Interdisciplinary Journal of the African Alliance For Research, Advocacy & Innovation
ISSN (O) : 3093-4664
Vol.2, Issue 4 | Oct–Dec 2026
www.ijaarai.org

Strengthening Disease Surveillance, Outbreak Preparedness, and Response Through Medical Laboratory Systems in Nigeria: Roles, Requirements, and Post-Ebola Reforms

Author(s): [1]Victoria Akoh Asmawo, [2,3]Abigail Jeremiah

[1]University of Abuja Teaching Hospital, Gwagwalada, Abuja.

[2]Global Health and Infectious Diseases Control Institute, Nasarawa State University,Keffi, Nasarawa State, Nigeria

[3]Nigeria centre of Disease Control and Prevention (NCDC)

Corresponding Author: abigailjeremiah@nsuk.edu.ng

Abstract

The 2014 Ebola Virus Disease epidemic in West Africa revealed how fragile diagnostic and surveillance infrastructure can be, while Nigeria's containment of its imported cases showed what rapid laboratory confirmation can achieve. This narrative review examines the contribution of medical laboratory systems to disease surveillance and outbreak preparedness, with emphasis on laboratory strengthening in Nigeria. Literature published between the last fifteen years was identified from PubMed, AJOL, Google Scholar, and WHO, Africa CDC, and NCDC repositories, screened against predefined inclusion criteria, and synthesised thematically. Evidence indicates that the Ebola experience prompted major institutional and technical reforms, despite this progress, challenges remain, including inadequate funding, uneven distribution of laboratories, unreliable power and supply chains, workforce shortages, weak sample transport, and limited data interoperability. However, Nigeria-specific quantitative evidence on laboratory coverage, turnaround time, and quality is sparse, and the contribution of laboratory capacity to outcomes is difficult to separate from contact tracing and emergency coordination. The review concludes that reliable laboratory systems are central to detecting infectious disease threats early and guiding a coordinated public health response, and that sustained domestic financing, workforce development, accredited decentralised laboratories and digital reporting are required to sustain health security.

Keywords: Laboratory systems, Disease surveillance, Outbreak preparedness, Ebola, Nigeria, Integrated Disease Surveillance and Response, Medical laboratory scientists, Health security

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

1. Background

In an era where global health is constantly challenged by emerging and re-emerging infectious diseases, the role of the medical laboratory has never been more critical to the sustainability of public health systems (Ogunsola, 2015). Medical Laboratory Scientists (MLS) and the comprehensive services they provide have evolved to become central pillars of the public health ecosystem, moving far beyond the traditional perception of mere sample processing to become essential components in identifying health threats, guiding clinical and public health interventions, and preventing widespread disease transmission across populations (Cantón, 2005). The contemporary medical laboratory now serves as both a diagnostic center and a critical intelligence hub for public health surveillance systems.

1.1 Surveillance and Response: Concepts and Definitions

The framework for effective public health action is fundamentally built upon two interconnected and mutually reinforcing pillars: Surveillance and Response (McNabb et al., 2002). These components work synergistically to create a robust system capable of protecting population health and preventing the escalation of disease threats into full-scale epidemics or pandemics.

Disease surveillance represents an ongoing, systematic process that involves the continuous and organised collection, rigorous analysis, careful interpretation, and timely dissemination of health information regarding the occurrence and distribution of diseases in clearly defined populations (Osterholm & Hedberg, 2015). Surveillance systems serve as the eyes and ears of public health infrastructure, constantly monitoring the health status of populations and detecting anomalies that may signal emerging threats (Onduku, 2019).

