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Incidental Discovery of Yellow Fever Cases during a West Nile Case Investigation in the Kidira Health District (Senegal)

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Abstract

Introduction: Sentinel surveillance of arboviral diseases (4S network) in the Tambacounda region (Senegal) revealed an autochthonous case of yellow fever detected during the investigation of a confirmed West Nile case in Sansanding (Kidira district). The objective of this study was to describe the circumstances of the yellow fever case discovery, its sociodemographic and clinical characteristics, its various contacts, and the environmental factors likely to increase the outbreak. **Methods:** A descriptive investigation study was conducted, combining active case finding, collection of clinical and vaccination data, blood sampling from suspected cases, and entomological/environmental surveys of at-risk households. The analysis was primarily narrative and descriptive. **Results:** One confirmed case of yellow fever (a 40-year-old woman) was identified with a favorable clinical outcome. Three suspected contacts were tested; no positive results for arboviral diseases were detected. Contextual factors included human-animal cohabitation, proximity to wildlife, and operational vulnerabilities (intermittent cold chain, limited logistical resources). District Health Information Software (DHIS2) data suggested infant yellow fever vaccination coverage of ≥90% at the health post and district levels, but adult vaccination status was often undetermined. **Conclusion:** The detection of a single case without an apparent cluster suggests persistent sylvatic circulation with a risk of spread. A regional yellow fever vaccination campaign, integrated clinical-entomological surveillance (One Health) with regular supervision, and improved routine practices are strongly recommended to prevent the amplification of outbreaks and strengthen the resilience of the regional system.

Keywords

Yellow Fever, West Nile Investigation, Senegal

1. Introduction

Arboviruses are viral infections transmitted to humans by blood-feeding arthropods, particularly mosquitoes and ticks, some of these viruses belonging to the genus *Flavivirus* (yellow fever, dengue, West Nile, Zika) [1]. The yellow fever virus occupies a special place: endemic in tropical Africa and South America, it circulates in a sylvatic cycle involving non-human primates and forest mosquitoes, with the possibility of urban transmission when *Aedes aegypti* is involved [2]. According to the World Health Organization (WHO), a modeling study based on African data estimates the burden at 84,000 - 170,000 severe cases and 29,000 - 60,000 deaths (2013), which justifies the priority given to vaccination and strengthening surveillance [3]. In West Africa, yellow fever remains endemic, with predominantly sylvatic transmission and sporadic urban episodes. In eastern Senegal, several studies have documented virus circulation in forest ecosystems involving *Aedes* spp. vectors, while the WHO emphasizes the biological confirmation criteria and notification requirements for international surveillance [4] [5]. In this context, yellow fever vaccination represents the primary prevention tool, as highlighted by international recommendations on travel health and public health [6]. Recent outbreaks in Africa, particularly in Angola (2015-2016), illustrate the risks of spread when vaccination coverage and control measures are inadequate [7]-[9]. These factors justify the present study, which focuses on the detection and management of an autochthonous case in a high-risk area, as well as the analysis of programmatic determinants that may influence case occurrence.

Southeastern regions of Senegal, such as Kédougou and Tambacounda, are considered foci of sylvatic yellow fever circulation [10], yet no human yellow fever outbreaks have ever been reported in these areas. The Tambacounda region has a sentinel site for syndromic surveillance of arboviruses at the Pont health post in the Tambacounda health district. As part of this arbovirus surveillance, a West Nile case was identified in October 2020, and its investigation led to the discovery of a yellow fever case in another district within the Tambacounda region. The objective of this study was to describe the circumstances surrounding the discovery of the yellow fever case, its socio-demographic and clinical characteristics, its various contacts, and the environmental factors potentially contributing to an outbreak.

