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Research

A one health investigation of the 2024 yellow fever outbreak in Bayelsa State, Nigeria: Epidemiology, response and lessons learned

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Abstract: BACKGROUND: Yellow fever, a mosquito-borne viral disease, is transmitted to humans through bites from infected mosquitoes. Bayelsa State, in Southern Nigeria, reported an outbreak of yellow fever in 2024 despite immunization efforts. This study outlines the outbreak findings and lessons learned.
METHOD: A secondary analysis of case-based surveillance data obtained from IDSR OO1C was conducted from January to December 2024, focusing on demographics such as age, sex, location, and time. Immunization coverage and entomological findings were also assessed.
FINDINGS: From January to December 2024, 85 suspected yellow fever cases were reported, 13 (15.29%) of which were presumptively positive and 6(7.06%) confirmed using RT-PCR and PRNT. Among suspected cases, 43(50.59) were males with an average age of 19.21 years and SD of ± 16.33. One death was reported amongst confirmed cases, giving a case fatality rate (CFR) of 16.7%. Among the six confirmed cases, one case each were identified in four LGAs of the state (Yenagoa, Southern Ijaw, Nembe and Brass), while two cases were reported in one LGA (Kolokuma/Opokuma). The January 2023 mass immunization campaign achieved 87% coverage. Entomological surveys in 5 communities, including areas with confirmed cases, identified three Aedes species (Aedes albopictus, Ae. luteocephalus, and Ae. simpsoni complex). Larval indices indicated a high epidemic risk across surveyed areas.
CONCLUSION: The findings show that while surveillance and vaccination remain important, robust environmental and vector control measures are essential for effective yellow fever prevention.

Keywords: Yellow fever, One health, prevention, outbreak, immunization.

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INTRODUCTION

Yellow fever (YF) is an acute, mosquito-borne viral hemorrhagic disease caused by an RNA virus of the genus *Flavivirus* (1). It is transmitted to humans mainly through the bites of infected Aedes species in Africa and Haemagogus species in South America (2), reflecting the complex interactions between viruses, mosquito vectors, nonhuman primates, and human populations within their environments. Beyond its biological dynamics, YF has historically shaped societies through recurrent outbreaks, the difficulty of managing severe cases, and its persistent threat to global health (3). First identified in West Africa in 1927, YF is currently endemic in 34 African countries and 13 nations across Central and South America (4,5). The World Health Organization (WHO) has set a goal of eliminating yellow fever epidemics by 2026 (6). Nevertheless, the disease continues to cause an estimated 200,000 infections and 30,000 deaths annually, with Africa accounting for about 90% of these fatalities (7). Clinically, YF presents with fever, jaundice, hemorrhage, vomiting, and multi-organ failure (1). Although only about 15% of infected individuals develop symptomatic disease, mortality among these cases can reach nearly 40% within 7–10 days of onset (8).

In Nigeria, yellow fever remains a significant public health concern, with periodic outbreaks driven by low vaccination coverage, rapid urbanization, and ecological changes (9). The earliest documented case in the country was reported in Lagos in 1864, with several outbreaks occurring intermittently until 1996 (9). This was followed by a 21-year period without any confirmed cases, before the re-emergence of yellow fever in September 2017. After yellow fever re-emerged in Nigeria in 2017, the country faced multiple outbreak waves. In 2019, Nigeria experienced a surge in yellow fever, with 4,288 suspected cases reported across 618 LGAs, affecting all states and the Federal Capital Territory. Of these, 227 were laboratory-confirmed, with 31 deaths among confirmed cases, resulting in a case fatality rate of 13.7% (10). In 2024, a total of 2,856 suspected cases of yellow fever were reported across 627 Local Government Areas (LGAs) spanning all 36 states and the Federal Capital Territory. Of these, 30 cases were laboratory-confirmed, including one death recorded in Bayelsa State, resulting in a case fatality rate of 3.3% among confirmed cases. (11). Bayelsa State reported its first confirmed outbreak in 2024, after previously being classified as non-endemic. This study seeks to epidemiologically describe the 2024 yellow fever outbreak in Bayelsa State, while also highlighting the immunization campaign and entomological findings offering insights essential for strengthening future prevention and control efforts.

