidelines, sensitization of clinicians on infection prevention and control measures for suspected and confirmed cases of Lassa fever. Training of case management team at NDUTH Okolobiri. Training of health workers on Lassa fever management and psychosocial support.	Fear and anxiety reported among some healthcare workers.	Continuous support and counseling for healthcare workers were implemented to alleviate fears.
3	Infection Prevention and Control	Infection prevention and control training of healthcare workers and distribution of personal protective equipment and other IPC materials to health facilities. Conducted safe burial for the first confirmed case of Lassa fever. Monitored disinfection of ambulance and mortuary used in transporting and keeping the body of the deceased Lassa fever case.	There were not enough personal protective equipment to distribute to facilities other than the two tertiary health facilities in the state.	Family of the deceased were cooperative in ensuring strict compliance with IPC guidelines.
4	Laboratory Pillar	Training of laboratory scientists on Lassa fever sample collection,	Logistic and funding	Efforts to secure additional

S/N	Pillar	Activities Conducted	Challenges	Remarks
		packaging, and transport.	challenges caused prolonged turnaround time for laboratory tests.	funding are ongoing to improve laboratory response times.
5	Logistic Pillar	Distribution of personal protective equipment, Ribavirin (injection and tablets), body bags, thermometers, hypochlorite, hand sanitizers, and sample collection materials. Developing and updating contingency plans for outbreaks, detailing logistical strategies to ensure a rapid and effective response. Collaborating with other pillars and response teams to ensure seamless integration of logistical efforts with medical, epidemiological, and communication activities.	Shortage/lack of some commodities such as oral Ribavirin and sample collection materials.	Funds were made available to procure some materials, albeit not adequate and as promptly as required.
6	Risk Communication Pillar	Media engagement and distribution of social behavioral change materials across the state. Sensitization of market women in Kpansia and Tombia market on Lassa fever and ways to properly store food products. Radio presentation and talk show on People's FM and Rhythm FM on Lassa fever and other priority diseases. Advocacy to the Honorable Commissioner of Agriculture to discuss ways to prevent zoonotic diseases in the state. Sensitization of the community of the deceased, advocacy, and mobilization of members of the community. Airing of jingles on Lassa fever and other priority diseases on Rhythm 94.7 and Peoples FM 93.1. Raising awareness among healthcare personnel throughout the state about Lassa fever and infection prevention and control through the utilization of social media channels such as WhatsApp groups. Partnering with organizations like the Nigeria Medical Association, National Association of Nigerian Nurses and Midwives, and Medical and Health Workers Union of Nigeria to enhance	Limited reach of communication strategies in remote areas.	Increased community engagement has led to better awareness and preparedness among the public.

S/N	Pillar	Activities Conducted	Challenges	Remarks
		awareness and raise the level of caution. Engaging and educating healthcare personnel in tertiary healthcare facilities across the state about Lassa fever using focus group discussions and specialized seminars for medical professionals, focusing on conversations on Lassa fever and other viral hemorrhagic fevers.		
7	Surveillance	Conducted outbreak investigation of the confirmed case and visited a private hospital and NDUTH Okolobiri for further information about the case and to list contacts of the case for follow-up. Active case search was conducted in health facilities and communities across the eight Local Government Areas for three months. Contact tracing team was constituted and deployed to follow-up contacts and monitor symptoms. Training of Disease Surveillance Notification Officers, Water, Sanitation, and Hygiene focal persons, and Health educators on Lassa fever surveillance, reporting, risk communication, and WASH activities during outbreaks. Reactivation and orientation of Local Government Area Rapid Response Team. Training of clinicians on identification, reporting, and management of Lassa fever cases.	Lack of funds for surveillance activities at the beginning of the response.	Funds were later made available for Disease Surveillance Notification Officers and other surveillance officers to conduct active case searches across all Local Government Areas.

Figure 2 illustrates the epidemiological curve of confirmed Lassa fever (LF) cases reported from epidemiological week 1 through week 33 in 2023. The curve highlights the temporal distribution of LF cases over this period, providing insight into the progression and impact of the outbreak. The first confirmed case, which tragically resulted in death, was recorded in week 6. This initial case marked the onset of the outbreak and prompted the activation of the State Public Health Emergency Operations Centre (PHEOC) to coordinate response efforts. The second confirmed case was reported in week 14. Unlike the first case, this patient survived, reflecting the effectiveness of the case

management and treatment protocols implemented by the health authorities. Throughout the entire period from week 1 to week 33, only two confirmed LF cases were reported. The epidemiological curve underscores the sporadic nature of the outbreak within the state, with cases occurring at intervals rather than in a continuous pattern. This pattern may reflect the success of the containment measures, such as surveillance, contact tracing, and infection prevention and control, which helped limit the spread of the virus following the identification of the initial cases. The epidemiological curve not only tracks the occurrence of confirmed cases but also serves as a vital tool for public health officials to assess the outbreak's trajectory and the effectiveness of the response strategies employed during this period.

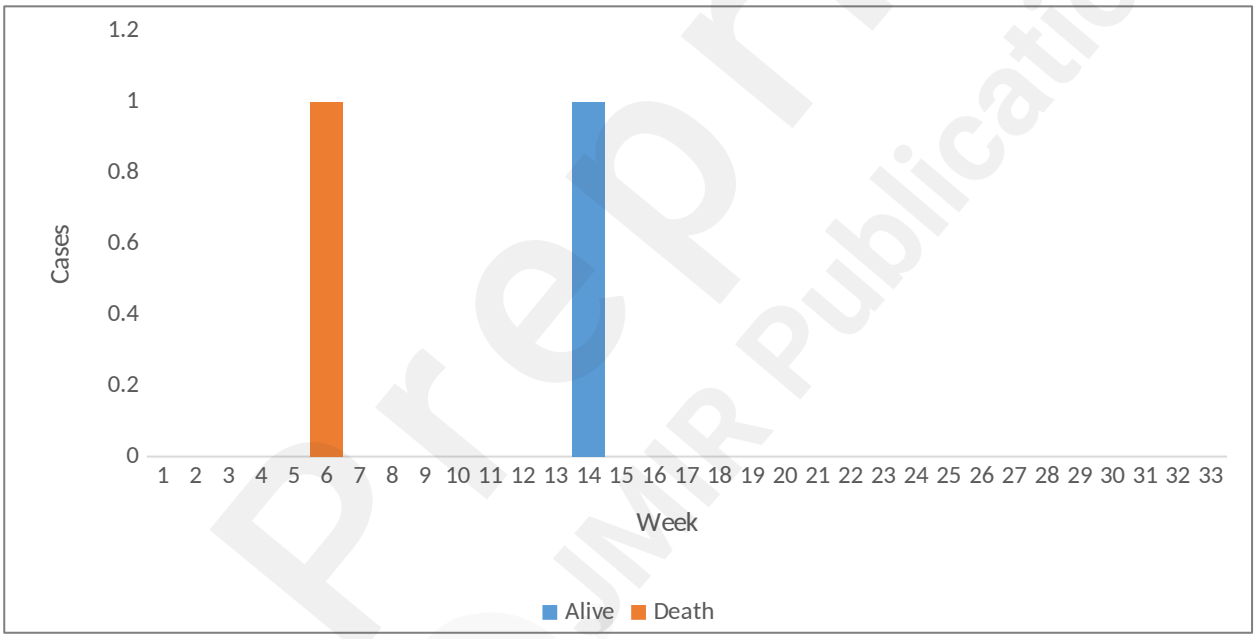

Figure 2: Epidemiological Curve of Confirmed Lassa Fever Cases from Week 1 to Week 33, 2023