2. Materials and Methods

2.1. Study Location

The investigation took place in the village of Sansanding, at the health post of the same name, in the Kidira health district. The district is bordered to the east by the

Kayes district (Republic of Mali), to the west by the Goudiry and Dianké Makhan districts, to the south by the Dianké Makhan and Saraya districts, and to the north by the Bakel district. It covers an area of 5922 km^2 with a population of 69,208 inhabitants in 2020. The district comprises one health center, 19 health posts, 11 health huts, and 63 integrated community surveillance and alert committees. The Sansanding health post (**Figure 1**), which serves three villages with an estimated population of 1446 inhabitants in 2020, is one of the district's health posts and is classified as a priority 2 site for the surveillance of diseases with epidemic potential. It is located 80 km from the Kidira health center, in the Kéniéba sub-prefecture. It is 5 km from the Toumboura health post, which it was formerly a health hut of before 2018. This health post is situated not far from the Niokolocoba National Park.

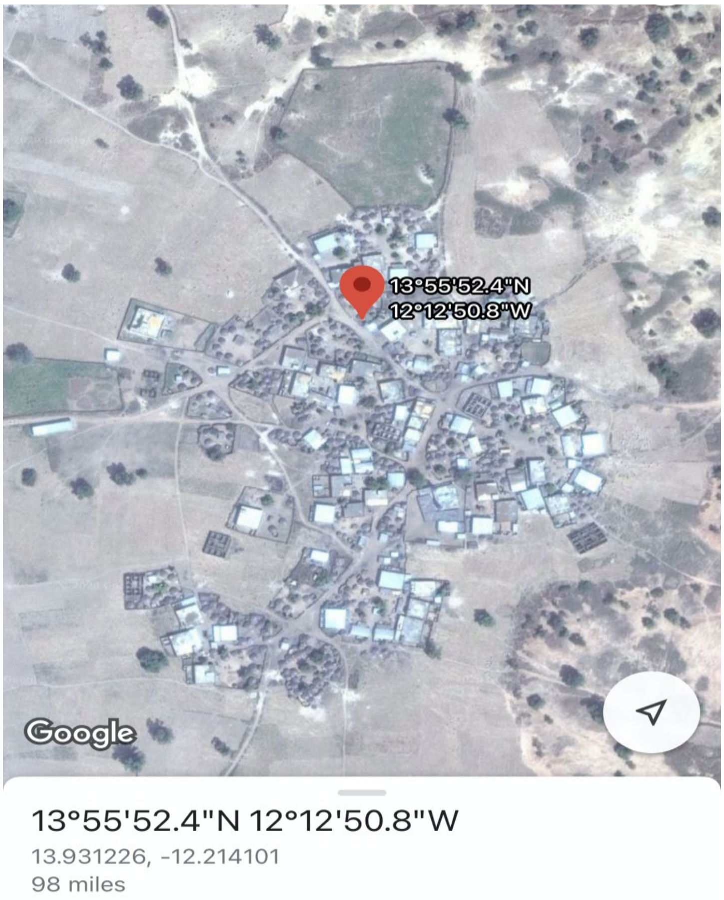

Figure 1. Satellite image of the village of Sansanding with Global Positioning System (GPS) coordinates of the health center, taken during the investigation on November 2, 2020, of a confirmed case of yellow fever (Source: Google Maps).

2.2. Study Type and Period

This is a descriptive cross-sectional study on a confirmed case of yellow fever. The investigation took place on November 2, 2020.

2.3. Study Population and Sampling

The epidemiological survey involved the confirmed case of yellow fever, the suspected cases identified during the investigation, and contact persons during the period from August 1 to October 31, 2020, in the area covered by the Sansanding and Toumboura health centers.

The entomological survey focused on the households of the confirmed case and suspected cases in the Sansanding area.

Two Types of Sampling Were Carried Out

Epidemiological investigation: A comprehensive sampling was conducted, taking into account confirmed cases and suspected cases of yellow fever from August 1st to October 31st, 2020, residing within or outside the area covered by the Sansanding and Toumboura health centers.

Entomological and environmental investigation: Sampling was conducted in all concessions where the case was identified or suspected, both within and in the surrounding area.

For the entomological and environmental investigation, surveys were conducted inside and outside the concessions to search for potential larval breeding sites that could be found in water storage containers, other containers (abandoned, etc.), and also to identify the presence of a vector or an intermediate host.

