

Research Article

Exploring the Performance, Challenges, and Digitalization Opportunities in Measles and Rubella Laboratory Surveillance in Nigeria: A Qualitative Study

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Abstract

Measles and rubella remain important vaccine-preventable diseases in Nigeria, with persistent transmission and variable surveillance performance across regions. This study examines the performance, challenges, and digitalization opportunities of measles and rubella surveillance in Nigeria. This study adopted a qualitative research design to explore the performance, challenges, and opportunities within the measles and rubella laboratory surveillance system in Nigeria. Data were collected through in-depth key informant interviews with 40 purposively selected laboratory personnel across eight national laboratories. Participants included heads of laboratories and officers responsible for data management, surveillance, quality assurance, and logistics. Interviews were transcribed and analysed using thematic analysis in QDA Miner to identify key themes related to laboratory performance, operational challenges, data quality, and digitalization opportunities. Findings indicated improving testing capacity but inconsistent turnaround times due to reagent stockouts, staffing gaps, and funding constraints. Six of nine respondents reported improving testing capacity, while five observed fluctuations in turnaround time linked to intermittent reagent shortages. Results further showed that the COVID-19 pandemic temporarily disrupted operations by diverting resources and reducing sample volumes. Data incompleteness was mainly attributed to inadequate training and poor documentation, despite the widespread use of validation mechanisms such as external quality assessments and data harmonization. Approximately seven of nine respondents identified reagent stockouts as the most significant operational challenge, while six highlighted unreliable internet connectivity as a major barrier to digitalization. Most laboratories used basic digital tools, with strong support for real-time electronic reporting despite challenges such as poor internet connectivity and limited training. Measles and rubella laboratory surveillance systems demonstrate improving capacity and functional quality assurance practices; however, sustained performance is constrained by supply chain instability, workforce limitations, and weak funding structures. Strengthening logistics systems, investing in human resources, and expanding tailored digital infrastructure are critical to achieving resilient, timely surveillance.

Keywords

Measles, Rubella, Laboratory Challenges, Digitalization Opportunities

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Received: 14 May 2026; Accepted: 22 May 2026; Published: 30 May 2026



1. Introduction

Measles and rubella are highly contagious viral diseases posing significant global public health challenges despite extensive vaccination and control efforts. Both diseases present distinct viral features, clinical manifestations, and complications ranging from mild to severe [1].

Measles and Rubella are widely recognized as common childhood illnesses [2]. Globally, an estimated 9,232,300 measles cases were reported in 2022 [3]. Despite the availability of a safe and cost-effective vaccine, measles remains a major cause of morbidity and mortality worldwide, accounting for approximately 136,000 deaths in 2022, most of which occurred among children under five years of age [3, 4].

Similarly, although an effective vaccine exists for rubella, gaps in immunization persist, with 19 countries yet to introduce the vaccine and nearly half of all countries still unable to achieve rubella elimination [5]. Rubella infections in both children and adults are typically mild and less severe, which makes detection through surveillance systems more difficult [6, 7].

Measles is caused by the measles virus, a member of the Paramyxoviridae family, and are primarily transmitted through respiratory droplets. It ranks among the most contagious diseases, with a basic reproduction number (R0) ranging between 12 and 18 [8].

Measles is a highly contagious febrile illness characterized by a maculopapular rash that appears on the face and spreads across the body [9]. In contrast, rubella is an infectious disease that generally presents with mild fever and rash in both children and adults [2].

Rubella, or German measles, is caused by the rubella virus, a member of the Togaviridae family. Although generally a mild illness in children, rubella can have severe consequences if contracted by pregnant women, potentially resulting in congenital rubella syndrome (CRS) [5, 9].

Measles and rubella remain significant public health challenges in Nigeria despite being vaccine preventable. The country continues to experience recurrent outbreaks due to gaps in immunization coverage and weaknesses in public health surveillance systems. According to the World Health Organization (WHO), Nigeria's measles vaccination coverage in 2021 was below the 95% threshold necessary for herd immunity, contributing to these outbreaks. Rubella poses a similar threat, particularly due to its risk of CRS in newborns when pregnant women contract the virus [10].

The surveillance of measles and rubella in Nigeria is crucial for controlling these diseases, but the current laboratory-based reporting system faces significant challenges. Data inconsistencies, incomplete reporting, and delayed responses hinder the early detection of outbreaks and limit the effectiveness of immunization programs. An evaluation of Nigeria's public health laboratory network reveals that infrastructure deficits,

inadequate funding, and a lack of skilled personnel further exacerbate these issues, making timely and accurate laboratory diagnoses difficult [11].