Materials and method

This research was conducted in Bayelsa State, situated in the Niger Delta region of Nigeria. It shares boundaries with Rivers State to the east and northeast, Delta State to the west and northwest, and the Atlantic Ocean to the south. The state covers a land area of about 10,773 km² and has an estimated population of 2,704,515. Administratively, Bayelsa is made up of eight Local Government Areas, which include Southern Ijaw, Kolokuma/Opokuma, Yenagoa, Nembe, Ogbia, and Sagbama (12).

A descriptive cross-sectional study was carried out in Bayelsa State between January 1 and December 31, 2024. Quantitative data were utilized for the analysis. Case-based surveillance data was obtained from IDSR 001C and Surveillance Outbreak Response Management and Analysis System (SORMAS) and examined for demographic characteristics including age, sex, location, and temporal distribution of cases. In addition to the surveillance data, immunization coverage reports were reviewed to assess population-level protection, while entomological investigations were analyzed to provide insights into vector dynamics and potential transmission risks.

Case definition

The Technical Guidelines for Integrated Disease Surveillance and Response (IDSR) in Nigeria outline the following standard case definitions:

Suspected case: Any person with acute onset of fever, with jaundice appearing within 14 days of onset of the first symptoms (13)

Presumptive positive case: A suspected case in whom was found the presence of YF IgM antibody in the absence of YF vaccination within the last 30 days before onset of illness or positive post-mortem liver histopathology or epidemiological link to a confirmed case or an outbreak(13)

Confirmed case: A presumptive case with one of the following: detection of YF IgM by PRNT; detection of four-fold rise in IgM or IgG antibody titers between acute and convalescent serum samples or both; detection of YF-specific neutralizing antibodies and absence of YF immunization within 30 days before onset of illness or one of the following: detection of YF viral genome in blood by polymerase chain reaction (PCR); or detection of

YF antigen in blood, liver or other organs by immunoassay; and isolation of YF virus and absence of YF immunization within 14 days before onset of illness(13)

Laboratory: All blood samples collected by the surveillance unit were sent to the University of Benin Teaching Hospital (UBTH) laboratory and the National Reference Laboratory (NRL), Gaduwa, Abuja, for testing using Immunoglobulin M (IgM) antibody assay and Reverse Transcription Polymerase Chain Reaction (RT-PCR). The choice of testing platform was based on the interval between symptom onset and sample collection. Samples collected within ten (≤10) days of symptom onset were first tested using RT-PCR, and if negative, further analyzed with the MAC-ELISA method. Samples collected more than ten days after symptom onset were tested directly using the MAC-ELISA assay. Those that produced positive, equivocal, or inconclusive results in Nigerian laboratories were forwarded to the WHO Regional Reference Laboratory, Institut Pasteur (IP) in Dakar, Senegal, for confirmatory testing using Plaque Reduction Neutralization Test (PRNT).

Yellow fever campaign: The supplementary immunization activity (SIA) was implemented in Bayelsa State from 28th January through 8th February 2023. Activities conducted before and during the implementation were; National training of trainers (NTOT), State level training/LGA and ward level training, microplanning, Advocacy, communication and social mobilization (ACSM), logistics and vaccine management, readiness assessment, flag off, supportive supervision/Independent monitoring, Adverse events following immunization (AEFI) monitoring and daily review meetings.

Entomological survey: An entomological survey was carried out in two (2) Local Government Areas (LGAs) Yenagoa and Kolokuma/Opokuma out of the five LGAs where confirmed yellow fever cases were reported. The survey covered five communities: Famgbe, Sabagreia, Opokuma, Kaima, and Kalama, with the objective of detecting the presence of yellow fever vectors and identifying their breeding sites. A larval survey was conducted in 190 households across these communities to collect the larval stages of *Aedes* mosquitoes. This approach enabled the measurement of two key larval indices the House Index and the Breteau Index to assess the level of vector infestation in the area. A larval index was classified as high when the House Index was ≥4% and/or the Breteau Index was ≥5%. In addition, Biogent Sentinel (BGS) traps were deployed to collect adult *Aedes* mosquitoes.

Data management: All data were retrieved and organized in Microsoft Excel, with demographic, laboratory, vaccination, and entomological information arranged on separate sheets. The datasets were cleaned and structured to ensure consistency across all key variables. Surveillance data were analyzed using SPSS, while other datasets were analyzed using Microsoft Excel.

Results

Table 1. Sociodemographic characteristics of participants

A total of 85 suspected Yellow Fever (YF) cases were reported between January and December 2024. Of these, 13 tested presumptively positive, and 6 of the presumptive cases were subsequently confirmed.

