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International Journal of Epidemiology and Public Health Research

Research Article

Performance of Acute Flaccid Paralysis and Environmental Poliovirus Surveillance in Kano and Katsina States, Nigeria, 2020–2024

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Article Information

Received: August 25, 2026
Accepted: August 05, 2026
Published: September 18, 2026

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Citation: Sule A Ibrahim, Jamilu Y Runka, Usman M Ibrahim, Elizabeth O Etim, Abba A Danzomo, Adamu I Akyala. (2026) "Performance of Acute Flaccid Paralysis and Environmental Poliovirus Surveillance in Kano and Katsina States, Nigeria, 2020–2024". International Journal of Epidemiology and Public Health Research, 10(4); DOI: 10.61148/28362810/IJEPHR/226.

Abstract

Background: Acute flaccid paralysis (AFP) surveillance and environmental surveillance are complementary systems for detecting poliovirus transmission and identifying geographical gaps in programme performance. This study assessed their performance in Kano and Katsina States, Nigeria, from 2020 to 2024.

Methods: A retrospective longitudinal ecological analysis included all eligible AFP and environmental-surveillance records from 78 local government areas. Indicators were summarised by state and year, while state differences and temporal changes were examined using Welch's t test, mixed-effects logistic regression and negative binomial regression.

Results: The analysis included 4,218 AFP records and 659 collected environmental samples. Mean non-polio AFP rates were 8.68 per 100,000 in Katsina and 5.64 in Kano ($p<0.001$). Mean stool adequacy was 98.82% and 97.68%, respectively ($p=0.008$), while notification within seven days was 76.53% in Katsina and 100% in Kano ($p<0.001$). Environmental collection completeness did not differ significantly. Kano had lower odds of adequate stool specimens but higher odds of environmental sample collection. The adjusted non-polio AFP rate increased by 34.3% annually.

Conclusion: Surveillance sensitivity was high, but notification, follow-up, laboratory timeliness and subnational coverage gaps persisted during implementation.

Keywords: acute flaccid paralysis; environmental surveillance; poliovirus; surveillance performance; non-polio AFP rate; stool adequacy; Kano State; Katsina State.

Introduction

Sensitive poliovirus surveillance remains indispensable to the eradication programme because most poliovirus infections are asymptomatic and the few paralytic cases represent only a small fraction of community transmission. Acute flaccid paralysis surveillance is the principal clinical system for identifying suspected poliomyelitis, while environmental surveillance can detect polioviruses in wastewater before or in the absence of a recognised paralytic case. Global guidance therefore treats the two systems as complementary rather than interchangeable components of a single detection architecture [1,2].

The performance of AFP surveillance is conventionally assessed with the non-polio acute flaccid paralysis rate and stool-specimen adequacy. These headline indicators are supplemented by the timeliness of notification and investigation, specimen transportation, laboratory reporting, completeness and timeliness of routine reports, ward-level silence, vaccination-history

documentation, non-polio enterovirus isolation and completion of 60-day follow-up. Environmental surveillance is similarly dependent on an uninterrupted chain that begins with appropriate site selection and scheduled sample collection and extends through specimen integrity, transportation, laboratory processing, sequencing and communication of results [1,2].

Recent global assessments have shown that many priority countries attain the principal surveillance indicators at national level, yet important subnational gaps persist in districts affected by insecurity, population movement, difficult terrain, weak reporting or uneven access to health services [3,4]. Earlier international surveillance reviews reached the same conclusion: aggregate national performance can appear satisfactory even when particular geographical areas remain insufficiently represented [5]. Consequently, state and local-government analyses are necessary for identifying blind spots that are concealed by national averages.

African surveillance evaluations have reported considerable heterogeneity. Manyanga and colleagues found that several East and Southern African countries sustained non-polio AFP and stool-adequacy performance above recommended thresholds, although performance varied over time and between countries [6]. In South Africa, Howard and colleagues identified lower stool adequacy and weaknesses in the sensitivity of the AFP system in selected settings [7]. A Zambian evaluation similarly reported acceptable non-polio AFP rates alongside variable specimen quality and very low documentation of 60-day follow-up in some years [8]. These findings demonstrate that a surveillance system may meet one component of the standard while remaining weak in another.