Recent advances in digital public health surveillance across Africa have demonstrated the potential of electronic surveillance systems and laboratory information management systems (LIMS) to improve outbreak detection, timeliness of reporting, data accuracy, and interconnectivity between laboratories and surveillance units. Platforms such as Surveillance Outbreak Response Management and Analysis System (SORMAS), Epi Info, and electronic Laboratory Information Management Systems (E-LIMS) have increasingly been adopted in several African countries to strengthen disease surveillance and response activities, particularly during outbreaks and public health emergencies [12]. Studies have shown that digital surveillance tools can enhance real-time data sharing, reduce reporting errors, improve laboratory workflow monitoring, and support evidence-based decision-making in low- and middle-income countries. However, implementation challenges, including poor internet connectivity, inadequate technical capacity, inconsistent funding, and limited integration between laboratory and surveillance systems, continue to affect sustainability and effectiveness in many African public health settings [13]. These realities highlight the need to better understand opportunities and barriers related to digitalization within Nigeria's measles and rubella laboratory surveillance system.

With the increasing global emphasis on digital health, there is potential to improve Nigeria's surveillance system through digital tools. Real-time data reporting and electronic systems could enhance the accuracy and efficiency of disease monitoring, but these technologies have not been widely adopted in Nigeria's public health network.

This study examines the performance, challenges, and digitalization opportunities of measles and rubella surveillance in Nigeria.

2. Materials and Methods

2.1. Study Design

This study adopted a qualitative research design to explore the performance, challenges, and opportunities within the measles and rubella laboratory surveillance system in Nigeria. The study focused on understanding the experiences, perceptions, and operational realities of laboratory personnel involved in measles and rubella testing and data management. It specifically examined system performance, operational challenges, data quality issues, and opportunities for digitalization within the national laboratory surveillance network.

2.2. Study Settings

The study was conducted across Nigeria, a country located in West Africa and divided into six geopolitical zones: North-East, North-West, North-Central, South-West, South-East, and South-South. Nigeria has a population exceeding 200 million people and a diverse health system structure that supports disease surveillance across all regions.

The study focused on eight reference laboratories within the national measles and rubella laboratory network, which are strategically distributed across the six geopolitical zones to support surveillance activities. These include: Central Public Health Laboratory (Lagos), Yusuf Danso Memorial Hospital (Kaduna), Maitama District Hospital (Abuja), Gombe State Specialist Hospital (Gombe), National Reference Laboratory (Abuja), University of Maiduguri Teaching Hospital (Borno), University of Benin Teaching Hospital (Edo), and University of Nigeria Teaching Hospital (Enugu). These laboratories play key roles in sample testing, data reporting, and coordination of surveillance activities across their respective regions.

2.3. Study Population

The study population comprised key informants directly involved in measles and rubella laboratory surveillance and data management across the selected laboratories. These included laboratory managers, data management officers, surveillance officers, quality assurance/control officers, and logistics/procurement officers. These individuals were selected due to their direct involvement in laboratory testing processes, reporting systems, and decision-making related to surveillance activities.

2.4. Sampling Techniques

A purposive sampling technique was employed to select participants among the selected facilities with relevant expertise and experience in measles and rubella laboratory surveillance. This approach ensured that only individuals with in-depth knowledge of laboratory operations, data systems, and surveillance challenges were included. The selection was based on predefined roles within each laboratory to ensure consistency and comprehensive representation of perspectives. Since the study involves interviewing key informants who are responsible for the laboratory testing and data management of measles and rubella samples, this method ensures that the most knowledgeable and relevant individuals are targeted.

2.5. Sample Size

A total of 40 key informants were included in the study, with five participants selected from each of the eight laboratories. The participants included the Head of Laboratory, the Data Management Officer, the Surveillance Officer, the Quality Assurance/Control Officer, and the Logistics/Procurement Officer. The sample size was deemed sufficient to achieve data saturation, as no new themes or insights emerged from

additional interviews. Data saturation was formally assessed during the interview process through concurrent preliminary review of interview transcripts and emerging themes. Recruitment of participants was discontinued once successive interviews yielded repetitive information without generating substantially new codes or thematic insights.