2.4. Case Definitions

During this investigation mission, the following case definitions were used:

- Suspected case of yellow fever: Any person presenting with a sudden onset of fever, with the appearance of jaundice within 14 days of the onset of the first symptoms.
- Probable case of yellow fever: A suspected case and one of the following:
  - Epidemiological link with a confirmed case or an outbreak.
  - Post-mortem liver histopathology positive.
- Confirmed case of yellow fever: Probable case and one of the following:
  - Detection of specific anti-yellow fever IgM antibodies*.
  - Detection of IgM and/or IgG antibody titers against yellow fever that are four times higher between the acute phase serum and the convalescent phase serum.
  - Detection of neutralizing antibodies specific to the yellow fever virus*.

*"*Specific*" *means that antibody tests* (*IgM or neutralizing antibodies*) *against other prevalent flaviviruses are negative. This analysis should include IgM tests for at least dengue and West Nile viruses, and possibly for other flaviviruses depending on the local epidemiology.*

Or, one of the following elements:

- Detection of the yellow fever virus genome in blood or other organs using PCR (in the absence of yellow fever vaccination within the 14 days preceding the onset of the disease).
- Detection of yellow fever virus genomic sequences in blood or organs by PCR.

- Immunohistochemical detection of yellow fever virus antigens in blood, liver, or other organs.
- Isolation of the yellow fever virus.

2.5. Collection Procedures

2.5.1. Data Collection Technique

This was carried out by:

- Interview for the active search of suspected cases around the confirmed case.
- Analysis of consultation records (general consultations, sick children, and sick pregnant women) for the period from August 1st to October 31st, 2020 at the Sansanding and Toumboura health centers.

2.5.2. Data Collection Tools: The Information Was Collected Using Two Forms

- Individual record for contacts benefiting from direct debit.
- Descriptive list for other contact cases.

2.6. Variables to Be Collected

For confirmed and suspected cases of yellow fever:

Patient information included: identity, age, sex, place of residence, relationship to the confirmed case, medical history (including symptoms, date of symptom onset, date of consultation), laboratory sample (specimen collected, date of collection), laboratory result, yellow fever vaccination status, and outcome (recovered, deceased, hospitalized, lost to follow-up, etc.).

For entomological and environmental data, the collected data consisted of the GPS coordinates of the area and household surveys.

2.7. Data Processing

The information constituting the variables was encoded and analyzed in an Excel spreadsheet.

2.8. Data Analysis

The analysis of the determinants of the occurrence of yellow fever cases was primarily descriptive.

2.9. Presentation of Results

The results are presented in narrative form with illustrative tables, figures, and photographs.

2.10. Ethical Considerations

The informed consent of the participants was obtained beforehand. They were all informed of the objectives and limitations of the investigation, as well as their right to refuse participation. The confidentiality of the collected data was ensured.

3. Results

Context of the investigation

In the framework of arbovirus surveillance through the 4S network, the Pont health post, located in the Tambacounda commune in the eponymous district, is one of the various sentinel sites for epidemiological surveillance in the country. This site reported a suspected arbovirus case on Saturday, September 17, 2020, which was confirmed as West Nile by the Pasteur Institute of Dakar (on October 17, 2020). This confirmed case, a resident of Sansanding in the Kidira health district, was investigated on October 18, 2020, and samples were collected from five (5) high-risk contacts who met the definition of a suspected West Nile case. Following these five samples, one yellow fever case was confirmed, while the other four were negative for arboviruses. After receiving the results from the central level via email on October 30 at 23:08, the Regional Chief Medical Officer was notified to prepare the investigation. Accordingly, a multidisciplinary team was formed to investigate the confirmed yellow fever case.

Description of sociodemographic and clinical characteristics

This is a 40-year-old female farmer residing in the village of Sansanding, with no known history of travel. In September, she began experiencing symptoms including fever, headaches, myalgias, fatigue, joint pain, and mild jaundice. Due to the persistence of these symptoms, she took paracetamol without seeking consultation at the local health post. Her condition resolved favorably. As part of sentinel arbovirus surveillance, she was sampled on October 18, 2020, as a contact of a confirmed West Nile case (her husband) in the same village.