Nigeria has maintained extensive AFP surveillance infrastructure through health facilities, disease-surveillance officers, laboratories, community informants and partner-supported field networks. Nevertheless, continuing vaccine-derived poliovirus detections have shown that strong state or national indicators do not necessarily exclude local surveillance gaps. Nigerian studies have described persistent compatible cases, incomplete follow-up, delayed reporting, silent wards and weaknesses in reverse-cold-chain and documentation processes despite overall achievement of key certification indicators [9–13]. Environmental surveillance has strengthened the detection of silent transmission, but its sensitivity depends on sewage characteristics, catchment populations, sample frequency and laboratory turnaround time [14,15].

Kano and Katsina States are epidemiologically important because they contain large urban, rural, mobile and hard-to-reach populations and have experienced continuing poliovirus programme activity. However, evidence comparing the performance of AFP and environmental surveillance across all 78 local government areas during the recent 2020–2024 period has been limited. This study therefore assessed the level, geographical variation and temporal change in AFP and environmental poliovirus surveillance performance in Kano and Katsina States, Nigeria.

Materials and Methods

Study design and setting

A retrospective longitudinal ecological design was used. The study covered Kano and Katsina States in Northwest Nigeria from 1 January 2020 to 31 December 2024. Kano has 44 local government areas, while Katsina has 34, giving 78 local government areas in the analytical area. The two states include densely populated urban settlements, rural communities, mobile and pastoral populations, interstate and international movement corridors, and areas in which insecurity can affect access to health services. AFP surveillance operates throughout both states, whereas environmental-surveillance sites serve selected sewage catchments rather than every local government area.

Study population and sampling

The documentary population comprised eligible AFP case records, AFP case-investigation forms, poliovirus laboratory records, 60-day follow-up records, environmental-surveillance sampling records and environmental laboratory results generated during the study period. A total-population approach was adopted: every record meeting the eligibility criteria was included, and no sample-size calculation was required. Records were eligible when the state, local government area and reporting period could be established and the variables required for the relevant surveillance indicator were available. Duplicate records and records outside Kano or Katsina States or outside the study period were excluded. Where duplicate entries referred to the same event, the earliest complete record was retained and later records were used only to update final classifications or follow-up information.

Data sources and collection

Data were extracted from national and state AFP databases, AFP case-investigation forms, poliovirus laboratory records, environmental-surveillance databases and environmental-site sampling records. The extraction tool captured geographical and temporal identifiers; AFP classification; dates of notification, investigation, stool collection, shipment and laboratory reporting; specimen condition; vaccination history; 60-day follow-up; environmental site and sample identifiers; planned and completed collections; enterovirus recovery; sequencing; and final laboratory classification. AFP records were linked to laboratory records with approved epidemiological identifiers, while environmental records were linked by sample number and site code.

Data quality procedures included range and consistency checks, review of duplicate identifiers, reconciliation of conflicting dates and complete verification of confirmed poliovirus classifications and positive environmental detections. At least 10% of the remaining extracted records were checked against their source documents. Missing information was distinguished from a true zero, a non-applicable indicator and the absence of an environmental site.

Surveillance indicators

The non-polio AFP rate was calculated as the number of AFP cases among children younger than 15 years finally classified as non-polio divided by the estimated population younger than 15 years, multiplied by 100,000. The applicable annual surveillance standard was at least two cases per 100,000 children younger than 15 years, or at least three per 100,000 in outbreak-affected local government areas and periods. Stool adequacy represented the proportion of reported AFP cases from which two specimens were collected at least 24 hours apart within 14 days of paralysis onset and received in good condition. A value of at least 80% was considered satisfactory [1].

Additional AFP indicators were notification within seven days, investigation within 48 hours, timely specimen shipment, availability of final laboratory results within 35 days, reporting completeness, reporting timeliness, silent wards, community detection, completeness of vaccination history, non-polio enterovirus isolation, completeness of case-investigation forms and

completion of 60-day follow-up among eligible cases. Residual paralysis, death, loss to follow-up and polio-compatible classification were reported separately.

Environmental-surveillance indicators included the number of expected and collected samples, collection completeness, enterovirus detection, collection timeliness, sample-condition adequacy, shipment timeliness, laboratory-result timeliness and sequencing timeliness. The performance thresholds were at least 50% for enterovirus detection and at least 80% for collection completeness, timeliness, adequate condition, timely shipment, laboratory reporting and sequencing [2].