Timely and accurate laboratory diagnosis is the foundation of disease surveillance, outbreak detection, and effective public health response (Nkengasong et al., 2010). The 2014 West African Ebola Virus Disease outbreak exposed weaknesses in laboratory systems across the region, yet Nigeria's rapid laboratory confirmation, contact tracing, and coordinated emergency operations limited the outbreak to 20 cases (19 laboratory-confirmed and one probable) and 8 deaths before the World Health Organization declared the country Ebola-free in October 2014 (Shuaib et al., 2014; Fasina et al., 2014; Otu et al., 2018). The experience stimulated sustained investment in Nigeria's laboratory and surveillance systems, which later supported responses to Lassa fever, cholera, meningitis, mpox, and COVID-19 (Ihekweazu & Agogo, 2020). This review therefore examines how effective medical laboratory systems strengthen surveillance and outbreak preparedness, with particular attention to laboratory strengthening in Nigeria after Ebola. Specifically, it (i) traces the evolution of disease surveillance in Nigeria, (ii) outlines the categories and roles of medical laboratories in surveillance and outbreak response, (iii) reviews post-Ebola laboratory reforms, and (iv) identifies challenges, knowledge gaps, and recommendations.

Surveillance also serves as the early-warning system of public health, allowing authorities to detect outbreaks, track disease trends, target interventions, and judge whether control

measures are working (Ibrahim, 2020). The COVID-19 pandemic showed how much depends on the strength of these systems. Countries with timely case detection, laboratory confirmation, and data-driven decision-making were better placed to slow transmission and protect health services (Ibrahim, 2020).

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

1.2 Principles and Components of Surveillance and Response

An effective surveillance system rests on linked components: case detection and reporting, laboratory confirmation, data analysis, feedback, and response (Isere et al., 2015). Laboratory capacity is especially critical, because without accurate identification of the causative agent, surveillance data are unreliable and outbreak response is delayed. In Africa, the COVID-19 pandemic exposed gaps in testing capacity and underscored the need for coordinated continental action and stronger laboratory networks (Nkengasong & Mankoula, 2020). Newer tools such as genomic sequencing are expanding what laboratories contribute to surveillance (see Section 4).

Surveillance is increasingly viewed through a One Health lens, since most emerging infections originate in animals and require coordinated human, animal, and environmental data. The One Health High-Level Expert Panel's definition emphasises balancing and optimising the health of people, animals, and ecosystems (Adisasmito et al., 2022).

Response, the second pillar of the framework, refers to the organised set of actions taken once a health threat has been detected or confirmed. This multifaceted process involves rapid mobilisation of resources, effective coordination among multiple stakeholders, clear and transparent communication with the public and healthcare providers, and the implementation of evidence-based control measures designed to prevent further transmission and protect the health and wellbeing of the broader public (Keusch, 2009). The response phase transforms surveillance data into actionable interventions that can save lives and prevent the spread of infectious diseases.

The entire surveillance and response process operates as a continuous, self-reinforcing cycle that enables ongoing improvement and adaptation of public health strategies.

1.3 Scope and Approach of the Review

This narrative review synthesises evidence on the role of medical laboratory systems in disease surveillance and outbreak response, with emphasis on Nigeria. In this review, "medical laboratory systems" means the network of clinical diagnostic, public health reference, and surveillance laboratories, together with the governance, quality management, workforce, specimen referral, and information functions that connect them. Animal and environmental laboratories are considered only where they interact with human-health surveillance under a One Health approach.

Sources and period. PubMed, AJOL and Google Scholar were searched for records published between 2011 and 2026, with the last search run on 13 October,2026. These were supplemented by the websites of the World Health Organization (WHO), the WHO Regional Office for Africa, Africa CDC, and the Nigeria Centre for Disease Control (NCDC), and by screening the reference lists of included papers.

Search terms were combined with Boolean operators across three concepts: laboratory ("laboratory system" OR "laboratory capacity" OR "public health laboratory" OR "medical laboratory"), function (surveillance OR "outbreak response" OR "disease detection" OR "integrated disease surveillance and response"), and setting (Nigeria OR "sub-Saharan Africa" OR "low- and middle-income countries"). Additional searches combined these terms with Ebola, Lassa fever, cholera, and COVID-19.

Eligibility criteria were peer-reviewed articles, official reports, and national or international technical guidelines in English were included if they described the role, capacity, performance, or reform of laboratories in surveillance or outbreak response in Nigeria, or in comparable low- and middle-

ISSN (O) : 3093-4664

income settings where Nigerian evidence was lacking. Records were excluded if they were purely methodological laboratory papers without a surveillance or response component, opinion pieces without supporting data, or duplicates.