The data on Lassa fever contacts in Bayelsa State reveals critical insights into the outbreak's management and the effectiveness of public health interventions. Among the 70 high-risk contacts identified, 13 individuals developed symptoms and were tested, yet none tested positive for the virus. This suggests that timely interventions and stringent infection control measures likely played a key role in preventing transmission within this group. Furthermore, the results highlight the importance of diligent monitoring and rapid response in managing high-risk contacts, ensuring that potential cases are quickly identified and contained. In contrast, the low-risk contact category presented a

more concerning outcome, with one out of seven tested individuals testing positive for Lassa fever. Despite the lower perceived risk, this case underscores the need for vigilance across all risk levels. The occurrence of a positive case within this group suggests that the current risk categorization may need reevaluation, particularly in newly affected regions where the dynamics of virus transmission might differ. This finding emphasizes the necessity of applying comprehensive testing and monitoring strategies to all contacts, regardless of their initial risk assessment. Lastly, the no-risk contact group, which had one symptomatic individual tested, yielded no positive cases. While this outcome aligns with expectations, it also serves as a reminder that even those categorized as no-risk should be closely observed, as symptoms can arise from other factors that require medical attention. The progression from high-risk to no-risk groups in the data illustrates the need for a robust and flexible public health response that adapts to varying levels of exposure. By ensuring that resources and attention are allocated to all contact levels, public health authorities can more effectively manage and mitigate the spread of Lassa fever during outbreaks.

Table 2: Frequency of symptoms, testing outcome and risk categorization of contacts of suspected LF cases in Bayelsa, Nigeria

Risk Level	Number of contacts	Number of contacts with symptoms	Number of contacts tested	Number positive
High	70	13	13	0
Low	11	1	7	1
No	14	1	1	0

High risk (HR) contacts reported were as follows; 52 in NDUTH, 14 in private hospital, 4 at Home (Family members).

The table 2 data on risk categorization across different environments i.e. Family care, NDUTH (Niger Delta University Teaching Hospital), and Home (Family) provides valuable insights into the exposure risks associated with Lassa fever in Bayelsa State. In the NDUTH setting, a significant majority of contacts, 52 out of 55 (94.5%), were categorized as high-risk. This high percentage

underscores the elevated exposure healthcare workers face in clinical environments where infection prevention and control measures are critical. In contrast, only three contacts were considered low-risk, and none were categorized as no-risk, highlighting the heightened vulnerability within healthcare settings when managing Lassa fever cases. In the Family care setting, the distribution of risk levels was more balanced, with 14 out of 29 contacts (48.3%) classified as high-risk and an equal number categorized as no-risk. This distribution suggests that while direct caregiving roles within families pose significant exposure risks, there are also situations where family members may have limited or no direct contact with infected individuals, thereby reducing their risk. The presence of both high-risk and no-risk categories within the same setting emphasizes the variability of exposure within family care contexts and the need for tailored public health messaging and interventions to protect those at highest risk. At Home (Family), the data reveals a different dynamic, with the majority of contacts (63.6%) classified as low-risk, and 36.4% as high-risk. The absence of no-risk contacts in the home environment indicates that even in less formal care settings, the potential for exposure remains, albeit at varying levels. This finding suggests that while households may have a lower overall risk compared to clinical settings, they still require targeted preventive measures to minimize transmission. The implications of these findings highlight the need for differentiated risk management strategies that address the unique challenges posed by different environments where Lassa fever exposure occurs.

Table 3: Risk categorization of contacts according to place of contact with index case

Risk categorization	**Family care**	**NDUTH**	**Home (Family)**
High	14(48.3%)	52(94.5%)	4(36.4%)
Low	1(3.4%)	3(5.5%)	7(63.6%)
No	14(48.3%)	0(0.00%)	0(0.00%)
Total	29	55	11

Figure 3 illustrates the contact tracing and risk categorization associated with the index case of Lassa fever. The figure categorizes all identified contacts into three risk levels: high, low, and no risk.

High-risk contacts are defined as those individuals who had direct exposure to the index case without the use of appropriate personal protective equipment (PPE), placing them at significant risk of contracting the virus. Low-risk contacts, on the other hand, include individuals who were in direct contact with the index case but were adequately protected by PPE, thereby reducing their risk of infection. Lastly, no-risk contacts are those who had no direct contact with the index case, either because they were not in the proximity of the patient or because they had no interaction with the patient during the infectious period. The implications of this categorization are critical for understanding the spread of Lassa fever and for implementing effective public health interventions. High-risk contacts, due to their lack of protective measures, are prioritized for immediate surveillance, testing, and potential isolation to prevent further transmission of the virus. This underscores the importance of rigorous infection prevention and control (IPC) practices, particularly the consistent and correct use of PPE in both healthcare and community settings. The distinction between high-risk and low-risk contacts also highlights the protective role of PPE, which, when used properly, can significantly mitigate the risk of transmission even in scenarios of direct exposure. Furthermore, the identification of no-risk contacts provides reassurance that not all individuals in the vicinity of a Lassa fever patient are equally at risk, which is crucial for managing public fear and focusing resources on those most in need. This stratification allows for a more efficient allocation of medical and public health resources, ensuring that those at the highest risk receive the attention and care required to prevent further spread of the disease. The data from figure 3 ultimately emphasizes the need for continuous training and reinforcement of IPC measures among healthcare workers and within communities to protect against future outbreaks.