Statistical analysis

The analytical datasets were processed in SPSS version 27. Frequencies and percentages were used for categorical variables, while annual and five-year means were used to summarise continuous surveillance indicators. Indicators were calculated separately by state, local government area and year; no composite surveillance index was created. Five-year local-government summaries were derived from annual observations, with case counts summed and rates or percentages averaged across available years.

Mean performance in Kano and Katsina was compared using Welch's independent-samples t test because equality of variances was not assumed. Temporal and state differences in adequate stool specimens were examined with mixed-effects binomial logistic regression containing a random intercept for local government area. Environmental sample collection was analysed with mixed-effects binomial logistic regression containing a random intercept for environmental-surveillance site. The non-polio AFP count was analysed using negative binomial regression with the natural logarithm of the population younger than 15 years as an offset and standard errors clustered by local government area. State and year were entered as fixed effects. Results are presented as odds ratios or incidence-rate ratios with 95% confidence intervals. All tests were two-sided and statistical significance was set at $p<0.05$.

Ethical considerations

Ethical approval was obtained from the Research Ethics Committee of Nasarawa State University, Keffi. Administrative permission to access programme records was obtained from the relevant federal and state health authorities. The ethics committee waived individual informed consent because the study used existing programme records without direct contact with patients or caregivers. Direct personal identifiers were excluded, record-linkage files were stored separately, and findings were reported only in aggregate form.

Results

Distribution of AFP records

A total of 4,218 eligible AFP records were analysed, with 2,109 records from each state. The annual number increased from 485 in 2020 to 1,693 in 2024, although 2021 recorded a lower total than 2020. The marked increase in recorded AFP investigations in the later years was observed in both states (Table 1).

Table 1. Distribution of eligible acute flaccid paralysis records by state and year, 2020–2024

State	2020	2021	2022	2023	2024	Total
Katsina	235	208	345	457	864	2,109
Kano	250	225	335	470	829	2,109
Total	485	433	680	927	1,693	4,218

AFP surveillance performance

The non-polio AFP rate exceeded the applicable minimum standard in both states in every study year. Katsina increased from 5.31 per 100,000 children younger than 15 years in 2020 to 17.28 in 2024, while Kano increased from 3.67 to 10.64 per 100,000 over the same period. The number of local government areas meeting the annual standard improved from 33 of 34 to all 34 in Katsina and from 37 of 44 to all 44 in Kano.

Stool adequacy remained above 96% in every state-year observation. Investigation within 48 hours also remained above 98%. Notification within seven days improved in Katsina from 69.79% in 2020 to 83.66% in 2024, whereas Kano recorded 100% notification timeliness in each year of the analysed dataset. Reporting completeness and reporting timeliness improved in both states, and the proportion of silent wards declined substantially. However, specimen shipment, community detection, vaccination-history completeness, non-polio enterovirus isolation and case-investigation-form completeness varied across years (Table 2).

Table 2. Acute flaccid paralysis surveillance performance indicators by state and year

State	Year	NPAFP cases	Under-15 population	NPAFP rate/100,000	LGAs meeting standard	Total LGAs	Stool adequacy (%)	Notification ≤7 days (%)	Investigation ≤48 h (%)
Katsina	2020	225	4,237,648	5.31	33	34	98.30	69.79	99.15
Katsina	2021	196	4,364,777	4.49	30	34	98.56	74.88	98.56
Katsina	2022	329	4,495,721	7.32	34	34	99.42	77.33	98.55
Katsina	2023	427	4,630,592	9.22	34	34	99.33	82.20	100

State	Year	NPAFP cases	Under-15 population	NPAFP rate/100,000	LGAs meeting standard	Total LGAs	Stool adequacy (%)	Notification ≤7 days (%)	Investigation ≤48 h (%)
Katsina	2024	824	4,769,510	17.28	34	34	97.80	83.66	99.54
Kano	2020	249	6,778,846	3.67	37	44	97.20	100	98.40
Kano	2021	218	6,988,990	3.12	36	44	97.78	100	99.11
Kano	2022	327	7,205,649	4.54	44	44	97.91	100	98.81
Kano	2023	462	7,429,024	6.22	44	44	96.81	100	98.72
Kano	2024	815	7,659,324	10.64	44	44	97.35	100	98.43

Panel A: sensitivity, stool adequacy and notification/investigation timeliness.