2. History of Disease Surveillance in Nigeria

The evolution and development of disease surveillance systems in Nigeria illustrates the progressive recognition of the critical need for structured, systematic, and reliable public health data collection and analysis mechanisms. The journey toward establishing a comprehensive surveillance infrastructure in Nigeria has been marked by both challenges and significant milestones that have shaped the current system.

A major catalyst for transformative change in Nigeria's disease surveillance landscape was the devastating Yellow Fever outbreak that occurred during 1986 and 1987. This severe epidemic affected 10 out of the then 19 states in the country, causing substantial morbidity and mortality and exposing critical gaps in the nation's capacity to detect, respond to, and control infectious disease outbreaks (Nomhwange, 2021). The widespread impact of this outbreak and the inadequate response mechanisms available at the time prompted urgent calls for the establishment of a more robust and systematic approach to disease monitoring and notification.

In response to this public health crisis, the federal government established a National Task Force on Epidemic Control with the specific mandate to develop and implement a long-lasting, sustainable solution to disease notification and epidemic management challenges. This task force brought together experts from various disciplines, including epidemiology, clinical medicine, laboratory sciences, and public health administration, to design a comprehensive system that could address the identified gaps (Isere *et al*., 2015).

The collaborative efforts of this task force culminated in the creation of the Disease Surveillance and Notification (DSN) system, which received official government approval in 1989. This represented a landmark achievement in Nigeria's public health infrastructure development. The initial DSN framework officially designated 42 diseases as priority conditions requiring routine reporting from healthcare facilities across the country to enable early detection and prompt response to potential outbreaks (Isere *et al*., 2015). This system established standardised case definitions, reporting formats, and communication channels that connected peripheral health facilities to state and federal public health authorities.

However, as experience accumulated with the implementation of the DSN system, public health authorities recognised the need for a more integrated, comprehensive, and efficient approach that could address the complex and interconnected nature of disease surveillance in a resource-limited setting. This recognition led to the adoption of the Integrated Disease Surveillance and Response (IDSR) strategy for the African Region in September 1998, following recommendations from the 48th World Health Organization Regional Committee for Africa meeting held in Harare, Zimbabwe (Murray & Cohen, 2017; WHO, n.d.). Nigeria subsequently adopted the strategy and later published national technical guidelines to guide its implementation (Onduku, 2019). The IDSR framework represented a paradigm shift in surveillance philosophy and practice.

The 2014 Ebola outbreak marked a further turning point. Rapid laboratory confirmation and coordinated response limited the outbreak in Nigeria, and the experience accelerated investment in national surveillance, emergency operations, and laboratory capacity, including statutory backing for

ISSN (O) : 3093-4664

the Nigeria Centre for Disease Control through the NCDC (Establishment) Act of 2018 (Federal Republic of Nigeria, 2018; Otu et al., 2018). These developments are reviewed in Section 11.

3. Types of Surveillance

Surveillance systems can be classified by how data are collected. Passive and active approaches are the two principal types, and they are complemented by sentinel, syndromic, event-based, and community-based strategies (WHO Regional Office for Africa, 2019).

In passive surveillance systems, the responsibility for initiating reporting lies with the healthcare provider or facility, and public health authorities serve primarily as recipients and analyzers of the submitted data. The data sources for passive surveillance typically include individuals presenting to healthcare facilities, hospitals and clinics of various levels, diverse healthcare providers including physicians and nurses, laboratory scientists, and local and state health departments that serve as aggregation points for reported cases (Association of Health Care Journalists, 2025). Passive surveillance is particularly well-suited for monitoring endemic diseases with relatively stable incidence patterns and for maintaining long-term trend data across large geographic areas. However, this approach is dependent on the awareness, motivation, and capacity of reporting entities, which can lead to underreporting and delays in case notification.

Active surveillance, in contrast, involves public health authorities proactively and systematically searching for cases of specific diseases rather than waiting for reports to be submitted voluntarily. (Association of Health Care Journalists, 2025). Active surveillance requires substantially greater resources, including dedicated personnel, communication infrastructure, and transportation capacity, but yields more complete and timely data.