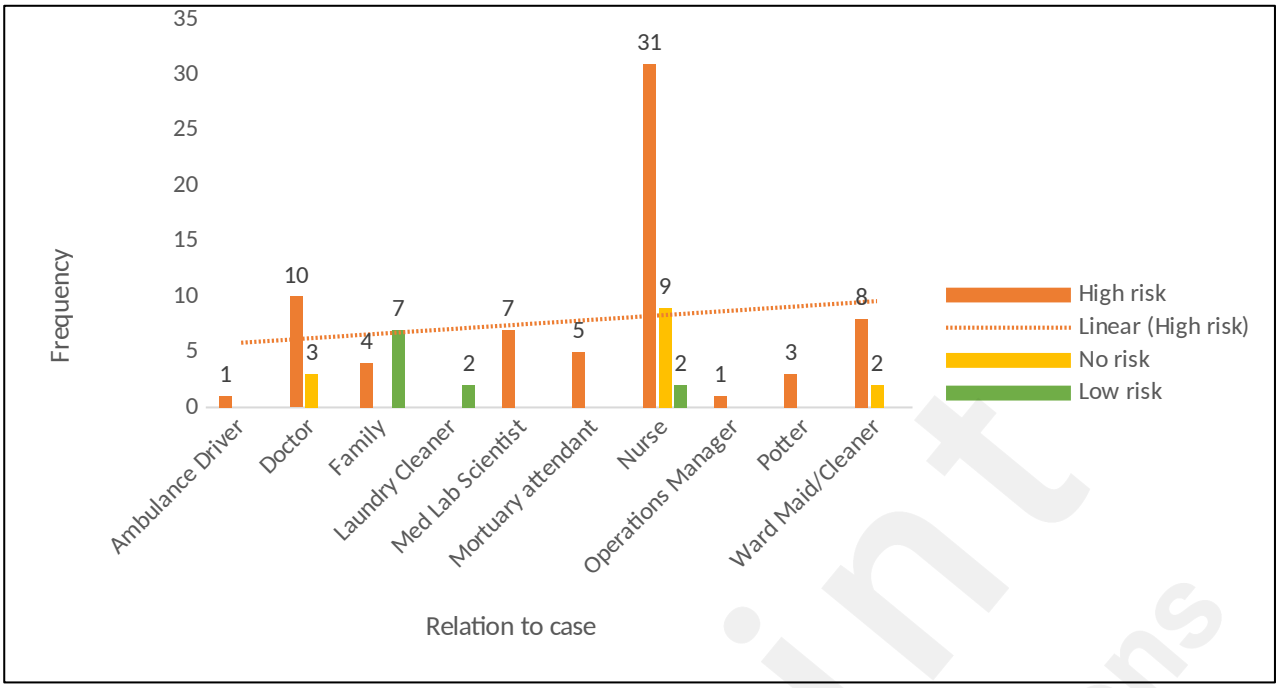

Figure 3: Risk categorization of contacts of index case in relation to the profession/status of contact.

4. Discussion

Lassa Fever Risk Categorization Findings with Existing Studies

The categorization of contacts into high, low, and no risk based on exposure to the index case and the use of PPE is a common approach in managing Lassa fever outbreaks. This method aligns with the guidelines provided by the World Health Organization (WHO) [1-8, 63], which emphasizes the importance of risk assessment in controlling the spread of the disease. In agreement with the findings by Ogoina [9], the study confirms that high-risk contacts, due to their lack of PPE, are at a significantly higher risk of infection compared to those in the low-risk category who had protective measures in place. This is consistent with WHO recommendations, which advocate for stringent use of PPE to minimize the risk of transmission, particularly in healthcare settings where exposure to Lassa fever is more likely. Moreover, the study's emphasis on high-risk contacts being the priority for surveillance and testing is also supported by the findings of Ilori et al. [10], who highlighted that timely identification and monitoring of high-risk individuals are crucial in preventing further spread of the virus. Their research demonstrated that high-risk contacts were more likely to develop

symptoms and require medical intervention, further validating the study's approach to categorization. This agreement with previous studies underscores the effectiveness of the risk-based approach in Lassa fever management, as it ensures that resources are allocated efficiently to those most in need of monitoring and treatment. However, there are some disparities in the way risk is perceived and managed. While this study found that low-risk contacts, who used PPE, had a significantly lower risk of contracting Lassa fever, Mariën *et al.* [69] suggested that even with PPE, the risk might not be entirely eliminated, particularly in cases where PPE is not used consistently or correctly. This slight disagreement highlights the need for continuous education and training for healthcare workers to ensure that PPE is used effectively. It also suggests that while PPE is crucial, other factors, such as the type of exposure and the environment, may also play a role in the overall risk of transmission, indicating that a more holistic approach to risk assessment might be necessary.

Implications of Lassa Fever Case Management in High-Risk Environments

The study's findings on the high incidence of Lassa fever among high-risk contacts who did not use PPE are in strong agreement with the literature, particularly the review by Coker *et al.* [49], which documented numerous cases of nosocomial infections among healthcare workers in Nigeria due to inadequate PPE use. This historical context reinforces the study's conclusion that the absence of PPE significantly increases the risk of Lassa fever transmission in healthcare settings. Coker *et al.*'s work further emphasized that proper training and availability of PPE are critical in preventing such infections, a recommendation that is echoed in the study's implications for policy and practice. Furthermore, the agreement between this study and the WHO's Target Product Profile for Lassa Virus Vaccine [70] highlights the importance of vaccine development as an additional layer of protection for high-risk individuals. The WHO document emphasizes that, while PPE is essential, the

development of an effective vaccine could provide long-term protection for healthcare workers and others at risk of exposure. The study's findings, which show a clear correlation between the lack of PPE and higher infection rates, support the WHO's call for accelerated vaccine research and development, particularly in regions where Lassa fever is endemic. Nevertheless, some researchers argue for a more integrated approach to Lassa fever prevention. For instance, Asogun *et al.* [71] suggested that in addition to PPE and vaccines, environmental control measures, such as rodent control, should be prioritized to reduce the overall incidence of Lassa fever. This perspective, which is somewhat broader than the study's focus on PPE, points to the need for a comprehensive public health strategy that includes not just personal protection but also environmental and community-level interventions. This difference in focus highlights the complexity of Lassa fever management and suggests that multiple strategies may need to be implemented simultaneously to achieve the best outcomes.

The Role of PPE and Environmental Controls in Reducing Lassa Fever Incidence

The study's findings underscore the critical role of PPE in protecting healthcare workers and others from Lassa fever, a conclusion that is strongly supported by the WHO's guidelines and various studies, such as those by Fisher-Hoch *et al.* [56]. Their work documented numerous cases of Lassa fever transmission due to inadequate PPE use, reinforcing the study's implication that PPE is a non-negotiable aspect of infection control in high-risk environments. This alignment with WHO and other authoritative sources further validates the study's recommendations for stringent PPE use and regular training for those at risk of exposure. In agreement with Ilori *et al.* [10], the study also highlights the importance of immediate and targeted interventions for high-risk contacts, including isolation and testing. This approach, which has been shown to be effective in controlling outbreaks, is consistent with global best practices for managing Lassa fever. The emphasis on rapid response and the

use of PPE is crucial in preventing the spread of the virus, particularly in healthcare settings where the risk of transmission is highest. This consistency across studies suggests that the principles of infection control are well-established and should continue to be a cornerstone of Lassa fever management strategies. However, the study also suggests that PPE alone may not be sufficient to fully protect against Lassa fever, particularly in environments where the virus is prevalent. This is in line with the findings of Mariën *et al.* [69], who argued that environmental controls, such as rodent management, are equally important in reducing the overall risk of transmission. Their research indicated that even in well-protected environments, the presence of rodents, which are the primary reservoir for Lassa virus, can undermine the effectiveness of PPE and other protective measures. This suggests that a more holistic approach, combining PPE with environmental controls, may be necessary to fully mitigate the risk of Lassa fever in endemic areas.

