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Detection of Immunoglobulin G and/or IgM antibodies specific for Lassa virus among HIV patients in the Northwestern region of Cameroon

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Abstract

Background Persons with HIV are prone to other infections. Lassa virus (LASV)coinfection with HIV is a public health concern. Viral hemorrhagic fever caused by LASV has been endemic in parts of West Africa. Clinical diagnosis has been a major challenge for effective management and control because the majority of patients are asymptomatic. As such, rapid diagnosis is desirable for prompt therapeutic intervention and the implementation of control measures. The high prevalence of LASV recorded in Nigeria, a neighboring country, places Cameroon at risk. However, the detection of LASV infection among HIV patients, which we investigated in this study, has not been carried out in Cameroon.

Methods Plasma samples were obtained between December 2021 and April 2022 from 330 HIV-positive patients who provided consent. They were tested for LASV IgG and/or IgM antibodies specific for LASV nucleoprotein and/or prefusion envelope glycoproteins via the ReLASV® Pan-Lassa Combo NP/Prefusion GP IgG/IgM ELISA Test Kit according to the manufacturer's instructions. The data were analysed via SPSS and GraphPad.

Results Analysis of these samples revealed that IgG and both IgG and IgM antibodies were detected in 2.4% (8/330) and 1.8% (6/330) of the samples, respectively. Our data revealed that both IgG and IgM antibodies do not depend ($p > 0.05$) on age, sex, or duration of antiretroviral therapy (ART), although the prevalence was high in individuals < 25 years of age, males, and those who had taken ART for < 5 years. The mean ODs of both IgG (0.6 0vs 0.03) and IgM (0.88 vs. 0.04) were significantly greater ($p < 0.05$) between LAVS-positive and LAVS-negative patients.

Conclusions The finding of this study shows co-infection of HIV and Lassa Virus. The presence of LASV-specific antibodies suggests exposure to LASV. These findings have direct implications for understanding the transmission risk,

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mitigation, and prevention and control of LASVs in Cameroon. Our results indicate the urgent need to extend LASV surveillance if there is recurrent LASV infection in any country.

Keywords Lassa virus, IgG, IgM, HIV, Cameroon

Introduction

Lassa fever caused by Lassa virus (LASV) is a deadly hemorrhagic fever that was neglected in recent decades following its discovery and characterization [1–3]. It is endemic in many parts of West Africa, predominantly in Ghana, Benin, Côte d'Ivoire, Mali, Sierra Leone, Guinea, Liberia, and Nigeria [2–5]. The disease is transmitted to humans by the primary reservoir host of the multimammate rodent called *Mastomys nataliensis*, which lives in association with humans in the greater part of Sub-Saharan Africa, including Cameroon [2, 5, 6]. Other primary reservoir hosts include *Mastomys erythroleucus*, *Hylomyscus pamfi*, *Rattus rattus*, and *Mus musculus* [5]. As such, most human infections with LASV result from rodent-to-human transmission, as well as human-to-human infection [4, 7]. There are an estimated 300,000–500,000 cases of Lassa fever each year [1, 5, 8, 9], with a case fatality rate of 15-33% for hospitalized patients and as high as 50% during an epidemic [4–6, 9, 10]. However, accurate estimates of the number of Lassa fever cases and deaths are not possible because of the limited availability of epidemiological data since most people infected with LASV have mild symptoms or are asymptomatic [4].

The application of strict quarantine strategies in endemic and nonendemic areas and the rapid diagnosis of the Lassa virus are needed for effective therapeutic intervention and prevention. However, current knowledge of Lassa cases is hindered by clinical diagnoses since the majority of infected patients are asymptomatic or present with flu-like and gastrointestinal symptoms such as fever, headache, malaise, abdominal pain, vomiting, body pains, and diarrhea, which are common to other febrile illnesses, such as malaria, typhoid fever, leptospirosis, and arbovirus diseases, which are common in West African hospitals [2, 7]. Thus, it is necessary to carry out a laboratory diagnosis of the disease. Laboratory diagnosis of LASV is a challenge due to the absence of proper infrastructure and equipment [2, 6, 7].