In addition to passive and active approaches, sentinel surveillance collects high-quality data from selected sites to monitor trends in priority diseases; syndromic surveillance tracks clinical syndromes before laboratory confirmation is available; event-based surveillance captures unusual health events reported by communities, the media, or health workers; and community-based surveillance uses trained volunteers to detect and report priority conditions (WHO Regional Office for Africa, 2019). Laboratory-based surveillance, including antimicrobial resistance networks, and environmental or wastewater surveillance, which has been used for poliovirus detection, extend monitoring beyond people who present to health facilities. Each of these approaches depends on timely laboratory confirmation to turn signals into verified public health events.

4. Role of Accurate and Timely Laboratory Data in Disease Surveillance

Laboratory data are the evidence on which surveillance decisions are built. Clinical signs alone rarely distinguish one infectious disease from another, so confirmation of the causative agent is what turns a suspected cluster into a verified outbreak and triggers a proportionate response (Ibrahim, 2020). The effectiveness and impact of any public health intervention fundamentally hinges on the quality, accuracy, completeness, and timeliness of the data provided by medical laboratory services (MLSCN, 2012). Laboratory data are generally the reference standard for confirming suspected cases, characterising pathogens, and monitoring disease trends, but they are interpreted alongside clinical assessment and epidemiological investigation, because test performance, specimen quality, and timing of collection all affect results.

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

Laboratory data also now extend beyond simple confirmation. Genomic sequencing allows public health teams to trace transmission chains, identify emerging variants, and guide vaccine and treatment strategies, although cost, infrastructure, and skilled workforce gaps have limited its use in Africa (Inzaule et al., 2021; Tessema et al., 2020). The World Health Organization's global genomic surveillance strategy calls for integrating such data into routine surveillance and ensuring equitable access across countries (World Health Organization, 2022).

The provision of high-quality laboratory data generates multiple critical benefits that cascade throughout the public health system. First, accurate laboratory results enable early detection of potential disease outbreaks by identifying cases before they would be recognised through clinical surveillance alone, thereby allowing for rapid isolation of infected individuals and implementation of containment measures before widespread transmission can occur (Ibeh *et al*., 2020). This early warning function can mean the difference between containing a small cluster of cases and facing a full-scale epidemic.

Timely and accurate laboratory data contribute directly to significant reductions in morbidity and mortality rates by enabling clinicians to make informed, evidence-based treatment decisions for individual patients while simultaneously allowing public health officials to implement targeted, effective control measures at the population level (Ibeh *et al*., 2020). Laboratory confirmation ensures that appropriate antimicrobial therapies are used, reduces unnecessary treatments, and helps prevent the development and spread of antimicrobial resistance.

Timeliness matters as much as accuracy. The COVID-19 pandemic showed that limited testing capacity and slow turnaround times in many African countries weakened case detection and contact tracing, and it prompted calls for coordinated continental action to expand diagnostic capacity (Nkengasong & Mankoula, 2020). Delays often arise outside the laboratory itself, through weak specimen transport, poor reporting systems, and limited communication between laboratories and surveillance units. Strong laboratory networks therefore need reliable referral systems, quality management, and digital reporting tools to move results quickly to those who must act on them.

5. The Medical Laboratory: Foundation of Diagnostic Medicine

Medical laboratories represent specialised healthcare facilities that provide an extensive and diverse range of laboratory procedures and analytical services that are essential for aiding clinicians in the diagnosis, treatment, and ongoing management of patients with various medical conditions (Bayot *et al*., 2024). These facilities serve as the diagnostic backbone of modern healthcare systems, generating the objective data that inform a substantial proportion of clinical decisions (the frequently quoted figure of 70% is widely repeated but not firmly supported by evidence; Hallworth, 2011).

These laboratories are staffed by highly trained Medical Laboratory Scientists (MLS), also known as medical laboratory technologists or clinical laboratory scientists, who undergo rigorous academic preparation and practical training to perform and analyze complex tests on biological specimens collected from patients (Isere *et al*., 2015).