Variables	Frequency (%)
Age Group (years)	
>0 – 10	32(37.65)
>10 - 20	25(29.41)
>20 - 30	10(11.76)
>30 - 40	8(9.41)
>40 - 50	3(3.53)
>50&above	7(8.16)
Mean age ± SD	19.21 ± 16.33
Gender	
Female	42(49.41)
Male	43(50.59)
Test Outcome	
Negative	72 (84.71)
Positive	13 (15.29)
Living Status	
Alive	82 (96.47)
Dead	3 (3.53)
Vaccination status	
Vaccinated	21(24.71%)
Unvaccinated	22(25.88%)
Unknown	42(49.41%)
LGA	

Urban	40(47.05)
Rural	45(52.94)

1(CFR=16.7%) death out of the 6 confirmed cases reported. Males were 43(50.59%), within the age group ≤ 10 years were the highest 32(37.65%) amongst suspected cases and rural LGAs had the highest number of suspected cases 45(52.94%).

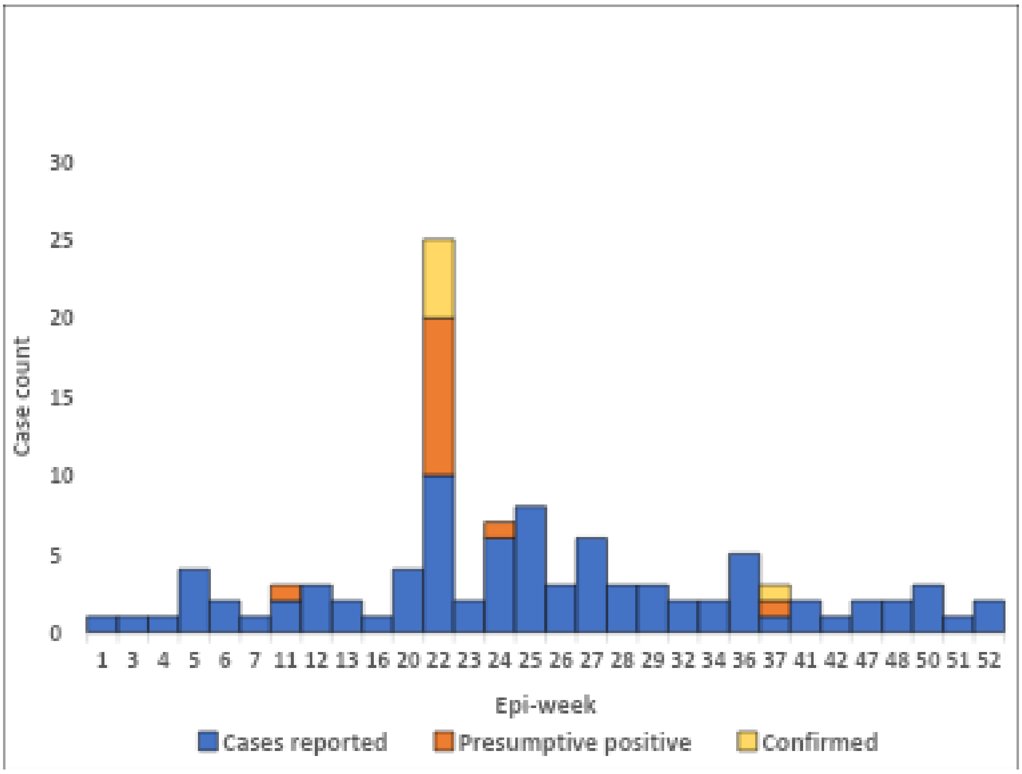
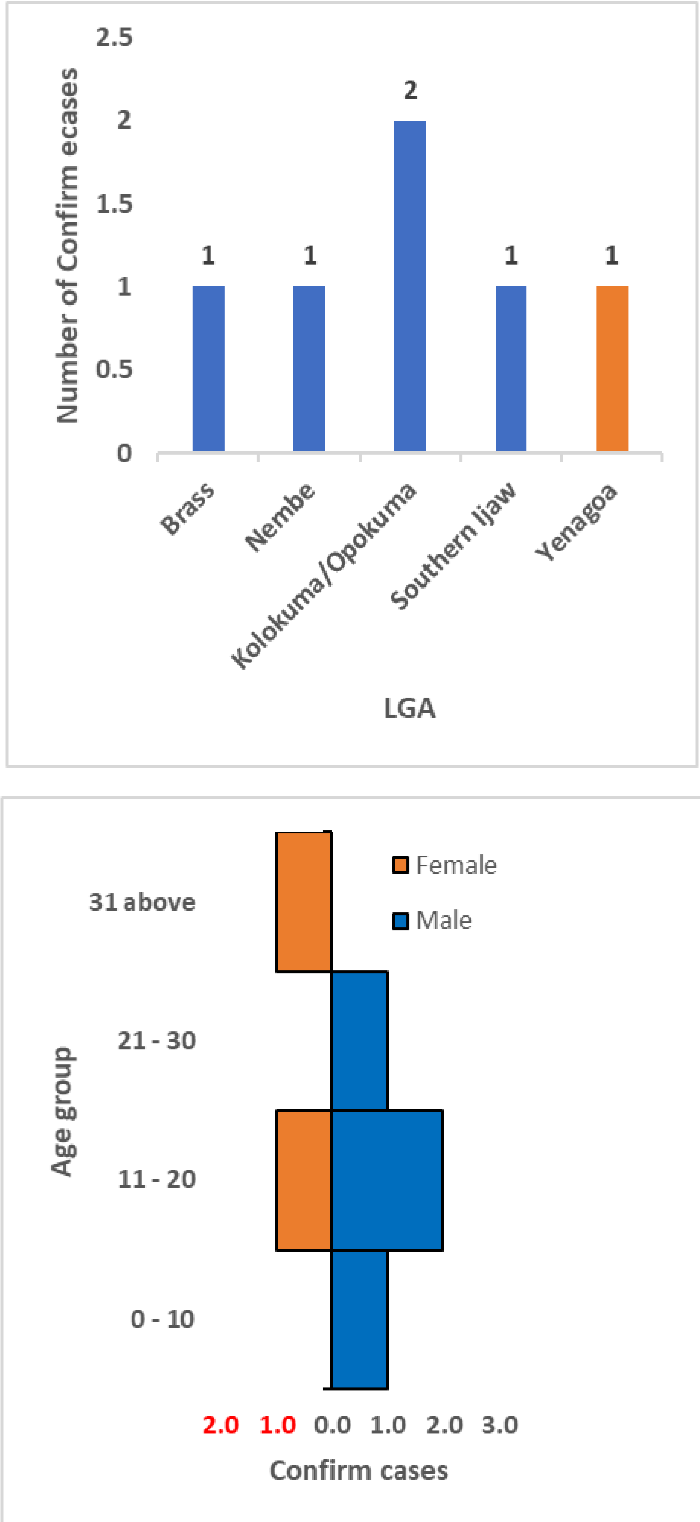