The definitive diagnosis of a Lassa virus infection to date depends on virus isolation or serological and molecular techniques [11]. Examples of molecular techniques include Reverse Transcription -Polymerase Chain Reaction (RT−PCR), and quantitative PCR. Nevertheless, the lack of infrastructure, equipment and funds in some developing countries in Africa makes it almost impossible to use [2, 11]. Considering that most Lassa-infected patients develop specific immunoglobulin M (IgM) and G (IgG) antibodies during the first days of illness, diagnostic immunoassays such as enzyme-linked immunosorbent assays (ELISAs), immunofluorescence assays (IFAs), and rapid diagnostic tests have been developed for the detection of antigens and antibodies with high sensitivity (> 88%) and specificity (90%) [2, 4, 11]. As such, laboratory diagnosis in West Africa relies on the detection of LASV antigen (Ag) via immunoassays. The porosity of the borders of Nigeria–Cameroon [12]and increased movement across countries in West Africa put Cameroon at risk of this important zoonotic pathogen. The possible migration of animals borderlessly remains a big risk factor in disease transmission. Interestingly, there have been no reports of Lassa fever diseases in Cameroon.

Recently, an outbreak of Lassa fever in Ghana, another country in West Africa [13], was a clear indication of a possible Lassa outbreak. As such, with the possibility of recurrent Lassa infection, there is a need for a robust surveillance system to quickly detect and respond to cases and a need to expand clinical research capacity since early identification of infected individuals is important for the prompt implementation of appropriate preventive barriers.

There is a dearth of data on the prevalence of Lassa virus disease in Africa, with no reports of LASV cases in Cameroon as a whole. Thus, it is important to evaluate the exposure of this virus among the immunocompromised population for proper clinical management and surveillance for adequate management during disease epidemiology.

Cameroon is one of the countries with a high prevalence of human immunodeficiency virus (HIV) in the West and Central African Sub Region [14]. The prevalence of HIV in this country stands at 2.9% [15]. HIV decreases the white blood cells of the human body, thereby weakening the immune system and making them susceptible to opportunistic infections [16]. Since the onset of HIV morbidity and mortality rates among people living with HIV have been increasing [17]. While cases of LASV continue to spread in West Africa, the effort to control the spread, especially in immunocompromised patients like HIV patients is vital for healthcare management. Cases of Lassa fever co-infection with HIV have been reported in Nigeria [17, 18]. However, reported cases of coinfection of Lassa virus and HIV are lacking in Bamenda which trans-boarded Nigeria with an outbreak of LASV [6]. Considering that HIV suppresses cellular immunity and elevates inflammatory conditions that can lead to aggravated symptoms in persons with co-infections it is necessary to investigate the prevalence of LASV among HIV patients [19]. Thus, it is important

to evaluate the exposure of this virus among the immunocompromised population for proper clinical management and surveillance for adequate management during disease epidemiology.

This study therefore sought to evaluate the seroprevalence of Lassa virus antibodies among HIV patients in the northwestern region of Cameroon. The data obtained from this study address the knowledge gap with a renewed commitment to prevent and control Lassa fever.

Methodology

Study design

This hospital-based cross-sectional study was conducted from December 1st, 2021, to April 30th, 2022, at the Day Hospital of Bamenda Regional Hospital. This hospital serves as a referral hospital to all HIV clinics. Serum samples were obtained from 330 HIV-consenting patients and tested for LASV antibodies via an Enzyme-Linked Immunosorbent Assay (ELISA).

Sample population

HIV-positive persons of all ages, genders, and occupations who provided written consent were included in this study. A total of 330 HIV patients were enrolled in the study. The biodata were collected via a closed-ended questionnaire. The required minimum sample size of 208 was computed via Cochran's sample size formula for categorical data for an alpha level (d) of 0.05 (error of 5%) = $N=(t)^{2*}(p)(q)/(d)^2$, where N is the sample size, t is the value for the selected alpha level (1.96) for a 95% confidence level, p is the estimated proportion (16.07%; prevalence rate of Lassa virus in Nigeria [20]), and q is 1-p. The study participants were selected via random sampling based on first-come first-serve individuals during the study period.

Ethics statement

All methods were carried out following relevant guidelines and regulations, including the Declaration of Helsinki. The study protocol was approved by the Research and Ethical Review Committee/Institutional Review Board of the University of Bamenda (2020/0244H/UBa/IRB), and written informed consent was obtained from the participants or parents/guardians of the children involved in the study.

Sample collection

Venous blood samples were collected in EDTA tubes, and plasma was obtained by centrifuging the blood samples at 3000 rpm for 5 min. The obtained plasma was aliquoted and stored at − 80 °C until it was transported on dry ice inside a styrofoam shipping box to the laboratory of the African Centre of Excellence for Genomics of Infectious Diseases, Redeemer's University, Nigeria.