The Importance of Comprehensive Public Health Strategies in Lassa Fever Prevention

The study's findings on the risk associated with inadequate PPE use are a crucial reminder of the need for comprehensive public health strategies in managing Lassa fever. In agreement with Tambo *et al.* [54], the study emphasizes the importance of a One Health approach, which integrates human, animal, and environmental health to address the multifaceted nature of Lassa fever transmission. Tambo *et al.* highlighted the need for community surveillance, rodent control, and public education, in addition to PPE use, to effectively control Lassa fever outbreaks. This broader perspective supports the study's call for integrated interventions that go beyond individual protection to include community and environmental measures. Additionally, the study's findings resonate with the recommendations of the NCDC [3-8, 63], which advocate for the strengthening of surveillance systems and the implementation of infection control protocols across healthcare facilities in Nigeria. The NCDC's guidelines emphasize the need for regular training and the availability of PPE to protect healthcare

workers, a point that is strongly supported by the study's findings on the correlation between PPE use and infection rates. The agreement between the study and the NCDC guidelines underscores the importance of adhering to established protocols to reduce the risk of Lassa fever transmission in healthcare settings. However, as the study and other research suggest, more needs to be done to address the root causes of Lassa fever transmission. For example, Olayemi *et al.* [72] pointed out that environmental factors, such as poor sanitation and the presence of rodents, play a significant role in the spread of Lassa fever. This perspective, which aligns with the study's findings on the limitations of PPE, suggests that a more comprehensive approach, which includes improving environmental conditions and enhancing community awareness, is necessary to effectively combat Lassa fever in Nigeria. This holistic approach is critical to reducing the incidence of Lassa fever and protecting vulnerable populations.

Challenges in Implementing Lassa Fever Control Measures in Resource-Limited Settings

The study's findings highlight the challenges of implementing Lassa fever control measures, particularly in resource-limited settings where PPE and other protective measures may not be readily available. This issue is in agreement with the observations of Asogun *et al.* [71], who noted that in many parts of Nigeria, the availability of PPE is limited, and healthcare workers often lack the necessary training to use it effectively. This lack of resources, combined with the high risk of exposure, creates a significant challenge for controlling Lassa fever outbreaks in these areas. The study's findings underscore the need for increased investment in healthcare infrastructure and training to ensure that healthcare workers are adequately protected. Furthermore, the study's emphasis on the need for immediate intervention for high-risk contacts aligns with the recommendations of the WHO (2023), which stress the importance of early detection and isolation in preventing the spread of Lassa fever. However,

as the study suggests, these measures are often difficult to implement in resource-limited settings, where healthcare facilities may be understaffed and under-resourced. This challenge is further compounded by the lack of public awareness about Lassa fever, which can lead to delays in seeking treatment and a higher risk of transmission. The study's findings highlight the need for targeted interventions that address these challenges, such as community education and the provision of resources for healthcare facilities. In contrast, some studies, such as those by Mylne *et al*. [73], argue that more focus should be placed on preventive measures, such as rodent control and improving sanitation, rather than solely on PPE and early intervention. Mylne *et al.* suggest that by addressing the environmental factors that contribute to Lassa fever transmission, the overall incidence of the disease can be reduced, thereby reducing the need for costly and resource-intensive interventions. This perspective, while not in direct disagreement with the study's findings, suggests that a more balanced approach, which includes both preventive and reactive measures, may be necessary to effectively control Lassa fever in Nigeria.

Harmonizing Public Health Approaches to Lassa Fever Control

Conclusively, the study's findings on the importance of PPE in controlling Lassa fever are strongly supported by the literature, particularly in terms of protecting high-risk individuals in healthcare settings. The study's agreement with WHO guidelines and other research emphasizes the need for strict adherence to PPE protocols to minimize the risk of transmission. However, the study also highlights the limitations of relying solely on PPE and the need for a more comprehensive approach that includes environmental controls and community engagement. The study's findings align with the broader public health strategies recommended by the NCDC and other experts, which advocate for a One Health approach to Lassa fever control. This approach, which integrates human, animal, and environmental health, is critical to addressing the complex factors that contribute to the spread of Lassa

fever. By harmonizing these different approaches, it is possible to develop more effective strategies for controlling Lassa fever and protecting vulnerable populations in Nigeria and other endemic areas. However, as the study and other research suggest, significant challenges remain in implementing these strategies in resource-limited settings. The lack of PPE, inadequate training, and limited public awareness are all significant barriers to effective Lassa fever control. Addressing these challenges will require increased investment in healthcare infrastructure, training, and community education, as well as a focus on preventive measures, such as rodent control and improving sanitation. By taking a holistic approach to Lassa fever control, it is possible to reduce the incidence of the disease and protect the health and well-being of populations in Nigeria and other affected areas.

5. Conclusion

The study has illuminated the critical importance of proper risk categorization and the use of personal protective equipment (PPE) in managing Lassa fever outbreaks, particularly in healthcare settings. By categorizing contacts into high, low, and no risk based on their exposure levels and PPE usage, the study aligns with global health guidelines and validates the effectiveness of a risk-based approach to infection control. The findings reinforce that high-risk contacts, especially those without PPE, are significantly more susceptible to infection, underscoring the urgent need for stringent protective measures. However, the study also highlights that PPE alone may not be sufficient in fully mitigating the risk of transmission, suggesting that a more comprehensive approach that includes environmental controls and community engagement is necessary for effective Lassa fever management. The study also emphasizes the complex challenges faced by healthcare facilities in resource-limited settings, where the availability of PPE and adequate training is often lacking. This scarcity exacerbates the vulnerability of healthcare workers and high-risk contacts to Lassa fever, particularly in endemic regions. While the study strongly supports the use of PPE as a

frontline defense against infection, it also acknowledges the need for broader public health strategies that address environmental factors, such as rodent control, which contribute to the transmission of the virus. The study's conclusions call for an integrated approach to Lassa fever control, combining PPE use with environmental and community-level interventions. Summarily, the study provides valuable insights into the dynamics of Lassa fever transmission and the critical role of PPE in protecting high-risk individuals. However, it also highlights the limitations of relying solely on PPE and the importance of adopting a holistic approach to disease management. The findings advocate for the implementation of comprehensive public health strategies that integrate personal protection with environmental controls and community engagement, thereby enhancing the overall effectiveness of Lassa fever prevention and control efforts in Nigeria and other affected regions.