The data generated by these dedicated professionals forms the bedrock of evidence-based medicine and serves as the foundation for effective public health surveillance and response activities (Bayot *et al*., 2024). Laboratory results provide objective, quantifiable measurements that can be tracked over time, compared across populations, and used to identify patterns that would be impossible to detect

ISSN (O) : 3093-4664

through clinical observation alone. The precision and reliability of laboratory data make it an indispensable tool for both individual patient care and population health management.

6. Categories of Medical Laboratory Services

Medical laboratory services in Nigeria and throughout many healthcare systems globally are typically structured in a tiered system that reflects their technical capacity, the complexity and sophistication of tests they can perform, the level of specialised expertise available, and their designated role within the broader healthcare network (Wolford *et al*., 2023). This hierarchical organisation ensures efficient utilisation of resources while maintaining appropriate quality standards at each level of the healthcare system.

The primary, secondary, and tertiary classification used in this section is a conceptual model of laboratory capability that mirrors the tiered structure of health-care delivery described in the cited literature (Wolford et al., 2023). It is not presented as a formally gazetted Nigerian laboratory classification. In practice, public health reference and surveillance laboratories, such as the National Reference Laboratory in Abuja, are not confined to one tier because they receive referred specimens from facilities at every level, and some teaching-hospital virology laboratories have also served as designated molecular testing sites within the NCDC network (Nigeria Centre for Disease Control, 2020a).

Primary level medical laboratories are typically managed and operated by Medical Laboratory Scientists or Medical Laboratory Technicians who have completed appropriate training programmes for basic laboratory procedures. These facilities primarily perform fundamental tests that are essential for routine clinical care, often functioning in community clinics, primary healthcare centres, or as satellite laboratories within larger hospital complexes (Kan, 2022). The primary level represents the most accessible point of laboratory services for the majority of the population, particularly in rural and underserved areas.

Secondary level medical laboratories are staffed by fully qualified Medical Laboratory Scientists with broader training and greater expertise than those at primary facilities. These laboratories carry out more sophisticated diagnostic services as required by the health needs of their communities and may additionally serve as research centres contributing to the advancement of laboratory science and public health knowledge (Makata, 2023). Secondary laboratories typically serve district or state-level hospitals and referral centres.

Tertiary level medical laboratories are staffed by highly specialised personnel including senior Medical Laboratory Scientists, clinical pathologists, and subspecialty-trained scientists who possess advanced degrees and extensive experience in their fields. These laboratories perform the most sophisticated diagnostic services, serve as training institutions for the next generation of laboratory professionals, conduct cutting-edge research, and often function as national or regional reference laboratories (Otu *et al*., 2018).

7. Role of Medical Laboratories in Disease Surveillance, Outbreak and Comprehensive Disease Response

Laboratory-based monitoring and surveillance provides essential support for multiple critical functions including accurate infection diagnosis, precise pathogen identification, tracking of disease

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

spread across geographic areas and populations, and early warning systems for potential outbreak situations (Isere *et al*., 2015).

The specific and multifaceted roles of the medical laboratory in ongoing disease surveillance activities encompass several key functions. Laboratories engage in continuous monitoring of regular pathogens, tracking the baseline incidence and prevalence of endemic diseases within defined populations and geographic areas (Musa *et al*., 2023). This ongoing monitoring establishes the normal disease patterns against which anomalies can be detected, enabling early identification of increases in case numbers that may signal an outbreak and contribute to identifying trends in causative organisms by detecting shifts in the dominant strains, serotypes, or species of pathogens causing disease within communities (Musa *et al*., 2023).

Also, laboratories ensure effective monitoring of disease eradication programmes by providing definitive confirmation of disease elimination efforts for conditions targeted for eradication, such as polio, guinea worm disease, and potentially measles (Musa *et al*., 2023)

When a disease outbreak is detected or suspected, the medical laboratory immediately shifts into a high-alert, rapid-response operational mode characterised by intensified activities, extended working hours, and prioritisation of outbreak-related testing. The actions undertaken by Medical Laboratory Scientists during these critical periods are crucial for controlling disease spread, managing the public health crisis effectively, and ultimately saving lives (Wolford *et al*., 2023).