Enzyme-linked immunosorbent assay (ELISA)

The samples were screened via the ReLASV® Pan-Lassa Combo NP/Prefusion GP IgG/IgM ELISA Kit (Zalgen Labs, Germantown, MD) to detect immunoglobulin M (IgM) and G (IgG) antibodies according to the manufacturer's instructions [21]. Briefly, all samples and positive and negative controls were prepared at a 1:101 dilution. A total of 100 µL of the prepared calibrator, positive and negative controls, diluted samples, and reagent blank were transferred in duplicate into the appropriate microwells. The plates were incubated for 30 min at ambient temperature (18–30 °C) and then washed. Anti-Hu IgG (or IgM) HRP conjugate solution was added to each well, and the samples were incubated for 30 min at ambient temperature and then washed. A total of 100 µL of one-component substrate was added and incubated for 10 min at ambient temperature while protected from light, followed by the addition of 100 µL of stop solution (2% methanesulfonic acid). The plates were read at 450 nm with a 630 nm reference. The mean O.D. values for the duplicate calibrator dilutions, reagent blanks, positive and negative controls, and samples were calculated from the difference between the mean O.D.630 nm reference and the mean O.D. 450 nm. The cut-off value for positive reactions was considered an OD of > 0.25 based on of positive LASV samples (obtained from Nigeria) as detected by polymerase chain reaction, Lassa positive convalescent samples, and test kit positive controls that were included in each assay.

Data analysis and statistical methods

The data were analysed via Microsoft Excel, SPSS 20.0, and GraphPad version 7 (Software, Inc., San Diego, CA). The statistical significance of differences in the prevalence of LASV and sociodemographics was determined via the chi-square test. GraphPad version 7.2 was used to analyse the proportions of IgG and IgM. Two-tailed p values < 0.05 were considered significant at a 95% confidence interval.

Results

Patient demographics

A total of 330 participants were enrolled in this study, 240 (72.7%) of whom were female. Their ages ranged from 3 to 75 years, with a mean (± SD) of 43.8 (± 14.9) years. Other characteristics are presented in Table 1.

IgG and IgM capture ELISA

Analysis of these samples revealed that IgG and both IgG and IgM antibodies were detected in 2.4% (8/330) and 1.8% (6/330) of the samples, respectively. The serological profile of LASV antibodies revealed that acute infection (IgM only), postinfection (IgG only), and ongoing

Table 1 Patient demographics

Variables	Frequency	Percentage
Age in years		
< 25	43	13.0
25–44	100	30.3
> 44	187	56.7
Gender		
Female	240	72.7
Male	90	27.3
Level of Education		
None	33	10.0
Primary	155	47.0
Secondary	115	34.8
Tertiary	27	8.2
Marital status		
Divorced	33	10.0
Married	137	41.5
Single	102	30.9
Widow/er	58	17.6
Occupation		
Salary earners	46	13.9
skilled workers	218	66.1
Unemployed	66	20.0
Duration of ARV in years		
< 5	82	24.8
5–10	74	22.4
> 10	174	52.7

infection rates (both IgG and IgM) were 0.0% (0/330), 0.6% (2/330), and 1.8% (6/330), respectively, as shown in Fig. 1.

Evaluating the prevalence of LASV antibodies according to sociodemographic and biodata characteristics

Our data showed no association ($p > 0.05$) between both IgG and IgM antibodies and age, sex, education, marital status, or occupation. Although the prevalence was high in the age group < 25 years, males, those who had attain primary education, widowers and salary earners. Although the IgG level was significantly high ($p = 0.027$) in those who had taken ART for < 5 years, the IgM level, on the other hand, was not significantly high ($p = 0.184$) in this same group (Table 2).

The ranges of IgG and IgM were 0.00–1.38 and 0.00-2.18, respectively. The means ± SDs of IgG and IgM were 0.044 ± 0.11 and 0.06 ± 0.16, respectively. A significant negative Pearson correlation existed between years of treatment and IgG (r =-0.208 $p = 0.0001$) and IgM (r=-0.144, $p = 0.009$) levels. The mean ODs of both IgG and IgM ($p < 0.05$) were significantly greater in LAVS-positive patients than in LAVS-negative patients. Figure 2.

Assessing viral load levels and Lassa antibody status

Viral load was classified as unsuppressed (> 1000 copies/mL), suppressed (detected but ≤ 1000 copies/mL), and undetectable (viral load not detected by the test used) [22].