Figure1. Epidemiological curve showing distribution of cases according to epidemiological week in 2024. [Week 22 as shown on the curve had the highest number of cases reported with 5 confirmed cases why week 37 had 1 confirmed case. Presumptive positive was reported in week 11, 22, 24 and 37 respectively.]



Panel 1.LGA distribution of confirmed cases and death(L), age sex distribution of confirm cases(R). [Kolokuma/Opokuma had 2 confirmed cases, while Yenagoa LGA had one confirmed case and the only death amongst confirmed cases during the outbreak. 4 confirmed cases were males, 11-20 age group had 3 confirm cases]

The yellow fever SIA recorded a total of 1,563,180 persons vaccinated with 1,641,330 doses of yellow fever vaccine out of which 2,473 children between 9 months to 23 months received yellow fever vaccine for the first time. The Bayelsa state yellow fever administrative coverage for the February 2023, Campaign was 87%, LGA-level performance varied from 48% in Kolokuma /Opokuma LGA to 104% in Nembe LGA (Panel 2).

Panel 2. Administrative Coverage of Yellow fever vaccination by LGA (9 Months - 44Yrs) (L), LGA/Ward coverage (%) of confirm cases reported in the outbreak (R).

[Ward level performance in areas where confirmed cases were recorded varied from 25% in Igbedi to 120% in Amassoma 3. The 2 cases in Kolokuma/Opokuma LGA reported in Igbedi and Sampou/Kalama ward were reported to have been vaccinated**]**.