The socio-demographic investigation revealed that she lives in a large family with cohabitation alongside animals. Goats, poultry, and donkeys are raised in her household. For her farming activities, she frequently visits the nearby forest adjacent to Niokolo-Koba National Park, where wild animals such as monkeys and Aedes vectors may be present.

Active searching and management of suspected cases.

At the home of the confirmed case, questioning revealed that there were four symptomatic contacts, one of whom had died. Blood samples were taken from the other three to test for the yellow fever virus.

The list of family contacts is described in Table A1 (in the Appendix).

Description of the variables:

- Age: For the suspected cases identified in the village, the average age was 181.6 months with a standard deviation of 178 months. The minimum age of these suspected cases was 8 months and the maximum age was 480 months, or 40 years.
- Gender: In the series of suspects, 60% of the cases were female.
- Place of residence: All suspected cases (100%) found during the active search in Sansanding and Toumboura lived in the village of Sansanding.
- Link to the positive case: A family relationship with the positive case was established in all suspected cases (100%).

- Symptomatology: During the investigation, 100% of suspected cases were symptomatic. Jaundice was present in 20% of cases. A fever of 37.5°C or higher was observed in 80% of cases. Only the remaining 20% had a history of fever. In this series, the outcome was favorable in 80% of cases. Only one death was recorded in the registers. Of the five cases tested, none tested positive for IgM antibodies against yellow fever virus or other arboviruses.

Identification of environmental factors:

The investigation of the case allowed us to identify cohabitation between animals and humans in the village of Sansanding. In the confirmed case's home, apart from goats, poultry, and donkeys, no wild animals were found.

On the day of the investigation, no stagnant water was found in abandoned containers that could promote the proliferation of Aedes mosquitoes in the case's home or in the surrounding area. However, it should be noted that there were abandoned containers and toilets near the confirmed case's room that could hold water during the rainy season (Figure 2).

(a) (b)

Figure 2. Containers abandoned near the room of the confirmed Yellow Fever case, Sansanding village, Kidira health district, during the investigation on November 2, 2020.

Evaluation of the functionality of the routine monitoring system

At the Sansanding health center, routine surveillance is being carried out effectively by trained personnel, despite some shortcoming:

- The failure to actively look for signs of jaundice during the clinical examination of patients and to document it in the consultation records.
- The list of case definitions and diseases under surveillance is not displayed.

- Lack of a cold chain for the preservation and transport of samples.
- Insufficient sampling equipment.
- All notification forms for diseases under surveillance are unavailable.
- Irregularity of site visits (priority 2 site) due to the inaccessibility of the location throughout the winter season.

Assessment of vaccination coverage in the VAA and the quality of vaccination

The assessment of vaccination coverage in the VAA was carried out at two levels:

- The exploitation of data entered into the DHIS2 platform.
- An investigation was conducted at two residences where suspected cases were found and samples were taken.

Table 1 and Table 2 show the vaccination coverage for yellow fever at the Sansanding health center and in the Kidira health district during the last three years.

Since 2019, vaccination coverage rates for hepatitis A in the district have been above the national target of 90%.

Table 1. Evolution of measles vaccination coverage in the Kidira health district between 2018 and September 2020 (Source: DHIS2).

Targets Periods	Target group (0 - 11 months)	Children vaccinated with VAA	Coverage at VAA
2018	2275	1525	67%
2019	2357	2247	95%
2020 (January-September)	1832	1748	95%

Table 2 shows that since the creation of the Sansanding health center in 2018, vaccination coverage for yellow fever has consistently exceeded the national target of 90%.

Table 2. Evolution of yellow fever vaccination coverage at the Sansanding health center, Kidira Health District, between 2018 and September 2020 (Source: DHIS2).