2.6. Data Collection Procedure

Key informant interviews are conducted with five (5) focal persons and data officers from each laboratory. They are the Head of the Laboratory (Laboratory Manager/Director), Data Management Officer (Data Analyst/Officer), Surveillance Officer (Epidemiologist/Public Health Officer), Quality Assurance/Control Officer and Logistics and Supply Chain Manager (Procurement Officer). This method helps to gather insights on measles and rubella surveillance, operational challenges, reagent supply, testing processes, and data management practices.

2.7. Eligibility Criteria

Inclusion Criteria:

Participants who held one of the predefined roles (Head of Laboratory, Data Management Officer, Surveillance Officer, Quality Assurance/Control Officer, or Procurement Officer) and had direct involvement in measles and rubella laboratory testing or data reporting during the study period were included.

Exclusion Criteria:

Individuals not directly involved in measles and rubella laboratory activities or those with limited experience in surveillance processes were excluded. Participants who declined consent were also excluded from the study.

2.8. Data Analysis

Qualitative data was analysed using thematic analysis with the support of QDA Miner software. Interview recordings were transcribed verbatim, and transcripts were reviewed for accuracy. The analysis followed a systematic process that included familiarization with the data, coding relevant text segments, developing categories, and identifying overarching themes.

Codes were both deductive (based on the study objectives) and inductive (emerging from the data). Themes were developed around key areas, including laboratory performance trends, data quality and validation processes, operational challenges, and digitalization opportunities. Narrative synthesis was used to present findings, supported by direct quotations from participants to enhance credibility and depth of interpretation.

2.9. Ethical Considerations

Ethical approval for the study was obtained from the Insti-

tutional Review Board (IRB) of the Nigerian Institute of Medical Research (NIMR). Informed consent was obtained from all participants prior to data collection. Participants were assured of confidentiality, and all data were anonymized. Audio recordings and transcripts were securely stored and used solely for research purposes.

3. Results

3.1. Qualitative Performance Trends (2014-2023)

Six of the nine respondents reported positive or improving trends in testing capacity. Five respondents observed fluctuations in turnaround time, largely attributed to intermittent reagent availability. In addition, five respondents reported that COVID-19 negatively affected laboratory operations, citing reduced sample volumes and diversion of resources.

3.2. Narrative Synthesis

Across participating laboratories, respondents generally described measles and rubella testing capacity over the past decade as stable to strongly improving, particularly in the most recent four years. One focal person noted that "We have maintained a consistent performance over these years e.g EQA, PT has been 100%", while another highlighted that "The testing trend has increased significantly from 84 samples in 2023 when the Laboratory was optimized for testing to over 500 samples annually currently." A smaller number of respondents emphasized that gains were more recent, explaining that "The trend has not been consistent but there is a significant improvement in the last 4 years." Perceptions of turnaround time were closely tied to the availability of reagents. Several respondents described how "TAT do improve when reagents is available and declined when faced with short supply", while others emphasized that, in the absence of major stockouts, "The TAT is steadily on a positive note" and that targets were largely met, with one participant recalling that "Except for 2019 when NRL could not reach a target of 80 percent, it has consistently reached the 80 percent target up to date." Taken together, these accounts suggest that the system is capable of meeting timeliness benchmarks when supply chains are stable.

The COVID-19 pandemic was widely perceived as a disruptive period for measles and rubella testing, primarily due to the diversion of human and material resources. One respondent reported that "Testing capacity was significantly reduced, probably due to diversion of resources to contain COVID-19", while another explained that the pandemic "Impacted negatively on the Turn-Around-Time due to diversion of Laboratory Scientists to the COVID-19 bench." Others pointed to a "Marked reduction in sample shipments", underscoring how both demand- and supply-side factors combined to temporarily depress routine surveillance capacity.

3.3. Data Quality and Completeness

A majority of respondents linked incomplete data primarily to limited training and documentation practices: roughly 2 of 9 explicitly mentioned lack of training, while 3 referred to incomplete or poorly completed case investigation forms. Respondents nevertheless described several validation mechanisms (n=8), including participation in external quality assessment schemes, routine harmonization of laboratory and surveillance datasets, and the use of dedicated data quality checker tools.