6. Recommendation

Based on the study's findings, several key recommendations emerge for improving Lassa fever prevention and control in Nigeria and other endemic areas. First, there is a critical need to ensure the availability and proper use of PPE in healthcare settings, particularly for high-risk contacts. This includes regular training for healthcare workers on the correct use of PPE, as well as the establishment of protocols to ensure that PPE is consistently available and accessible. Healthcare facilities should prioritize the protection of their staff and patients by implementing strict infection control measures and ensuring that PPE is used correctly and consistently. Second, the study recommends the adoption of a comprehensive public health strategy that goes beyond PPE use. This strategy should include environmental controls, such as rodent management, to reduce the overall risk of Lassa fever transmission. Public health authorities should work to improve sanitation in communities, implement effective rodent control programs, and increase public awareness about the importance of environmental hygiene in preventing the spread of Lassa fever. These measures, when combined with the

use of PPE, can significantly reduce the incidence of Lassa fever and protect vulnerable populations. Finally, the study suggests that investment in healthcare infrastructure and resources is crucial for the effective management of Lassa fever. This includes not only the provision of PPE and training but also the strengthening of surveillance systems, early detection and isolation protocols, and the development of community-based interventions. By investing in these areas, public health authorities can enhance the capacity of healthcare facilities to respond to Lassa fever outbreaks and improve overall outcomes for affected populations. The study's recommendations highlight the need for a coordinated and well-resourced approach to Lassa fever control that addresses both individual and environmental risk factors.

7. Study Limitations

While the study provides important insights into Lassa fever transmission and control, it is not without limitations. One of the primary limitations is the reliance on self-reported data from healthcare workers and contacts, which may be subject to recall bias or inaccuracies in reporting. This could potentially affect the accuracy of the risk categorization and the assessment of PPE usage, leading to either an overestimation or underestimation of the true risk of Lassa fever transmission among different contact groups. Additionally, the study's focus on healthcare settings may limit the generalizability of the findings to other environments where Lassa fever transmission occurs, such as community settings or rural areas. Another limitation is the potential for confounding variables that were not fully accounted for in the study. For instance, factors such as the type of exposure, duration of contact with the index case, and the condition of the healthcare environment (e.g., ventilation, cleanliness) could influence the risk of Lassa fever transmission but were not comprehensively analyzed. These unmeasured variables may have introduced bias into the study's findings, potentially affecting the conclusions drawn about the effectiveness of PPE

and the categorization of contact risk. Further research is needed to explore these factors and their impact on Lassa fever transmission more fully. Finally, the study's scope was limited by the resources available for conducting a thorough and extensive investigation across multiple regions. The study was conducted in specific healthcare facilities in Nigeria, which may not fully represent the diversity of healthcare settings and practices across the country or other Lassa fever-endemic regions. Additionally, the study's cross-sectional design limits the ability to draw causal inferences about the relationship between PPE use, risk categorization, and Lassa fever transmission. Longitudinal studies that follow contacts over time would provide a more robust understanding of these relationships and help to validate the study's findings.

8. Significance Statement

The significance of this study lies in its contribution to the understanding and management of Lassa fever, particularly in healthcare settings where the risk of transmission is high. By emphasizing the critical role of PPE in protecting high-risk contacts, the study reinforces the importance of stringent infection control measures and provides evidence-based recommendations for improving the safety of healthcare workers and patients. The study's findings align with global health guidelines and offer practical insights that can inform policy and practice in regions affected by Lassa fever, thereby enhancing the overall effectiveness of disease control efforts. Moreover, the study's exploration of the limitations of PPE use and the need for comprehensive public health strategies underscores the complexity of managing Lassa fever in resource-limited settings. The study highlights the importance of integrating environmental controls, such as rodent management, with personal protection measures to address the multifaceted nature of Lassa fever transmission. This holistic approach, advocated by the study, has the potential to significantly reduce the incidence of Lassa fever and improve public health outcomes in Nigeria and other endemic regions. Finally, the study's significance extends to its implications for future research and public health interventions.

The study identifies key areas where further investigation is needed, such as the role of environmental factors in Lassa fever transmission and the effectiveness of community-based interventions. By addressing these gaps in knowledge, the study provides a foundation for developing more effective and sustainable strategies for Lassa fever prevention and control, ultimately contributing to the global effort to reduce the burden of this deadly disease.

List of Abbreviations

WHO	World Health Organization
NCDC	Nigeria Centre for Disease Control
PHEOC	Public Health Emergency Operations Centre
RRT	Rapid Response Team
IPC	Infection Prevention and Control
DSNO	Disease Surveillance Notification Officer
WASH	Water, Sanitation, and Hygiene
FCT	Federal Capital Territory
COVID-19	Coronavirus Disease 2019
SBC	Social Behavioral Change
LGAs	Local Government Areas
VHF	Viral Hemorrhagic Fever
PPE	Personal Protective Equipment
LGA	Local Government Area
HFs	Healthcare Facilities
NPC	National Pharmacovigilance Centre
ZPC	Zonal Pharmacovigilance Centres
PV	Pharmacovigilance
ACSM	Advocacy, Communication, and Social Mobilization
AWD	Acute Watery Diarrhea
EPI	Expanded Programme on Immunization
GAVI	Global Alliance for Vaccines and Immunization

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Authors Contribution:

All authors contributed equally to conceptualization, validation, writing review and editing.

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References

1. World Health Organization. (2017). *Target Product Profile for Lassa virus Vaccine*. Retrieved from http://www.who.int/blueprint/prioritydiseases/keyaction/Lassa Virus Vaccine2018.pdf
2. World Health Organization. (2022). *Lassa Fever*. Retrieved February 15, 2022, from https://www.who.int/health-topics/lassa-fever#tab=tab_1
3. Nigeria Centre for Disease Control (NCDC). (2023). *Lassa fever situation report. Epi week 52: 26 December 2022 – 1 January 2023*. Retrieved from https://www.ncdc.gov.ng/#
4. Nigeria Centre for Disease Control (NCDC). (2016). *Viral haemorrhagic fevers preparedness and response plan*. Reviewed June 2017. Retrieved from https://www.ncdc.gov.ng
5. Nigeria Centre for Disease Control (NCDC). (2019). *Lassa fever*. First published: April 9, 2019. Last updated: April 9, 2019. Retrieved from https://www.ncdc.gov.ng/diseases/factsheet/47
6. Nigeria Centre for Disease Control (NCDC). (2021). *Public Health advisory*. December 11, 2021. Abuja. Retrieved from https://www.ncdc.gov.ng/
7. Nigeria Centre for Disease Control (NCDC). (2018). *National guideline for Lassa fever case management*. November 2018. Retrieved from https://www.ncdc.gov.ng/
8. Nigeria Centre for Disease Control (NCDC). (2017). *Viral Haemorrhagic Fevers preparedness and response plan*. Abuja.
9. Ogoina, D. (2013). *Lassa fever: A Clinical and Epidemiological Review*. Niger Delta Journal of Medicine and Medical Research, 1(1), 1-10.
10. Ilori, E. A., Furuse, Y., Ipadeola, O. B., Dan-Nwafor, C. C., Abubakar, A., Womi-Eteng, O. E., et al. (2019). Epidemiologic and clinical features of Lassa fever outbreak in Nigeria, January 1-May 6, 2018. *Emerging Infectious Diseases*, 25, 1066-1074. doi:10.3201/eid2506.181035
11. Ireye, F. O. (2021). *Demographic and Socioeconomic Determinants of Lassa Fever in Edo State, Nigeria*. Walden Dissertations and Doctoral Studies. 11083. Retrieved from https://scholarworks.waldenu.edu/dissertations/11083.
12. Nwankwo, C., Okwor, T. J., Igbokwe, I. O., Adetunji, A. O. (2023). Evaluation of the

response to the Lassa fever outbreak in Nigeria: A qualitative study. *BMC Health Services Research*, 23, 456.