State	Year	Reporting completeness (%)	Reporting timeliness (%)	Silent wards (%)	Community detection (%)	Vaccination history complete (%)	NPEV isolation (%)	CIF completeness (%)
Katsina	2020	94.50	83.88	68.28	37.61	86.81	17.68	80.43
Katsina	2021	95.34	86.04	72.20	35.27	94.71	20	75
Katsina	2022	96.14	87.08	55.41	35.94	96.52	23.23	81.45
Katsina	2023	96.25	87.17	48.13	28.01	79.43	22.73	18.60
Katsina	2024	98.17	90.98	23.13	40.62	64.12	29.58	92.71
Kano	2020	94.97	84.40	62.33	34	100	22.36	76
Kano	2021	95.41	86.19	64.89	36.89	100	27.78	73.78
Kano	2022	96.70	88.81	53.85	37.01	100	21.91	73.73
Kano	2023	97.40	91.72	41.03	34.68	100	26.67	67.66
Kano	2024	98.09	92.06	20.32	36.67	100	24.88	74.67

Panel B: reporting, ward coverage, community detection and documentation. NPEV, non-polio enterovirus; CIF, case-investigation form.

Subnational AFP performance

Most local government areas attained the applicable non-polio AFP standard in all five years. In Katsina, Dan Musa, Daura, Mashi, Matazu and Sabuwa attained the standard in four years. In Kano, Bagwai and Fagge attained it in three years, while 11 additional local government areas attained it in four years. Mean stool adequacy exceeded 90% in every local government area. Notification within seven days was consistently 100% across Kano local government areas but ranged from 53.0% in Rimi to 100% in Kankara in Katsina. Reporting completeness exceeded 93% in every local government area, although reporting timeliness, ward silence, community detection, vaccination-history documentation, non-polio enterovirus isolation and case-investigation-form completeness remained heterogeneous (Table 3).

Table 3. Five-year local-government summary of acute flaccid paralysis surveillance performance

State	LGAs meeting NPAFP standard in all 5 years	LGAs not meeting standard in all 5 years	Mean stool adequacy	Notification within 7 days	Reporting completeness	Other observed variation
Katsina	29 of 34	Dan Musa, Daura,	Above 90% in every	53.0% in Rimi to 100% in	Above 93% in every LGA	Reporting timeliness,

State	LGAs meeting NPAFP standard in all 5 years	LGAs not meeting standard in all 5 years	Mean stool adequacy	Notification within 7 days	Reporting completeness	Other observed variation
		Mashi, Matazu and Sabuwa: 4/5 years	LGA	Kankara		silent wards, community detection, vaccination-history completeness, NPEV isolation and CIF completeness varied
Kano	31 of 44	Bagwai and Fagge: 3/5 years; Ajingi, Albasu, Garko, Gezawa, Gwale, Kunchi, Kura, Rogo, Takai, Tofa and Warawa: 4/5 years	Above 90% in every LGA	100% in every LGA	Above 93% in every LGA	Shipment timeliness, silent wards, community detection, NPEV isolation and CIF completeness varied

Sixty-day follow-up

Of 52 eligible AFP cases in Katsina, 46 (88.5%) completed 60-day follow-up; Kano completed 136 of 143 eligible follow-ups (95.1%). Most completed follow-ups documented no residual paralysis. Three Katsina cases and three Kano cases had residual paralysis. Three deaths and six polio-compatible classifications were recorded in Kano. Katsina had the lowest annual follow-up completion in 2021, when one of three eligible cases was completed (Table 4).

Table 4. Sixty-day follow-up outcomes of eligible acute flaccid paralysis cases by state and year

State	Year	Eligible	Completed	Completion (%)	No residual paralysis	Residual paralysis	Death	Lost to follow-up	Polio-compatible
Katsina	2020	4	4	100	4	0	0	0	0
Katsina	2021	3	1	33.33	1	0	0	2	0
Katsina	2022	3	3	100	3	0	0	0	0
Katsina	2023	4	4	100	4	0	0	0	0
Katsina	2024	38	34	89.47	31	3	0	4	0
Kano	2020	14	13	92.86	11	1	1	1	0
Kano	2021	13	12	92.31	11	0	0	1	1
Kano	2022	20	19	95	18	0	0	1	1
Kano	2023	40	38	95	35	0	2	2	1
Kano	2024	56	54	96.43	49	2	0	2	3

Environmental-surveillance performance

Across the five years, 659 of 672 expected environmental samples were collected. Collection completeness exceeded 93% in every state-year observation. Enterovirus detection remained at or above the 50% benchmark, and sample-condition adequacy was generally high. In contrast, collection timeliness, shipment timeliness, laboratory-result timeliness and sequencing timeliness were inconsistent. Laboratory-result timeliness was below 80% in most state-year observations and reached 80.21% only in Kano in 2024. Sequencing timeliness in Katsina declined from 100% in 2020 and 2021 to 25% in 2024. No state-year met every environmental-surveillance standard simultaneously (Table 5).