3.4. Narrative Synthesis

Participants consistently linked incomplete surveillance data to upstream documentation and capacity gaps at facility and district levels. Respondents pointed to "Lack of proper filling of CIFs by the DSNOs" and "Lack of training for some DSNOs and Incomplete CIF forms", while others emphasized that the "Right people [are] not trained at the facility level." Workload and competing demands were also cited, with one participant attributing gaps to "Lack of commitment from the data person and Much workload and desire to meet up with the deadline for weekly data submission."

Despite these challenges, respondents described a range of mechanisms used to safeguard data accuracy. Several laboratories reported that "We do that by consistently participating in External quality assessment with the Regional Reference Laboratory" and emphasized routine "Harmonization of the Laboratory data with Surveillance data." Others mentioned the use of specific tools, noting that "The accuracy is validated by using data quality checker tool." These practices suggest that, even where primary data capture is imperfect, there are structured attempts to validate and reconcile surveillance information.

3.5. Operational and Systemic Challenges

Across sites, reagent stockouts dominated the operational landscape: approximately 7 of 9 respondents identified stockouts as their single biggest challenge, and 7 described stockouts as occurring multiple times per year. In parallel, around 3 respondents perceived current staffing as inadequate, and several highlighted persistent equipment (5 mentions) and power (3 mentions) constraints.

Operational narratives converged strongly on reagent availability as the most critical constraint on laboratory performance. Multiple respondents simply described "Stock out of testing reagents" as their single biggest challenge, while others linked this to broader capacity limitations such as "Reagent Stockout and lack of molecular testing capability" and "Periodical reagent and consumables stock out. Inconsistent equipment calibration and back up equipment." One laboratory summarized the frequency and severity of these disruptions, stating that stockouts occurred "Most times twice in a year. 'Presently out stock reagents in March/April and now from August to date.'"

Staffing and workload emerged as additional cross-cutting pressures. Participants reported that "It is not adequate. Staff working in the lab are not permanently stationed hence they can be transferred. The staff also are saddled with other activities" and that "The current staffing levels are not adequate, most of the staff working on measles and rubella bench are still engaged in other routine work in the lab affecting their commitment." Others described the situation more succinctly as "Inadequate (need for committed staff)." These accounts point to both numerical shortages and issues of role clarity and stability. Underpinning many of these challenges are structural funding gaps. One respondent noted that "There is no specific budget allocated to the lab for its day to day running. Funding gap for repair of equipment & maintenance, data for Internet connectivity", while another explained that "The FP used his personal data to send reports every week for the past 3 1/2 years now. No budget for Measles Rubella laboratory activity." Others highlighted the risks of reliance on a narrow funding base, emphasizing that "Funding is from only one channel. Need for more funding partners." Together, these perspectives reinforce the conclusion that operational weaknesses are closely tied to the absence of predictable, dedicated financing.

3.6. Digitalization Opportunities

Most laboratories reported using basic electronic tools, particularly Epi Info (approximately 5 of 9 respondents), while a smaller number used more advanced platforms such as SORMAS, E-LIMS or Power BI, and 2 reported having no digital tools in routine use. Perceived benefits of a real-time electronic reporting system were largely positive: about 7 of 9 respondents anticipated faster, more accurate reporting and improved access to results. However, respondents also highlighted important barriers to digital adoption, most notably unreliable internet or network connectivity (mentioned by 6 respondents) and the need for additional staff training (mentioned by 3 respondents). Notwithstanding these barriers, most respondents felt that staff could manage a fully digital system provided appropriate training and support were available (around 9 affirmative responses).

3.7. Narrative Synthesis

Digital practices across laboratories ranged from complete absence of tools to the use of more advanced platforms. Most participants reported reliance on Epi Info alone, while a small subset described using additional tools such as SORMAS, E-LIMS and Power BI. Despite this variation, there was broad agreement that a move to real-time electronic reporting would be beneficial. One respondent anticipated that "It will improve timeliness in data sharing, it will reduce data error as the attention can be drawn to any error committed and it is rectified immediately", while others felt it would "Enhance real time reporting and access to the results by the state, LGA, facilities" and "Will improve Data storage analysis and archiving."

At the same time, participants highlighted a set of structural barriers that currently limit digital transformation. Several respondents pointed to "Lack of adequate Internet and training of staff" and broader "Network challenge, lack of government commitment", while others emphasized practical resource constraints such as "Data for Internet connectivity, data clerk." One participant also noted that existing "Surveillance tools does not fit very well for laboratory, there is need for Laboratory data tool", underscoring the importance of laboratory-specific system design rather than simple extension of general surveillance platforms.