13. Okechukwu CO, Ainu M, Adias TC, Elemuwa CO, Rotifa SU, Ogbointuwei C, Raimi MO, Oweibia M, Alabo AF, Okoyen E, Appah WW (2024) Evaluating the Impact of Rotavirus Vaccination on Childhood Diarrhea Incidence in Bayelsa State, Nigeria: Achievements, Challenges, and Future Directions. JMIR Preprints. 27/07/2024:64822. DOI: 10.2196/preprints.64822. URL: https://preprints.jmir.org/preprint/64822.
14. Raimi MO, Omidiji AO, Abdulraheem AF, Ochayi EO (2018) A Survey of Hand Washing Behaviour and Awareness among Health Care Workers in Health Care Facilities in Kubwa District of Bwari Area Council, F.C.T. Abuja, Nigeria. *Annals of Ecology and Environmental Science Volume 2, Issue 2, 2018, PP 1-18.*
15. Raufu, Y. O., Olayinka, A. S., Raimi, M. O., Olawale, S. H., & Olabisi, O. L. (2023). Assessment of occupational risks of waste scavenging in Ilorin metropolis . AfricArXiv. https://doi.org/10.21428/3b2160cd.ffbb315b.
16. Rauf, Y. O., & Raimi, M. O. (2023). Wastes, Wastes, Everywhere Not A Place to Breathe: Redressing and Undressing Ilorin and Yenagoa City. *AfricArXiv*. https://doi.org/10.21428/3b2160cd.52bfd7dd.
17. Yusuf OR, Opasola OA, Adewoye SO, Raimi OM and Balogun EM (2023) Assessment of Occupational Risks of Wastes Scavenging in Ilorin Metropolis. *J of Agri Earth & Environ mental Sciences* 2(3), 01-08.
18. Raimi MO, Omidiji AO, Odipe OE, Suleiman HO (2019) Open Defecation and Public Toilets Importance: An Economic Perspective. *Preventing Health Care in Nigeria: Everyone, Everywhere Leaving Nobody Behind.* July 29 – August 1, 2019 National Open University Auditorium, University Village, Jabi Abuja.
19. Olalekan R. M, Vivien O. T, Adedoyin O. O, *et al.* (2018). The sources of water supply, sanitation facilities and hygiene practices in oil producing communities in central senatorial district of Bayelsa state, Nigeria. *MOJ Public Health.* 2018;7(6):337–345. DOI: 10.15406/mojph.2018.07.00265
20. Raimi MO, Abdulraheem AF, Major I, Odipe OE, Isa HM, Onyeche C (2019). The Sources of Water Supply, Sanitation Facilities and Hygiene Practices in an Island Community: Amassoma, Bayelsa State, Nigeria. *Public Health Open Access* 2019, 3(1): 000134. ISSN: 2578-5001. DOI: 10.23880/phoa-16000134.
21. Oluwaseun EO., Raimi MO, Nimisingha DS, Abdulraheem AF, Okolosi-PE, Habeeb Modupe

Lateefat and Mary Fadeyibi (2019) Assessment of Environmental Sanitation, Food Safety Knowledge, Handling Practice among Food Handlers of Bukateria Complexes in Iju Town, Akure North of Ondo-State, Nigeria. *Acta Scientific Nutritional Health* 3.6 (2019): 186-200. DOI: 10.31080/ASNH.2019.03.0308

22. Raimi, OM., Sunday, OA., Mcfubara, KG., Adias, TC., Raimi, GA., Daniel, AA., Izah, SC., Okoyen, E., Ogbointuwei, C., Clement, A., Godspower, A., & Funmilayo, AA. (2022). Perspective Chapter: Applying Innovative Research as a Tool to Advance Immunization Coverage in Bayelsa State, Nigeria. In M. O. Raimi, O. A. Sunday, H. O. Sawyerr, & T. C. Adias (Eds.), Emerging Issues in Environmental Epidemiology and Its Reflection [Working Title]. IntechOpen. https://doi.org/10.5772/intechopen.106513.
23. Raimi, MO., Sawyerr, HO., Ezekwe, IC., & Gabriel, S. (2022). Toxicants in Water: Hydrochemical Appraisal of Toxic Metals Concentration and Seasonal Variation in Drinking Water Quality in Oil and Gas Field Area of Rivers State, Nigeria. In P. H. Saleh, & P. A. I. Hassan (Eds.), Heavy Metals - New Insights [Working Title]. IntechOpen. https://doi.org/10.5772/intechopen.102656. ISBN 978-1-80355-526-3.
24. Morufu OR, Aziba-anyam GR and Teddy CA (2021) 'Silent Pandemic': Evidence-Based Environmental and Public Health Practices to Respond to the Covid-19 Crisis. *IntechOpen.* DOI: http://dx.doi.org/10.5772/intechopen.100204. ISBN 978-1-83969-144-7. https://www.intechopen.com/online-first/silent-pandemic-evidence-based-environmental-and-public-health-practices-to-respond-to-the-covid-19-Published: December 1st 2021; ISBN: 978-1-83969-144-7; Print ISBN: 978-1-83969-143-0; eBook (PDF) ISBN: 978-1-83969-145-4. Copyright year: 2021
25. Joshua MT, Austin-Asomeji I, Izah SC, Raimi MO (2024) Environmental Factors Exacerbating Hepatitis Transmission: A Mini Review. J. Pharmacol Clin Toxicol 12(1):1181.https://www.jscimedcentral.com/jounal-article-info/Journal-of-Pharmacology-and-Clinical-Toxicology/Environmental-Factors--Exacerbating-Hepatitis--Transmission%3A-A-Mini-Review-11615. DOI**: https://doi.org/10.47739/2333-7079/1181**
26. Mariën, J., Borremans, B., Kourouma, F., Baforday, J., Rieger, T., Günther, S., Magassouba, N., Leirs, H., Fichet-Calvet, E (2019).: Evaluation of rodent control to fght Lassa fever based on feld data and mathematical modelling. Emerg. Microbes Infections 8(1), 640–649.
27. Olugasa, B. O., Odigie, E. A., Lawani, M., Ojo, J. F. (2015). Development of a time-trend model for analyzing and predicting case-pattern of Lassa fever epidemics in Liberia, 2013–2017. *Annals of African Medicine*, 14(2), 89.