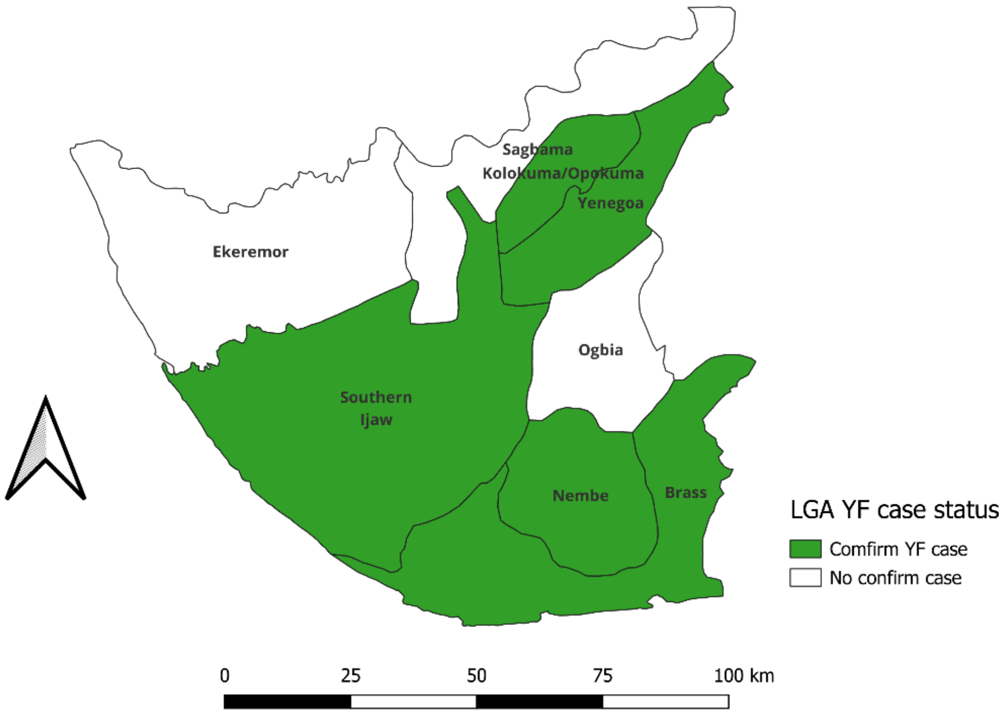


Figure 2*. Map of Bayelsa State showing LGA with confirm YF cases*

Table 2. *Household and Container productivity of Aedes species per community*

S/N	LGA (Community)	No of Houses	No of Houses Positive	No of Containers	No of Containers Positive	Type of Container Positive
1	Yenagoa (Famgbe)	30	1	19	19	**Plastic cover of water storage container; large water storage container and discarded small plastic can**
2	Kolokuma/Opokuma (Kaiama)	35	1	66	10	**Drink bottles**
3	Kolokuma/Opokuma (Kalama)	49	3	59	5	**Small, discarded plastic; discarded head pan and plant axils**
4	Kolokuma/Opokuma (Opokuma)	26	1	23	1	**Discarded tomato tin**
5	Kolokuma/Opokuma (Sabagreia)	50	6	77	8	**Discarded motorcycle tyres and small plastics**
	Total	190	12	244	27	

S/N	LGA(Community)	House Index (%)	Container Index (%)	Breteau index
1	Yenagoa (Famgbe)	3.3	15.8	10
2	Kolokuma/Opokuma (Kaiama)	2.9	15.1	28.8
3	Kolokuma/Opokuma (Kalama)	6.1	8.5	10.2
4	Kolokuma/Opokuma (Opokuma)	3.8	4.3	3.8
5	Kolokuma/Opokuma (Sabagreia)	12	10.4	16

Panel 3. Larval indices across the communities visited(L), summary of modified human landing catch (mHLC) and biogent Sentinel Trap.

[Three Aedes species; Aedes albopictus, Ae. luteocephalus and Ae. simpsoni complex. Aedes albopictus emerged as the most dominant and diverse species. In Kalama, Opokuma, and Sabagreia, yellow fever vectors were found in the residence of presumptive positive and confirmed cases, indicating that Aedes albopictus may be the disease's primary vector in the LGAs surveyed]

Discussion

This study investigates the 2024 Yellow Fever outbreak in Bayelsa State, examining its occurrence in relation to person, place, and time, and highlighting findings from the immunization campaign and entomological assessments. Despite the 2023 mass vaccination campaign and maintaining active surveillance, the state reported an outbreak of YF.