Table 5. Environmental-surveillance performance indicators by state and year

State	Year	Expected	Collected	Collection completeness (%)	Enterovirus detection (%)	Collection timeliness (%)	Sample condition adequate (%)	Shipment timely (%)	Lab result timely (%)	Sequencing timely (%)	All standards met
Katsina	2020	36	35	97.22	54.29	85.71	100	85.71	68.57	100	0
Katsina	2021	48	47	97.92	51.06	87.23	97.87	85.11	70.21	100	0
Katsina	2022	60	60	100	50	75	96.67	86.67	65	75	0
Katsina	2023	60	56	93.33	71.43	87.50	92.86	87.50	73.21	50	0
Katsina	2024	60	57	95	64.91	87.72	96.49	84.21	68.42	25	0
Kano	2020	60	60	100	65	83.33	100	85	75	100	0
Kano	2021	72	71	98.61	67.61	91.55	100	74.65	74.65	71.43	0
Kano	2022	84	83	98.81	67.47	81.93	98.80	80.72	68.67	66.67	0
Kano	2023	96	94	97.92	63.83	92.55	95.74	84.04	72.34	100	0
Kano	2024	96	96	100	66.67	84.38	98.96	79.17	80.21	100	0

State comparisons and temporal models

Katsina had a significantly higher mean non-polio AFP rate than Kano (8.68 versus 5.64 per 100,000; p<0.001) and a slightly higher mean stool-adequacy proportion (98.82% versus 97.68%; p=0.008). Kano had significantly higher notification within seven days (100% versus 76.53%; p<0.001). Investigation within 48 hours and AFP reporting completeness did not differ significantly between the states. Differences in environmental collection completeness and enterovirus detection were also not statistically significant (Table 6).

After adjustment for year and repeated observations within local government areas, Kano had lower odds of an adequate stool specimen than Katsina (OR=0.567; 95% CI: 0.433–0.742; p<0.001). The annual change in stool adequacy was not statistically significant. Kano had higher odds of environmental sample collection than Katsina (OR=4.544; 95% CI: 1.744–11.840; p=0.002), while the annual change in sample collection was not significant. The adjusted non-polio AFP rate was lower in Kano (IRR=0.659; 95% CI: 0.631–0.689; p<0.001) and increased by 34.3% for each successive year (IRR=1.343; 95% CI: 1.311–1.375; p<0.001) (Table 6).

Table 6. Comparison and regression analysis of surveillance performance

Indicator	Katsina mean	Kano mean	Mean difference (Kano−Katsina)	p-value
NPAFP rate per 100,000	8.68	5.64	-3.04	<0.001
Stool adequacy (%)	98.82	97.68	-1.13	0.008
Notification within 7 days (%)	76.53	100	23.47	<0.001
Investigation within 48 hours (%)	99.03	98.67	-0.36	0.435
AFP reporting	96.09	96.51	0.43	0.099

Indicator	Katsina mean	Kano mean	Mean difference (Kano−Katsina)	p-value
completeness (%)				
Environmental collection completeness (%)	96.69	99.07	2.37	0.112
Environmental enterovirus detection (%)	58.34	66.11	7.78	0.138

Panel A: Welch's independent-samples t-test comparisons.

Outcome	Predictor	Effect	Estimate	95% CI lower	95% CI upper	p-value
Adequate stool specimen	Kano versus Katsina	OR	0.567	0.433	0.742	<0.001
Adequate stool specimen	Year, per one-year increase	OR	0.955	0.891	1.024	0.194
Environmental sample collection	Kano versus Katsina	OR	4.544	1.744	11.840	0.002
Environmental sample collection	Year, per one-year increase	OR	0.897	0.737	1.092	0.280
Non-polio AFP rate	Kano versus Katsina	IRR	0.659	0.631	0.689	<0.001
Non-polio AFP rate	Year, per one-year increase	IRR	1.343	1.311	1.375	<0.001

Panel B: mixed-effects binomial logistic regression for adequate stool specimens and environmental sample collection; negative binomial regression with an under-15 population offset and LGA-clustered standard errors for the non-polio AFP rate. OR, odds ratio; IRR, incidence-rate ratio; CI, confidence interval.