28. Okwor, T. J., Igbokwe, I. O., Ojo, J. F., Okwor, A. C. (2022). Lassa fever: A public health challenge in Nigeria. *Nigerian Journal of Clinical Practice*, 25(5), 45-50.
29. Adebimpe, W. O., Okwor, T. J., Ojo, J. F., Igbokwe, I. O. (2023). The role of health education in controlling Lassa fever in Nigeria. *Journal of Health Education Research & Development*, 41(1), 1-8.
30. Eze, U. C., Igbokwe, I. O., Okwor, T. J., Adebimpe, W. O. (2023). Socioeconomic factors influencing the spread of Lassa fever in Nigeria. *Journal of Public Health Policy*, 44(2), 234-245.
31. Igbokwe, I. O., Okwor, T. J., Eze, U. C., Adebimpe, W. O. (2022). Risk factors for Lassa fever transmission in Nigeria: A case-control study. *International Journal of Environmental Research and Public Health*, 19(3), 1234.
32. Adetunji, A. O., Okwor, T. J., Igbokwe, I. O., Eze, U. C. (2022). The role of the Nigeria Centre for Disease Control in managing Lassa fever outbreaks. *Health Policy and Planning*, 37(7), 879-887.
33. Raufu YO, Olayinka AS, Olawale SH, Raimi MO (2022). Incidence of hepatitis B and C viruses among the scavengers in Kwara State, Nigeria. Microbes Infect Dis 2022; Article-In-Press, DOI: 10.21608/mid.2022.118313.1241.
34. Raimi, Morufu Olalekan, Lucky, Emmanuel Chukwuma, Okoyen, Ekoja, Clement, A., Ogbointuwei, Chukwudi (2021). Making Better Informed, More Confident COVID-19 Decisions: Vaccine Hesitancy, Its Barriers and Impact Studies: Taking Bayelsa State as an Example. *International Journal of Vaccine and Immunization*, 5(1). doi:10.16966/2470-9948.126. Retrieved from https://sciforschenonline.org/journals/vaccines/IJVI126.php.
35. Afolabi AS, Raimi MO (2021) When Water Turns Deadly: Investigating Source Identification and Quality of Drinking Water in Piwoyi Community of Federal Capital Territory, Abuja Nigeria. *Online Journal of Chemistry*, 2021, 1, 38-58; DOI: 10.31586/ojc.2021.010105. www.scipublications.org/journal/index.php/ojc.
36. Raimi, MO., Mcfubara, KG., Abisoye, OS., Ifeanyichukwu EC., Henry SO., & Raimi, GA (2021) Responding to the call through Translating Science into Impact: Building an Evidence-Based Approaches to Effectively Curb Public Health Emergencies [COVID-19 Crisis]. *Global Journal of Epidemiology and Infectious Disease*, 1(1). DOI: 10.31586/gjeid.2021.010102. Retrieved from https://www.scipublications.com/journal/index.php/gjeid/article/view/72.
37. Morufu OR, Ebikapaye O, Tuebi M, Aziba-anyam GR, Adedoyin OO, Aishat FA, Mariam

OR, Beatrice OJ (2021) Do Weak Institutions Prolong Crises? [#ENDSARs] in the Light of the Challenges and opportunities beyond COVID-19 Pandemic and the Next Normal in Nigeria. *Communication, Society and Media.* ISSN 2576-5388 (Print) ISSN 2576-5396 (Online) Vol. 4, No. 2, DOI: https://doi.org/10.22158/csm.v4n2p1. http://www.scholink.org/ojs/index.php/csm/article/view/3790.

38. Raimi MO & Raimi AG (2020). The Toughest Triage in Decision Impacts: Rethinking Scientific Evidence for Environmental and Human Health Action in the Times of Concomitant Global Crises. *CPQ Medicine,* 11(1), 01-05.
39. Raimi MO, Ihuoma BA, Esther OU, Abdulraheem AF, Opufou T, Deinkuro NS, Adebayo PA and Adeniji AO (2020) "Health Impact Assessment: Expanding Public Policy Tools for Promoting Sustainable Development Goals (SDGs) in Nigeria". *EC Emergency Medicine and Critical Care* 4.9 (2020).
40. Samson T. K, Ogunlaran O. M, Raimi O. M (2020); A Predictive Model for Confirmed Cases of COVID-19 in Nigeria. *European Journal of Applied Sciences*, Volume 8, No 4, Aug 2020;pp:1-10. DOI: 10.14738/aivp.84.8705. DOI: https://doi.org/10.14738/aivp.84.8705.
41. Gift RA, Olalekan RM, Owobi OE, Oluwakemi RM, Anu B, Funmilayo AA (2020). Nigerians crying for availability of electricity and water: a key driver to life coping measures for deepening stay at home inclusion to slow covid-19 spread. *Open Access Journal of Science*. 2020;4(3):69–80. DOI: 10.15406/oajs.2020.04.00155.
42. Olalekan RM, Oluwatoyin OA, Olawale SH, Emmanuel OO, Olalekan AZ (2020) A Critical Review of Health Impact Assessment: Towards Strengthening the Knowledge of Decision Makers Understand Sustainable Development Goals in the Twenty-First Century: Necessity Today; Essentiality Tomorrow. *Research and Advances: Environmental Sciences*. 2020(1): 72-84. DOI: 10.33513/RAES/2001-13. https://ospopac.com/journal/environmental-sciences/early-online.
43. Gift R A, Olalekan RM (2020). Access to electricity and water in Nigeria: a panacea to slow the spread of Covid-19. *Open Access J Sci.* 2020;4(2):34. DOI: 10.15406/oajs.2020.04.00148. https://medcrave.com/index.php?/articles/det/21409/
44. Olalekan R. M, Oluwatoyin O and Olalekan A (2020) Health Impact Assessment: A tool to Advance the Knowledge of Policy Makers Understand Sustainable Development Goals: A Review. *ES Journal of Public Health*; 1(1); 1002. https://escientificlibrary.com/public-health/in-press.php.
45. Suleiman RM, Raimi MO and Sawyerr HO (2019) A Deep Dive into the Review of National

Environmental Standards and Regulations Enforcement Agency (NESREA) Act. *International Research Journal of Applied Sciences.* pISSN: 2663-5577, eISSN: 2663-5585. DOI No. Irjas.2019.123.123. www.scirange.com. https://scirange.com/abstract/irjas.2019.108.125.