The study revealed that Yellow Fever (YF) cases were predominantly recorded among young individuals, especially those aged 11–20 years, with males accounting for most of the confirmed cases (Panel 1). This finding aligns with previous studies conducted in Nigeria (14). Confirmed cases were reported in five out of the eight Local Government Areas (LGAs) in the state, with Kolokuma/Opokuma LGA recording the highest number. The occurrence of YF in this areas is consistent with its known association with rainforest and swampy regions of Nigeria (15). The outbreak started in the month of May, while only one case was reported in September (Fig. 1). Previous studies in Nigeria have shown that YF transmission peaks during the rainy season, a period marked by increased mosquito populations and intensified farming activities that heighten human exposure to *Aedes* mosquitoes (14,15). One death was recorded among the confirmed cases, resulting in a case fatality rate (CFR) of 16.7% (Tab. 1). Although the CFR observed in this study is slightly lower, it remains comparable to findings from other studies, which report rates ranging from 20% to 60% (16).

The February 2023 Yellow Fever vaccination campaign achieved an impressive administrative coverage of 87%, reflecting a generally successful implementation across the state. According to WHO, a minimum coverage of 80% is required to achieve herd immunity against Yellow Fever, indicating that the campaign effectively met this target (17). Despite this achievement, Kolokuma/Opokuma LGA, which recorded the highest number of confirmed cases, had the lowest vaccination coverage at 40%. Ward-level data further showed high coverage in most areas with confirmed YF cases, except for the two wards within Kolokuma/Opokuma (Panel 2). Interestingly, case-based surveillance data revealed that the confirmed cases in this LGA had been vaccinated during the campaign. Studies show that yellow fever (YF) outbreaks can occur even in populations with documented immunization, although such events are uncommon. Despite the high effectiveness of the YF vaccine providing approximately 95% protection within 30 days breakthrough infections may arise due to individual variations in immune response, timing of vaccination, or gaps in population-level immunity(18).

The communities surveyed in this study were mainly riverine and agrarian, featuring rainforest and swampy vegetation typical of Bayelsa State. *Aedes* species were identified in several households, with 6.31% of households and 11.06% of containers testing positive for *Aedes* larvae. Similar to findings from previous studies, Yellow Fever outbreaks have been reported in agricultural communities with swampy environments (19), although household larval indices observed in other regions of Nigeria were generally higher (15) (Tab. 2). The most common breeding sites identified included plastic water storage covers, water containers, discarded plastic cans, drinking bottles, used motorcycle tyres, and plant axils. This observation aligns with earlier reports that also detected *Aedes* larvae in plastic containers and plant axils (15). Epidemic risk is considered high when larval indices exceed the standard thresholds Container Index ≥3%, House Index ≥4%, and/or Breteau Index ≥5. The elevated larval indices recorded across all surveyed communities therefore indicate a significant potential for Yellow Fever transmission. *Aedes albopictus* was found to be the most dominant and widespread species, suggesting it may serve as the primary vector sustaining transmission during the outbreak. Evidence from studies conducted both within and outside Nigeria further supports that the presence of *Aedes* mosquitoes increases the likelihood of local Yellow Fever transmission (15,17) (Panel 3).

This study has some limitations. The reliance on secondary data may have led to underestimation of the true number of cases due to potential gaps in the surveillance system. In addition, the entomological survey was conducted in only two LGAs, which may limit the generalizability of vector-related findings to other areas. However, these limitations are unlikely to substantially affect the overall interpretation of the results, as the findings remain consistent with existing evidence from similar studies.

Bayelsa State experienced a yellow fever outbreak despite ongoing immunization efforts. The entomological survey identified the presence of *Aedes* mosquitoes, indicating an increased risk of transmission in the area. This outbreak highlights the role of multiple risk factors and reinforces the need for a multidisciplinary One Health approach to prevent future occurrences.

We recommend that relevant health authorities strengthen One Health collaboration and implement targeted interventions to prevent Yellow Fever outbreaks in both endemic and non-endemic areas. Key priorities include improving immunization coverage, strengthening surveillance systems, conducting regular entomological surveys to identify high-risk areas, implementing effective vector control measures, eliminating mosquito breeding sites within communities, and promoting sustained public awareness on Yellow Fever prevention.

Competing interests

The authors declare no competing interests.

Author's contributions

All authors have read and agreed to the final manuscript.

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