4. Discussion

4.1. Performance of Measles and Rubella Testing Capacity

Findings indicate that measles and rubella testing capacity has been largely stable or improving over the past decade, with more pronounced gains reported in the last four years. Respondents highlighted improvements in sample throughput, sustained external quality assessment (EQA) performance, and increasing testing volumes following laboratory optimization. These trends are consistent with reports from WHO-supported laboratory networks in low- and middle-income countries (LMICs), where targeted investments in laboratory strengthening, quality assurance, and staff capacity have led to measurable improvements in diagnostic performance and surveillance sensitivity over time [14].

However, the observed fluctuations in turnaround time (TAT) underscore the fragility of these gains. Similar to findings from measles and rubella laboratory evaluations in sub-Saharan Africa, TAT performance in this study was strongly dependent on uninterrupted reagent supply [15, 16]. While laboratories were generally able to meet the 80% timeliness benchmark during periods of adequate supply, intermittent stockouts led to performance dips, highlighting supply chain reliability as a key determinant of surveillance effectiveness.

The COVID-19 pandemic emerged as a major disruptive force, with respondents consistently describing reduced testing volumes, staff redeployment, and delayed reporting. These experiences mirror global evidence showing that routine immunization and vaccine-preventable disease surveillance systems were significantly compromised during the pandemic due to resource diversion and movement restrictions [17]. Importantly, the qualitative accounts in this study suggest that the impact was largely temporary, reinforcing the underlying capacity of the system to rebound when resources were restored.

4.2. Key Challenges Affecting the Functioning of Measles and Rubella Public Health Laboratory Network

Incomplete data, particularly poorly completed case investigation forms (CIFs) was identified as a persistent challenge,

primarily attributed to limited training, high workload, and weak documentation practices at peripheral levels. These findings align with previous studies across Africa that have identified frontline surveillance capacity, rather than laboratory processes, as a major bottleneck to data completeness and quality [18]. Similar challenges have been reported in integrated disease surveillance and response (IDSR) systems, where competing reporting demands and insufficient supervision contribute to documentation gaps.

Despite these upstream weaknesses, respondents described multiple downstream validation mechanisms, including routine data harmonization between laboratory and surveillance units, participation in EQA schemes, and the use of data quality checker tools.

Reagent stockouts emerged as the dominant operational challenge, reported by the majority of respondents and occurring multiple times per year. This finding is consistent with a substantial body of literature identifying procurement delays, dependence on donor-supported supply chains, and limited national buffer stocks as chronic challenges for public health laboratories in LMICs [19]. The frequency and duration of stockouts described in this study suggest that they are not isolated events but rather systemic weaknesses that directly affect testing capacity and timeliness.

Staffing constraints further compounded these challenges. Respondents described inadequate staffing levels, frequent staff redeployment, and lack of dedicated personnel for measles and rubella testing. Similar human resource challenges have been documented in national reference laboratories, where multitasking across disease programs dilutes focus and reduces accountability [20]. Importantly, respondents emphasized not only numerical shortages but also the lack of permanent assignment, highlighting governance and workforce management issues beyond simple headcount.

Underlying many of these operational difficulties were funding gaps and the absence of dedicated laboratory budgets. Reliance on a single funding stream and the use of personal resources to sustain routine reporting reflect broader concerns raised in the literature about the sustainability of vertical disease surveillance programs [13]. Without predictable domestic financing, laboratories remain vulnerable to interruptions in consumables, equipment maintenance, and connectivity, even when technical capacity exists.

4.3. Digitalization Opportunities and Constraints

The findings reveal a heterogeneous digital landscape, with most laboratories relying on basic tools such as Epi Info, while only a few had adopted more advanced platforms like SORMAS or electronic laboratory information management systems (E-LIMS). This pattern is consistent with regional assessments showing incremental rather than comprehensive digital transformation of surveillance systems [12]. Encourag-

ingly, respondents overwhelmingly perceived real-time electronic reporting as beneficial, particularly for improving timeliness, reducing errors, and enhancing data accessibility across levels of the health system.

Nevertheless, significant barriers to digital adoption were identified, notably unreliable internet connectivity, insufficient training, and lack of laboratory-specific digital tools. These constraints echo findings from other LMIC contexts, where digital surveillance initiatives have struggled due to infrastructure limitations and insufficient alignment between laboratory workflows and surveillance platforms [13]. The observation that existing surveillance tools may not adequately fit laboratory needs underscores the importance of co-designing digital systems that integrate laboratory and epidemiological data rather than simply extending case-based reporting platforms.