46. Raimi MO, Omidiji AO, Adeolu TA, Odipe OE and Babatunde A (2019) An Analysis of Bayelsa State Water Challenges on the Rise and Its Possible Solutions. *Acta Scientific Agriculture* 3.8 (2019): 110-125. DOI: 10.31080/ASAG.2019.03.0572.
47. Olalekan RM, Adedoyin OO, Ayibatonbira A, *et al* (2019). “Digging deeper” evidence on water crisis and its solution in Nigeria for Bayelsa state: a study of current scenario. *International Journal of Hydrology.* 2019;3(4):244–257. DOI: 10.15406/ijh.2019.03.00187.
48. Raimi MO, Omidiji AO, Ebikapaye O, Moses T, Adeolu TA, Makanjuola Bosede C (2019), Situational Analysis of National Immunization Programme in Nigeria, *Journal of Immunology and Inflammation Diseases Therapy.* Doi: http://dx.doi.org/10.31579/2637-8876.2019/008.
49. Coker AO, Isokpehi RD, Homas BN, Fagbenro-Beyioku AF, Omilabu SA (2000) Zoonotic infections in Nigeria: Overview from a medical perspective. Acta Trop 76: 59-63
50. Ojo, A. O., Okwor, T. J., Igbokwe, I. O., Adetunji, A. O. (2023). Community perceptions of Lassa fever in Nigeria: Implications for public health response. *Journal of Community Health*, 48(1), 123-130.
51. Okonko, I. O., Okwor, T. J., Igbokwe, I. O., Abubakar, I. R. (2022). Lassa fever: Epidemiology, clinical features, and public health implications. *Journal of Infectious Diseases and Epidemiology*, 8(2), 45-54.
52. Abubakar, I. R., Okwor, T. J., Igbokwe, I. O., Adetunji, A. O. (2022). Lassa fever: A neglected tropical disease in Nigeria. *Tropical Medicine and Health*, 50(1), 1-9.
53. Fadeyi, A., Okwor, T. J., Igbokwe, I. O., Adetunji, A. O. (2023). The impact of Lassa fever on healthcare workers in Nigeria. *Journal of Occupational Health*, 65(1), e12345.
54. Tambo E, Adetunde OT and Olalubi OA (2018). Re-emerging Lassa fever outbreaks in Nigeria: re-enforcing ‘One Health’ community surveillance and emergency practice. Infect Dis Poverty; 7: 37.
55. Okokhere, P. O., Ibekwe, T. S., Akpede, G. O. (2009). Sensorineural hearing loss in Lassa fever: two case reports. *Journal of Medical Case Reports*, 3, 13.
56. Fisher-Hoch, S. P., Tomori, O., Nasidi, A., Perez-Oronoz, G. I., Fakile, Y., Hutwagner, L. (1995). Review of cases of nosocomial Lassa fever in Nigeria: the high price of poor medical

practice. *BMJ*, 311, 857–859. doi:10.1136/bmj.311.7009.857.

57. Raimi MO, Abdulraheem AF, Major I, Ebikapaye O, Bilewu OO (2019). Public Health Impact of Substance Use on Adolescent: A Snapshot of Yenagoa in Bayelsa State, Nigeria. *American Journal of Biomedical Science & Research. 2019 - 4(3). AJBSR.MS.ID.000796. DOI: 10.34297/AJBSR.2019.04.000796.* https://biomedgrid.com/current-issue.php.
58. Funmilayo AA, Robert OT, Olalekan RM, Okoyen E, Tuebi M (2019). A study of the context of adolescent substance use and patterns of use in yenagoa local government, Bayelsa State, Nigeria. *MOJ Addiction Medicine and Therapy.* 2019;6(1):25–32. DOI: 10.15406/mojamt.2019.06.00142.s
59. Abdulraheem A. FO, Olalekan R. M, Abasiekong E. M (2018) Mother and father adolescent relationships and substance use in the Niger delta: a case study of twenty-five (25) communities in Yenagoa local government of Bayelsa state, Nigeria. *Sociol Int J.* 2018;2(6):541–548. DOI: 10.15406/sij.2018.02.00097
60. Gift R.A, Obindah F (2020). Examining the influence of motivation on organizational productivity in Bayelsa state private hospitals. Open *Access Journal of Science.* 2020;4(3):94–108. DOI: 10.15406/oajs.2020.04.00157.
61. Adeyemo, T. A., Onakoya, P. A., Owoeye, J. F., & Ogun, O. C. (2021). Knowledge and attitudes towards Lassa fever among healthcare workers in Ogun State, Nigeria. *Journal of Infection and Public Health*, *14*(3), 403-409. doi:10.1016/j.jiph.2020.11.007
62. Creswell, J. W., Plano Clark, V. L. (2018). *Designing and Conducting Mixed Methods Research* (3rd ed.). Sage Publications.
63. Nigeria Centre for Disease Control (NCDC). (2021). *National Guidelines for the Management of Lassa Fever in Nigeria*. Nigeria Centre for Disease Control.
64. Ajayi, N. A., Ukwaja, K. N., Ifebunandu, N. A., Nnabu, R., Onwe, F., & Ezike, N. (2020). Lassa fever in Ebonyi State, Nigeria: A 3-year retrospective review of confirmed cases. *African Journal of Infectious Diseases*, *14*(1), 18-22. doi:10.21010/ajid.v14i1.3
65. Smith, J., & Noble, H. (2014). Bias in research. *Evidence-Based Nursing*, *17*(4), 100-101. doi:10.1136/eb-2014-101946
66. Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research*, 42(5), 533-544.
67. Creswell, J. W., Poth, C. N. (2018). *Qualitative Inquiry and Research Design: Choosing*

Among Five Approaches (4th ed.). Sage Publications.

68. World Medical Association. (2013). *WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects*. Retrieved from https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/
69. Mariën, J., Borremans, B., Kourouma, F., Baforday, J., Rieger, T., Günther, S., Magassouba, N., Leirs, H., Fichet-Calvet, E. (2019). Evaluation of rodent control to fight Lassa fever based on field data and mathematical modelling. *Emerging Microbes & Infections*, 8(1), 640–649.
70. World Health Organization. (2017). *Target Product Profile for Lassa Virus Vaccine*. Retrieved from http://www.who.int/blueprint/prioritydiseases/keyaction/LassaVirusVaccine2018.pdf
71. Asogun D.A, Günther S, Akpede G. O, Ihekweazu C, Zumla A, Lassa Fever: Epidemiology, Clinical Features, Diagnosis, Management and Prevention Vol. 33, Infectious Disease Clinics of North America, W.B. Saunders, 2019, pp. 933–951.
72. Olayemi, A., Okwor, T. J., Igbokwe, I. O., Adetunji, A. O. (2022). Epidemiological trends of Lassa fever in Nigeria, 2018–2021. *PLOS ONE*, 17(12), e0278528.
73. Mylne, A. Q. N., Pigott, D. M., Longbottom, J., Shearer, F., Duda, K. A., Messina, J. P., & Golding, N. (2015). Mapping the zoonotic niche of Lassa fever in Africa. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 109, 483–492.

Appendix 1

Panel 1: NDUTH Isolation Centre (Top), IPC/Safe Burial Team at the Mortuary (R) and Cemetery (L) to Bury the First Lassa Fever Case.