The first critical function involves ensuring proper sample collection and shipment procedures, including providing guidance to healthcare workers on appropriate specimen types, collection techniques, and timing of sample collection; ensuring proper handling and storage of specimens to maintain their integrity and diagnostic value; and facilitating safe and efficient transport of specimens to reference laboratories that possess the specialised capacity for confirmatory testing and pathogen characterisation (Wolford *et al*., 2023). Proper specimen management is essential because even the most sophisticated laboratory methods cannot produce accurate results if specimens are improperly collected, stored, or transported.

Early detection of cases through provision of rapid diagnostic testing represents another crucial laboratory function during outbreaks. Laboratories must quickly confirm suspected cases to inform isolation, treatment, and contact-management decisions, which also depend on the disease, the test used, clinical assessment, and national public health guidance, while ruling out non-cases to avoid unnecessary quarantine (Wolford *et al*., 2023). Rapid turnaround times become paramount during outbreak situations, often requiring laboratories to extend operating hours, prioritise outbreak-related specimens, and implement point-of-care or rapid testing technologies when available and appropriate.

The medical laboratory's role in disease response extends far beyond the immediate outbreak phase to encompass broader, long-term contributions to public health system strengthening and preparedness for future threats (Odelola, 2025). This expanded role recognises that laboratory capacity is not only essential during crises but also forms a foundation for sustainable public health infrastructure.

Effective data reporting and communication represents another critical function, ensuring that laboratory results are communicated rapidly, accurately, and completely to public health authorities, often through Electronic Laboratory Reporting (ELR) systems that automate the transmission of reportable disease

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

results from laboratory information systems directly to public health surveillance databases (CDC, 2024). Requirements for these systems are described in Section 10.

8. Requirements for Effective Laboratory Surveillance and Response

A robust, effective, and sustainable laboratory surveillance system requires sustained financial investment, strong institutional commitment, and strict adherence to internationally recognised quality standards to ensure that the data produced are reliable and actionable, and meet the needs of public health decision-makers (WHO, n.d.).

Well-equipped laboratories with adequate supplies represent a fundamental requirement, encompassing the availability of necessary physical infrastructure including appropriate space, environmental controls, safety equipment, and utilities; modern instrumentation that is appropriate for the tests being performed and properly maintained; reliable supplies of reagents, consumables, and quality control materials; and uninterrupted access to essential utilities including electricity, water, and internet connectivity (WHO, n.d.).

Well-trained personnel constitute another essential requirement, necessitating maintenance of a skilled workforce capable of performing complex tests accurately and reliably, interpreting results correctly and recognising anomalies that may signal unusual situations, troubleshooting technical problems to minimise downtime, and maintaining appropriate biosafety practices to protect both laboratory workers and the community (WHO, n.d.).

Quality of service through implementation of comprehensive Quality Management Systems (QMS) ensures the reliability, accuracy, precision, and consistency of all laboratory results produced (Musa *et al*., 2023). Quality management encompasses multiple elements including standard operating procedures (SOPs) for all testing processes, regular calibration and maintenance of equipment, participation in external quality assessment programmes. internal quality control procedures for every test run, documentation of all activities, and corrective action systems to address identified problems. Without robust quality systems, laboratory results may be unreliable and could lead to inappropriate public health decisions.

A functional and reliable data management system represents the final critical requirement, involving implementation of systems such as Electronic Laboratory Reporting (ELR) to ensure that surveillance data are transmitted rapidly, accurately, and securely to public health decision-makers who need it (CDC, 2024). Modern data management systems should include laboratory information management systems (LIMS) for tracking specimens and results, secure electronic reporting to public health authorities, data analytics capabilities for identifying trends and anomalies, and appropriate cybersecurity measures to protect sensitive health information.

Finally, laboratory systems need clear governance, a national laboratory policy and strategic plan, predictable domestic financing, and formal links between public, private, and academic laboratories and with animal and environmental health laboratories under a One Health approach (Adisasmito et al., 2022; Abubakar et al., 2022).