Targets Periods	Target group (0 - 11 months)	Children vaccinated with VAA	Coverage at VAA
2018	40	48	120%
2019	50	76	152%
2020 (January-September)	39	37	95%

Regarding the investigation in the two concessions where suspected cases of yellow fever were found, yellow fever vaccination was documented in the vaccination records of children aged 9 months to 5 years. The other children, whose vaccination records were unavailable, were reported by their parents or guardians to have received the yellow fever vaccine. Among adults, none recalled being vaccinated against yellow fever, and none possessed any documentation confirming yellow fever vaccination.

Regarding the quality of vaccination at the Sansanding health center, despite the availability of qualified and trained personnel, some shortcomings were noted:

- Lack of a refrigerator in the clinic to store the antigens.
- Using public transport to transport vaccines and supplies between the district depot and the health center.
- There is a very long delay between the vaccine's arrival at the district depot and its administration to children (approximately 24 hours), during which it is stored in a vaccine carrier.
- Remaining vials of antigens were discarded due to a lack of a cold chain (but were not used by the vaccination unit): see **Figure 3** in the annexes.

(a) (b)

Figure 3. Unusable vaccines due to the lack of a cold chain at the Sansanding health center, Investigation of November 2, 2020.

4. Discussion

This study highlights the incidental discovery of an autochthonous yellow fever case during an investigation initiated by a confirmed West Nile virus infection, within the framework of integrated arbovirus surveillance in eastern Senegal. This finding illustrates the co-circulation of multiple flaviviruses in the same ecological setting and underscores the importance of combining clinical investigation with biological and entomological evidence to detect sporadic transmission events in rural and forest-adjacent areas [4] [11]. Such integrated approaches have been shown to improve early detection and situational awareness in regions where arboviruses circulate silently and intermittently.

The epidemiological context observed in this investigation is consistent with the classical sylvatic transmission ecosystem of yellow fever virus in West Africa, characterized by close human-wildlife interfaces and occupational or subsistence activities such as farming and forestry near protected areas. Several studies conducted in eastern Senegal and neighboring regions have documented sustained sylvatic amplification cycles involving non-human primates and forest-dwelling *Aedes* vectors during favorable climatic conditions [4] [10] [12]. These ecological dynamics align closely with the exposure profile of the index case and support the hypothesis of a sporadic sylvatic spillover rather than sustained human-to-human transmission.

From a clinico-epidemiological standpoint, the diagnostic strategy applied in this investigation—combining specific serological testing with molecular techniques when appropriate—is in accordance with international recommendations for yellow fever confirmation. In endemic settings, differential diagnosis remains particularly challenging due to overlapping clinical presentations and serological cross-reactivity among flaviviruses such as dengue, West Nile, and Zika viruses [5] [6] [13]. The systematic exclusion of other prevalent flaviviruses is therefore essential to avoid misclassification and to ensure accurate surveillance data. The absence of secondary confirmed cases and the negative laboratory results among tested contacts suggest a low-intensity, isolated transmission event.

The high level of routine childhood yellow fever vaccination coverage reported by district health services may have contributed to limiting further spread of the virus. However, this apparent protection must be interpreted with caution, as several operational vulnerabilities persist. These include uncertainties regarding adult vaccination status, weaknesses in cold chain maintenance, and logistical constraints related to accessibility and mobility in remote areas—factors that have been repeatedly identified as barriers to effective prevention and response in endemic regions [3] [6] [14]. Similar gaps have been described in other African contexts where sylvatic transmission persists despite satisfactory infant immunization coverage.

When compared with major outbreaks documented in Africa—such as the 2015-2016 yellow fever epidemic in Angola, which was marked by sustained urban transmission and large-scale population movement—the situation described in this study appears more consistent with a sentinel event occurring in a sylvatic context [7]-[9]. This contrast highlights the critical role of sensitive surveillance systems capable of detecting early warning signals before amplification occurs. It also underscores the importance of maintaining robust laboratory capacity, strengthening logistical systems, and, where appropriate, implementing targeted catch-up vaccination campaigns for adult populations at increased risk of exposure [7]-[9] [14].