Notably, most respondents expressed confidence in their ability to transition to fully digital systems with adequate training and support. This optimism aligns with evidence suggesting that human capacity is often less of a barrier than infrastructure and sustained investment. As such, digitalization represents a clear opportunity for strengthening measles and rubella surveillance, provided that investments address connectivity, system design, and ongoing technical support.

From a policy perspective, strengthening digital surveillance integration within Nigeria's measles and rubella laboratory network requires coordinated national investment in interoperable health information systems, reliable internet infrastructure, and sustainable financing mechanisms. Expanding the use of electronic laboratory information management systems and integrating laboratory reporting platforms with existing surveillance systems, such as SORMAS, could improve real-time data sharing, outbreak detection, and response coordination across all levels of the health system. In addition, practical implementation pathways should include phased digital deployment, continuous workforce training, dedicated technical support, and the development of laboratory-specific reporting tools that align with operational workflows. Strengthening collaboration between government agencies, development partners, and telecommunications providers may further support infrastructure expansion and long-term sustainability of digital surveillance systems in Nigeria.

5. Limitation and Strategies

This study is subject to potential limitations, including recall bias, as participants may not accurately remember past events or experiences over the 2014–2023 period. There is also the possibility of social desirability bias, where respondents may provide overly positive accounts of laboratory performance or underreport system challenges. Additionally, the purposive sampling approach, while appropriate for expert insight, may limit the generalisability of findings beyond the selected laboratories. Variations in participant roles and institutional contexts may also influence the consistency of responses.

To mitigate these limitations, participants were carefully selected based on their direct involvement in measles and rubella surveillance to ensure informed and reliable responses. Data triangulation across different cadres of laboratory personnel helped to validate findings and reduce individual bias. The use of a semi-structured interview guide ensured consistency in data collection across all sites, while audio recording and verbatim transcription improved accuracy and reduced information loss. Confidentiality assurances were provided to encourage honest and unrestricted responses, thereby minimizing social desirability bias.

6. Conclusions

This study highlights that measles and rubella laboratory surveillance in Nigeria has shown overall improvement in testing capacity and quality assurance performance over the past decade, particularly in recent years. Despite these gains, the system remains vulnerable to recurrent operational challenges, especially reagent stockouts, inadequate staffing, limited funding, and infrastructure constraints. These weaknesses directly affect turnaround time, data completeness, and service continuity. While laboratories have adopted basic digital tools and demonstrated readiness for more advanced electronic reporting systems, successful digital transformation will require reliable internet access, targeted training, and systems tailored to laboratory workflows. Strengthening supply chain management, securing sustainable financing, and investing in workforce development and digital infrastructure are essential to ensure a more resilient, timely, and high-performing measles and rubella surveillance system.

Abbreviations

ART	Antiretroviral Therapy
CIF	Case Investigation Form
COVID-19	Coronavirus Disease 2019
CRS	Congenital Rubella Syndrome
DSNO	Disease Surveillance and Notification Officer
EAC	Enhanced Adherence Counseling
E-LIMS	Electronic Laboratory Information Management System
EQA	External Quality Assessment
HIV	Human Immunodeficiency Virus
IDSR	Integrated Disease Surveillance and Response
IRB	Institutional Review Board
LMICs	Low- and Middle-Income Countries
NCDC	Nigeria Centre for Disease Control
NIMR	Nigerian Institute of Medical Research
PT	Proficiency Testing
QDA	Qualitative Data Analysis
SARI	Severe Acute Respiratory Infection

SORMAS	Surveillance Outbreak Response Management and Analysis System
STI	Sexually Transmitted Infection
TAT	Turnaround Time
WHO	World Health Organization

Acknowledgments

We sincerely appreciate the contributions of all the authors to this study. Their dedication, expertise, and valuable insights were instrumental in shaping this work.

Author Contributions

Kayode Akanbi: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft

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Data Availability Statement

The datasets analyzed in the current study are not publicly available due to confidentiality agreements and the qualitative nature of the data, which involve participant interviews, but are available from the corresponding author upon reasonable request and with permission from the relevant institutions.

Conflicts of Interest

The authors declare no conflicts of interest.

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