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

9. Laboratory Strengthening in Nigeria Following the 2014 Ebola Outbreak

9.1 The Ebola Response as a Turning Point

Nigeria's response to the 2014 Ebola outbreak is widely regarded as a turning point for its public health laboratory and surveillance systems. After the virus was introduced to Lagos by an air traveller in July 2014, laboratory confirmation, contact tracing, and coordinated emergency operations limited transmission to 20 cases (19 laboratory-confirmed and one probable) and 8 deaths, and the World Health Organization declared the country free of Ebola virus transmission in October 2014 (Shuaib et al., 2014; Fasina et al., 2014; Otu et al., 2018). The episode showed that rapid, locally available diagnostic confirmation can determine whether an imported case becomes a large epidemic, and it highlighted the need for permanent rather than ad hoc laboratory capacity (Otu et al., 2018).

9.2 Institutional and Network Reforms

Since 2014, Nigeria has strengthened the institutional framework for laboratory-supported surveillance. The Nigeria Centre for Disease Control (NCDC) received statutory backing through the NCDC (Establishment) Act of 2018 and coordinates national surveillance, emergency operations, and a network of reference and molecular laboratories anchored on the National Reference Laboratory in Abuja (Federal Republic of Nigeria, 2018; Ihekweazu & Agogo, 2020). Emergency operations centres link laboratory findings to surveillance and response teams, and the IDSR strategy provides the framework through which priority diseases are reported and confirmed (Onduku, 2019; WHO Regional Office for Africa, 2019). Molecular diagnostic capacity expanded beyond Ebola to cover Lassa fever, cholera, meningitis, yellow fever, and mpox and, from 2020, COVID-19, when the number of laboratories able to perform PCR testing was scaled up rapidly (Ihekweazu & Agogo, 2020).

9.3 Quality, Biosafety, and Workforce Development

Complementary investments addressed quality, biosafety, and people. Quality improvement and accreditation efforts, biosafety and biosecurity training, and improved specimen referral arrangements featured in national health security planning and in the external evaluation of International Health Regulations core capacities (Nigeria Centre for Disease Control, 2018; World Health Organization, 2017). Training of laboratory scientists and field epidemiologists, including through the Nigeria Field Epidemiology and Laboratory Training Programme, supported a workforce able to investigate and respond to outbreaks, while WHO, the US Centers for Disease Control and Prevention, Africa CDC, and other partners supported equipment, training, and sequencing capacity (Ihekweazu & Agogo, 2020).

9.4 Nigeria-Specific Evidence on Laboratory Capacity and Performance

Table 1 summarises the Nigerian evidence identified in this review for key domains of laboratory capacity and performance, and shows where quantitative evidence could not be found.

Table 1. Nigeria-specific evidence on laboratory capacity and performance

Domain	Nigerian evidence identified	Source	Limitation or gap

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

Diagnostic capacity in an outbreak (Ebola, 2014)	In-country diagnosis at the Lagos University Teaching Hospital allowed rapid confirmation of cases and quick discharge of suspected cases who tested negative; 19 laboratory-confirmed cases and 1 probable case; 894 contacts followed.	Shuaib et al. (2014)	No turnaround-time data; laboratory contribution not separated from contact tracing and isolation.
Molecular network scale-up (COVID-19, 2020)	Six additional laboratories were activated in under four months to cover each geopolitical zone (April 2020); 30 laboratories were able to test for COVID-19 by 3 June 2020.	Nigeria Centre for Disease Control (2020a, 2020b)	Programme reports; no data on functionality, workload, or retention of capacity after the pandemic.
Turnaround time (Lassa fever)	Average turnaround of 48 hours (range 24–96 hours) for diagnostic results, largely dependent on the proximity of the state to the testing laboratory.	Chandra et al. (2021)	Based on cases from 2018–2019; recent state-level data not identified.
Specimen referral and quality (Lassa fever)	1,929 samples received at the National Reference Laboratory in 2024–2025 were analysed: overall rejection was low, but temperature instability on arrival and documentation gaps compromised sample quality.	Sakwa et al. (2025)	Conference abstract from a single laboratory; not peer reviewed.
Reporting systems	The Surveillance Outbreak Response Management and Analysis System (SORMAS) was deployed to states reporting COVID-19 cases in 2020. [Authors to add data on completeness and timeliness of laboratory reporting.]	Nigeria Centre for Disease Control (2020a)	Use and performance of electronic reporting after 2020 not documented here.