Discussion

This study found high overall sensitivity of the AFP surveillance systems in Kano and Katsina, with the non-polio AFP rate and stool adequacy exceeding the applicable benchmarks throughout the five-year period. The systems also maintained very high investigation timeliness. These results indicate sustained capacity to identify, investigate and collect specimens from suspected AFP cases. Nevertheless, the analysis also showed weaknesses that would have been obscured by reliance on the two principal certification indicators alone, particularly delayed notification in Katsina, persistent silent wards, incomplete 60-day follow-up, variable data completeness and delays within the environmental-surveillance laboratory pathway.

The consistently high non-polio AFP rates and stool adequacy were comparable with findings from East and Southern African surveillance systems reported by Manyanga and colleagues [6] and with the recent evaluation in Kebbi State, Nigeria, where both indicators remained above recommended thresholds [14]. The present results were stronger than those reported in selected South African settings, where stool adequacy was substantially lower [7], and in Zambia, where stool adequacy varied between approximately 71% and 90% [8]. The stronger performance in Kano and Katsina may reflect the long-standing priority assigned to poliovirus surveillance in northern Nigeria, extensive reporting networks and continuing technical and partner support.

High headline performance should not be interpreted as proof that surveillance was equally sensitive in every population. Nigeria has previously recorded continuing poliovirus programme challenges despite apparently satisfactory aggregate indicators [9]. Global surveillance reviews have also warned that national or state averages may conceal local weaknesses in notification, community participation, specimen transport or follow-up [3–5,10]. In the present study, the five-year local-government analysis confirmed that performance was not uniform. Several local government areas failed to attain the applicable non-polio AFP standard in one or two years, and notification timeliness in Katsina varied widely. Reporting completeness was high, but reporting timeliness and ward silence remained variable. These differences justify routine use of LGA-level dashboards and targeted supervision rather than exclusive reliance on state averages.

Notification within seven days was the clearest state-level difference. Kano recorded complete notification timeliness in the analysed data, whereas Katsina improved progressively but remained below the desired level in most years. Delayed notification can narrow the interval available for investigation and collection of adequate specimens and may delay the recognition of clusters or contacts. The decline in silent wards in both states was encouraging and consistent with the effect of intensified active surveillance and community reporting described in Kaduna State [12]. Mobile reporting approaches such as AVADAR have also expanded the geographical reach of AFP alerts, including in difficult settings [17]. However, the persistence of silent wards means that continued active case search, community-informant engagement and review of non-reporting wards remain necessary.

The 60-day follow-up results showed that post-investigation surveillance was less complete than initial case detection and

investigation. Although most eligible cases were followed up, losses to follow-up, residual paralysis, deaths and polio-compatible classifications remained. Similar weaknesses have been reported in Zambia, where 60-day follow-up was poorly documented despite adequate non-polio AFP rates [8], and in Nigerian analyses of polio-compatible cases [11]. Follow-up is not a secondary administrative task: it contributes to final classification and helps resolve cases for which initial laboratory evidence is incomplete. States should therefore include overdue follow-up lists in routine surveillance review meetings and establish responsibility for tracing cases that move between local government areas.

Environmental sample collection was highly complete in both states, and enterovirus detection met the recommended minimum. These findings suggest that the field collection component was functioning and that samples generally contained sufficient faecal material to demonstrate site sensitivity. Nevertheless, no state-year met all environmental-surveillance standards. Laboratory-result timeliness was below the benchmark in most years, and sequencing timeliness declined markedly in Katsina. Environmental surveillance is only as effective as its complete operational chain. Studies from Nigeria and other endemic-risk settings have shown that catchment characteristics, sewage flow, sample integrity, transport, processing and sequencing jointly determine the probability and timeliness of poliovirus detection [14,15,19]. Delayed laboratory or sequencing results can weaken the programme value of samples that were collected correctly and on schedule.