In Fig. 3, participants with undetectable viral load did not present with either IgG or IgM antibodies. The prevalence of IgG was the same in participants with suppressed 4(50%) and unsuppressed viral load 4(50%). On the contrary Lassa IgM antibodies were higher 7(66.7%) in participants with unsuppressed viral load. These differences were significant ($p = 0.0001$).

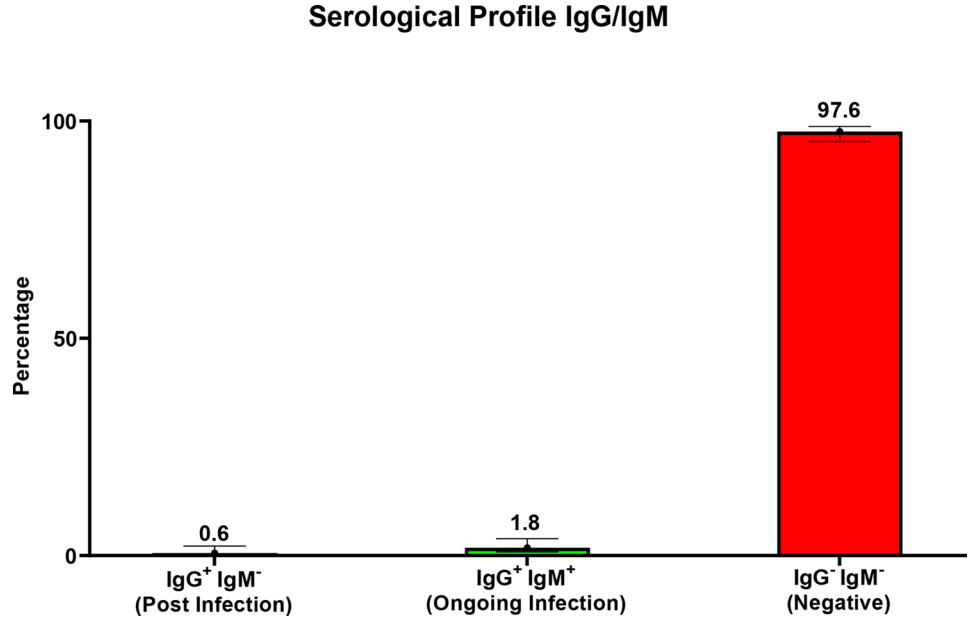


Fig. 1 Serological profile of LASV antibodies

Table 2 Prevalence of LASV antibodies according to sociodemographic and biodata characteristics

variables	Frequency (%)	IgG positive (%)	χ^2	p-value	IgM positive (%)	χ^2	p-value
Age in years							
<25	43(13.0)	**2 (4.7)**	1.808	0.405	**2(4.7)**	3.893	0.143
25-44	100(30.3)	1(1.0)			0(0.0)		
>44	187(56.7)	5 (2.7)			4(2.1)		
Gender							
Female	240(72.7)	5(2.1)	0.432	0.511	4(1.7)	0.113	0.737
Male	90(27.3)	**3(3.3)**			**2(2.2)**		
Level of Education							
None	33(10.0)	0(0.0)	3.090	0.378	0(0.0)	1.620	0.655
Primary	155(47.0)	**6(3.9)**			**4(2.6)**		
Secondary	115(34.8)	2 (1.7)			2(1.7)		
Tertiary	27(8.2)	0(0.0)			0(0.0)		
Marital status							
Divorced	33(10.0)	1(3.0)	0.962	0.810	0(0.0)	3.104	0.376
Married	137(41.5)	2(1.5)			1(0.7)		
Single	102(30.9)	3(2.9)			3(2.9)		
Widow/er	58(17.6)	**2(3.4)**			**2(3.4)**		
Occupation							
Salary earners	46(13.9)	**2(4.3)**	0.966	0.617	**2(4.3)**	0.067	0.967
Unemployed	66(20.0)	1(1.5)			1(1.5)		
skilled workers	218(66.1)	5(2.3)			3(1.4)		
Duration of ARV in years							
<5	82(24.8)	**5(6.1)**	7.21	0.027	**3(3.7)**	3.387	0.184
5-10	74(22.4)	2(2.7)			2(2.7)		
>10	174(52.7)	1(0.6)			1(0.6)		

Discussion

Currently, there are no licensed vaccines for LASV prevention [3, 5, 23]; as such, prompt diagnosis of LASV infection is imperative for proper clinical management, control, and prevention of further transmission. Thus, the detection of LASV antibodies is important since early identification of infected individuals is imperative for the prompt implementation of appropriate barrier nursing guidelines. The incidence of LASV-specific antibodies suggests exposure to the LASV in this region.