Overall, this study confirms the persistence of sylvatic yellow fever risk in eastern Senegal despite high routine infant vaccination coverage. Operational priorities should include reinforcing differential laboratory diagnosis, securing and maintaining the cold chain, systematically verifying vaccination status among at-risk adult populations, and integrating entomological data into routine surveillance frameworks. Such measures are essential to anticipate and rapidly interrupt potential micro-foci of transmission. In this context, regionally coordinated vaccination strategies, supported by strengthened surveillance and intersectoral collaboration, remain a cornerstone for limiting viral propagation and enhancing epidemic preparedness.

5. Conclusion

The identification of an autochthonous yellow fever case in Sansanding village (Kidira district)—the first regional detection reported in 2020 through the 4S sentinel surveillance network—provides clear evidence of silent yellow fever virus circulation in eastern Senegal and highlights the public health relevance of integrated arbovirus surveillance systems. The multidisciplinary investigation confirmed a single case with a favorable clinical outcome and identified a set of ecological and social determinants conducive to sylvatic transmission, including close human-animal cohabitation, proximity to the Gambia River and Niokolo-Koba National Park, and environments favorable to vector and non-human host presence. Although no secondary transmission was detected, these findings underscore the persistent risk of sporadic sylvatic spillover at the human-wildlife interface and the permeability of forest-related transmission cycles. The corrective actions implemented in response to this event should therefore be embedded within a sustainable, long-term strategy that acknowledges ongoing viral circulation in wildlife reservoirs and the potential for amplification under favorable ecological and operational conditions. In this context, the implementation of a preventive yellow fever vaccination campaign targeting all individuals aged 9 months and older is warranted under the leadership of national and regional health authorities. Such an intervention should be preceded and supported by strengthened cold chain capacity, secure vaccine supply management, targeted risk communication, and effective intersectoral coordination incorporating entomological and veterinary components in line with a One Health approach. Concurrently, maintaining and reinforcing sentinel surveillance, ensuring regular supervision of peripheral health facilities, and promoting joint analysis of clinical, entomological, and environmental signals are essential to enhance early detection, anticipate potential outbreaks, and adapt response measures in a timely manner. Together, these actions will contribute to strengthening regional preparedness and resilience against yellow fever and other emerging arboviral threats.

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Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this article.

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Abbreviations

Ae. aegypti	*Aedes aegypti* (vector mosquito)
CDC	Centers for Disease Control and Prevention (United States)
DENV	Dengue virus
DHIS2	District Health Information Software 2
FJ	Yellow fever
IC95%	95% confidence interval
IgG	Immunoglobulin G
IgM	Immunoglobulin M
M&E	Monitoring and evaluation
One Health	One Health approach
PCR	Polymerase chain reaction
VAA	Yellow fever vaccine
WHO	World Health Organization
WNV	West Nile virus
YFV	Yellow Fever Virus
ZIKV	Zika virus
4S	Syndromic surveillance network (arboviruses)

Appendix

Table A1. Socio-demographic and clinical characteristics of suspected cases.

N°	First Name Last Name	Age	Sex	Address	Relationship to the confirmed case	Symptomatic	Types of symptoms	Date of symptom onset	Consultation	Date of consultation	Sample taken	Sampling date	Sampling result	Evolution
1	H D	40 years	F	Sansanding	Herself	Yes	Fever + Pain syndrome + Subicterus	September 2020	No	Non	Yes	18/10/20	In progress	Favorable
2	S D	10 years	F	Sansanding	Relative	Yes	Jaundice + Repeated vomiting, temperature: 38.1˚C	September 2020	Yes	07/10/20	No			Deceased
3	O D	10 years	M	Sansanding	Parent	Yes	Fever at 38˚C + headaches	October 2020	Yes	02/11/20	Yes	02/11/20	In progress	Favorable
4	A D	15 years	M	Sansanding	Parent	Yes	History of fever (35.5˚C), headaches	Does not know	No		Yes	02/11/20	In progress	Favorable
5	A D	08 months	F	Sansanding	Relative	Yes	Fever (38˚C)	10/31/20	Yes	02/11/20	Yes	02/11/20	In progress	Favorable