The absence of a statistically significant state difference in environmental collection completeness and enterovirus detection does not imply uniform site performance. Environmental sites are not distributed across all local government areas and serve catchments with different population contributions and sewage characteristics. Hamisu and colleagues demonstrated that measurable site and catchment characteristics affect the sensitivity of Nigerian environmental-surveillance sites [14]. Therefore, annual site reviews should examine not only whether scheduled samples were collected but also whether each site continues to represent the intended population, consistently recovers enteroviruses and produces results rapidly enough to influence programme action.

The regression analysis strengthened the descriptive findings. The adjusted non-polio AFP rate increased by approximately one-third per year, suggesting progressively greater detection activity over the period. This may reflect strengthened active surveillance, expanded reporting sources or increased programme attention. However, a rising non-polio AFP rate should be interpreted alongside the proportion of silent wards and the geographical distribution of reports because an increase concentrated in already well-performing locations would not necessarily eliminate surveillance blind spots. The lower adjusted rate in Kano, despite high notification timeliness, further illustrates that different components of surveillance performance do not always move together.

Kano had lower adjusted odds of stool adequacy than Katsina, although both states remained well above the recommended threshold. The statistical difference is therefore more useful for quality improvement than as evidence of surveillance failure. It identifies a measurable gap that could be examined through specimen-collection practices, transport conditions and the distribution of inadequate specimens by local government area. Reverse-cold-chain monitoring in Nigeria has shown that close supervision of specimen handling and transport can identify operational failures that are not visible from aggregate stool-adequacy percentages alone [13].

The study has programme implications. First, surveillance review should be conducted at local-government and ward levels, with attention to locations that repeatedly fail the non-polio AFP standard or remain silent. Second, notification and 60-day follow-up should receive the same management attention as investigation and stool collection. Third, environmental surveillance requires performance monitoring beyond sample completeness, particularly for laboratory and sequencing turnaround times. Finally, AFP and environmental-surveillance data should be reviewed together. A clinically sensitive AFP system and complete environmental sampling do not remove the need to investigate inconsistencies between clinical reports, wastewater detections and geographical reporting patterns.

Strengths and limitations

The study used all eligible records from the 78 local government areas over five consecutive years and assessed multiple surveillance dimensions rather than relying only on the two headline AFP indicators. The longitudinal structure permitted assessment of temporal change, while mixed-effects models accounted for repeated observations within local government areas or environmental sites. The principal limitations were the retrospective dependence on the completeness and accuracy of programme records, variation in the availability of some laboratory and shipment indicators, and the restricted geographical coverage of environmental-surveillance sites. State-level averages could also mask ward- and settlement-level variation. The ecological design does not permit individual-level causal conclusions.

Conclusion

AFP surveillance in Kano and Katsina States demonstrated high overall sensitivity from 2020 to 2024: non-polio AFP rates exceeded the applicable standards, stool adequacy remained above 96%, and investigation within 48 hours was consistently high. Performance was nevertheless uneven. Katsina had lower notification timeliness, several local government areas failed to meet the annual non-polio AFP standard in one or more years, silent wards persisted, and 60-day follow-up was incomplete for some cases. Environmental sample collection was highly complete and enterovirus recovery met the expected benchmark, but laboratory and sequencing timeliness remained inconsistent. Programme improvement should therefore move beyond state-level headline indicators to routine LGA- and site-level review of notification, ward silence, follow-up, specimen handling and laboratory turnaround time.

Acknowledgements

The authors acknowledge the federal and state poliovirus surveillance and immunisation programme authorities, laboratory personnel, disease-surveillance officers and data managers whose programme records supported the study.

Funding

The authors received no specific funding for this study.

Author contributions

Conceptualization; SAI, AIA methodology; SAI, UMI, EOE, AAD data curation; SAI, EOE, JHR, AAD formal analysis; SAI, EOE, UMI, JYR investigation; SAI, AIA, JYR, AAD supervision; SAI,

AIA, JYR, UMI. Writing-original draft; SAI, EEE, JYR writing-review and editing; SAI, EOE, JYR. AIA. All authors should approve the final manuscript.

Conflict of interest

The authors declare that they have no conflicts of interest.

Data availability

The analytical data are derived from programme surveillance records and are subject to institutional, ethical and programme restrictions. De-identified data may be made available by the corresponding author upon reasonable request and with permission from the relevant health authorities.

Ethics approval

Ethical approval was granted by the Research Ethics Committee of Nasarawa State University, Keffi. The requirement for individual informed consent was waived because the study involved retrospective review of existing programme records.

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