Serological diagnosis of acute LF cases requires a demonstration of detectable IgM or a significant increase in IgG. Previous studies carried out in Cameroon in 1988 showed no Lassa antibodies [24]. We report for the first time the occurrence of Lassa virus antibodies in Cameroon, hence there is need for active surveillance of the infection in the country. Our data showed that the prevalence of IgM only was 0.0% (0/330). This indicated that no participant presented with the acute phase of the disease that requires isolation [25]. On the other hand, the post-infection rate (IgG only), was 0.6% (2/330). Most probably, these individuals might have recovered from the disease or are in the latent phase. It has been reported that IgG antibody response persists for years after the onset of infection [26]. Secondly, the high IgG prevalence over IgM prevalence is because IgM specific for LASV rarely persists beyond one month in the serum of infected patients [27].

	IgG^+	IgM^+	IgG^-	IgM^-
Geometric mean	0.6321	0.6032	0.01560	0.03106

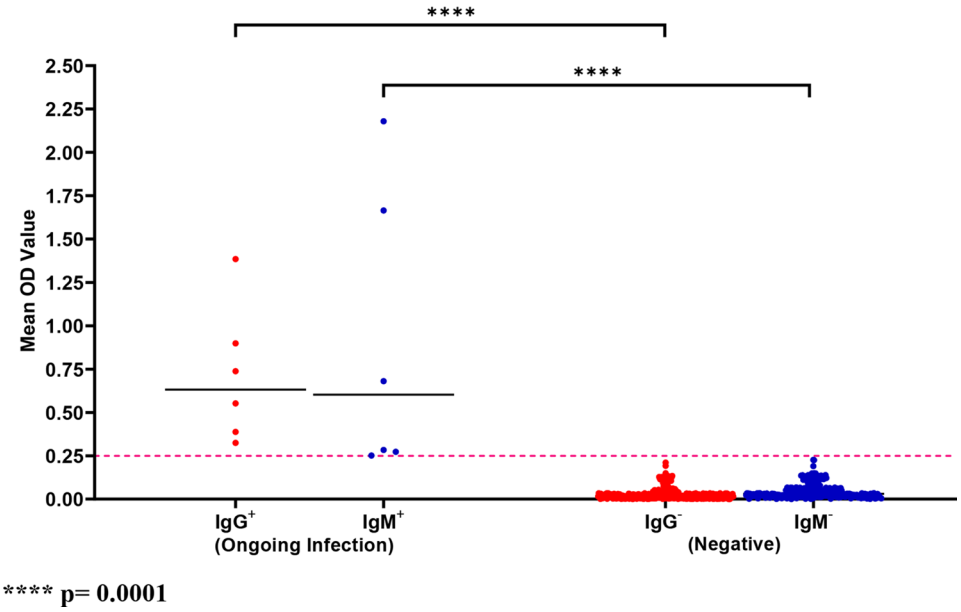
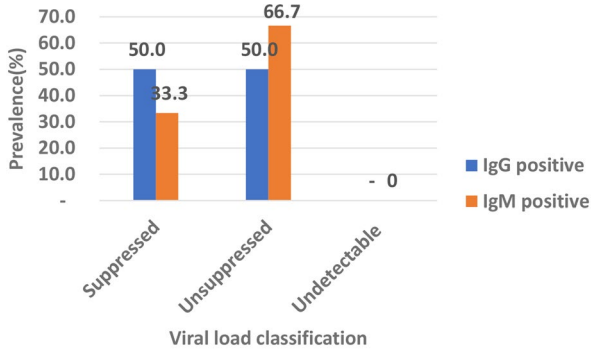


Fig. 2 Comparison of the mean ODs of IgG and IgM within the study population



For IgG, $\chi 2$ = 11.05 p=0.0001; For IgM, $\chi 2$ = 15.53 p=0.0001

Fig. 3 Prevalence of LASV antibodies with respect to viral load classification

The presence of IgG suggests previous exposure to the virus, whereas the presence of IgM indicates that the exposure was recent since most LASV-infected patients develop IgM antibodies within several days after infection in humans [11] and in animals [28].

The occurrence of IgG and IGM antibodies as reported in this study shows that these participants are exposed to LASV. A higher prevalence of IgG-to-IgM seroreactivity was recorded in this study. A similar finding has also been reported with patients from Sierra Leone and Nigeria [25, 29] and also in rodents [5]. The occurrence of IgG and IGM antibodies can be attributed to the presence the primary reservoir host (*Mastomys nataliensis)* in Cameroon [5, 6]. The porous interborder travel between Nigeria and the Bamenda-Ekor transporter highway allows the movement of persons, food, or household items that might have been contaminated with rodent urine or faeces [30]. This can further be explained by the fact that during the sample collection period, there was an outbreak of LASV fever in Nigeria [5, 6].

Despite the identification of IgM antibodies in this study, there haven't been any Lassa outbreaks in Cameroon. The mechanisms underlying its pathogenesis and the role that host and viral factors play remain unclear [31]. Secondly considering these HIV patients were on ARV it is not clear if these drugs have an impact on the pathogenesis of the disease. Lastly, considering that symptoms of LASV resemble many other common infections such as malaria, influenza, and typhoid fever [2, 7] lack of proper diagnosis might have missed out on the outbreak of LASV. This therefore calls for more epidemiological surveillance and genetic studies to ascertain this.

This study revealed that LASV infection does not depend ($p > 0.05$) on age, sex, level of education, marital status, or occupation. Although there is a dearth of information on LASV and sociodemographic data, previous studies [20, 32] also reported that LASV disease outcomes do not correlate with age or sex. Although fatality or recovery outcomes are associated with age. The higher prevalence observed among participants aged < 25 years can be related to the fact that most of these individuals have not taken ARV for a longer period. Similarly, the high prevalence in males might be due to frequent exposure to some risk factors, such as interactions with rodent (*Mastomys natalensis*) reservoirs.

The negative correlation observed between IgG/IgM and the number of years on ART can be attributed to the importance of ART in the life of HIV patients. Considering that all the patients were receiving combined therapy with nucleoside analogues that interfere with viral replication by inhibiting RNA-dependent nucleic acid synthesis, this might explain why these patients did not present with any clinical symptoms. These nucleoside analogues have a similar mechanism of action as the ribavirin drug used as the drug of choice in the treatment of Lassa fever [2, 3, 5, 11]. However, further investigations are needed to confirm this finding.

Higher level 7(66.7%) of Lassa IgM antibodies in participants with unsuppressed viral load might be due to the fact that persons with unsuppressed viral load may present with decreased T cells. In a similar study, Murphy et al. [33] reported that T cells help clear the infection.

Limitations of the study

Unfortunately, owing to the lack of appropriate sample transportation, the molecular assay could not be performed. Another potential limitation of our study is that we included only HIV-positive patients as such we were unable to determine if immune state of the participants plays a role in the epidemiology and pathogenesis of this disease.

Conclusions

This pioneer study in Cameroon highlights the need to broaden Lassa fever surveillance to the entire population in all regions. Pioneering studies constitute a wake-up call for policymakers to develop strategies to improve the welfare of their people in the case of an outbreak.

This calls for a rapid preparedness and response strategy by the Ministry of Public Health in the case of any future pathogen with pandemic or epidemic potential. There is a need to educate the public on the mode of transmission of this virus and the need for proper hygiene, as the vector *Mastomys nataliensis* lives in association with humans.

Abbreviations

Ag	Antigen
ELISA	Enzyme-linked immunosorbent assay
HIV	Human immunodeficiency virus
IFA	Immunofluorescence assay
IgG	Immunoglobulin G
IgM	Immunoglobulin G
LASV	Lassa virus

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Author contributions

LEA and KN contributed to the design of the study protocol.LEA, TR, and KN collect data for the study LEA, NHN, MA, OLA, DL, PE, and CU, Methodology and sample analysis: LEA, OLA and CU did statistical analyses OF and CH gave the financial and administrative supportAll authors have read and approved the final manuscript.

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Data availability

Data is available with the authors and shall be share upon request.

Declarations

Ethics approval and consent to participate

All methods were carried out following the relevant guidelines and regulations, including the Declaration of Helsinki. The study protocol was approved by the Research and Ethical Review Committee/Institutional Review Board of the University of Bamenda (2020/0244H/UBa/IRB). The study procedures were performed in accordance with the applicable guidelines. All the participants were given an oral explanation of the purpose and content of the study. Written informed consent was obtained from the participants or parents/guardians of the children 18 years and younger who were involved in the study.

Consent for publication

Not applicable. All the material and figures in the article were collected, analysed, and prepared by the authors.

Competing interests

The authors declare no competing interests.

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