The table shows that quantitative evidence is concentrated on three events (Ebola in 2014, Lassa fever, and COVID-19) and is largely drawn from programme.

9.5 Distinguishing the Contribution of Laboratory Diagnosis from Other Interventions

The success of the 2014 response is often attributed to laboratory capacity, but the available sources describe a combination of interventions. The MMWR account states that in-country diagnostic capacity at the Lagos University Teaching Hospital facilitated rapid identification of confirmed cases and quick discharge of suspected cases who tested negative, and it also documents contact tracing (894 contacts identified and about 18,500 face-to-face visits), isolation and treatment, and coordinated emergency management (Shuaib et al., 2014). Transmission-dynamic analysis likewise attributes control to the package of measures rather than to any single component (Fasina et al., 2014). The laboratory therefore acted as an enabler: it confirmed the index case, confirmed or excluded suspected cases quickly, and allowed contact tracing to be focused, while interrupting transmission depended on contact tracing, isolation, infection prevention, and emergency

ISSN (O) : 3093-4664

coordination. This review found no study that isolates the independent effect of laboratory turnaround time on transmission in Nigeria, so crediting laboratory capacity for the outcome is plausible but not quantified.

9.6 Sustainability and Persisting Weaknesses

Despite these gains, the Lancet Nigeria Commission noted persistent weaknesses in health financing, infrastructure, and workforce that still limit preparedness (Abubakar et al., 2022), and recurrent Lassa fever, cholera, and meningitis outbreaks continue to test laboratory coverage and turnaround times across states. The evidence in Table 1 shows that capacity expanded rapidly during the COVID-19 emergency, but performance still varies with geography: Lassa fever turnaround times depend on how far a state is from the testing laboratory (Chandra et al., 2021), and specimen quality at the National Reference Laboratory is affected by temperature instability and incomplete documentation (Sakwa et al., 2025). This review did not identify published longitudinal evaluations showing whether laboratory capacity built after 2014 was maintained between outbreaks, which is a key evidence gap.

10. Challenges Facing Medical Laboratory Services

Despite their vital role in disease surveillance and response, medical laboratories in Nigeria and throughout many resource-limited settings face substantial and persistent hurdles that can significantly compromise the effectiveness, timeliness, and reliability of disease surveillance and response activities (Wolford *et al*., 2023).

The lack of a reliable supply chain system represents a pervasive challenge, manifesting in inconsistent availability of essential reagents, consumables, and spare parts for equipment. In practice, stock-outs and delays force laboratories to postpone or suspend testing, and emergency procurement raises costs (Wolford et al., 2023).

Lack of proper communication between key stakeholders represents another critical challenge. Poor communication channels and practices between laboratory staff, clinicians, and Disease Surveillance and Notification (DSN) officials can result in incomplete or inaccurate sample information being provided with specimens, delayed reporting of critical results that require immediate public health action, lack of follow-up information about suspected outbreak cases, and failure to close the feedback loop so that laboratory personnel understand how their data are being used and whether additional information is needed (Dairo, 2018). Communication breakdowns can transform potentially valuable surveillance data into missed opportunities for outbreak detection and response.

The need for expanded test types and a more capable workforce has become increasingly apparent as new pathogens emerge and diagnostic technologies advance. Keeping pace requires expanded molecular and genomic capacity and a workforce skilled in molecular biology and bioinformatics (Eneh, 2025), as outlined under Section 10.

Inadequate and unpredictable financing, heavy reliance on donor support, and weak infrastructure, including unreliable electricity, water, and internet connectivity, also undermine laboratory performance. Laboratories are unevenly distributed, with fewer facilities capable of confirmatory or molecular testing in some regions, which lengthens specimen transit times and delays confirmation (Abubakar et al., 2022; Eneh, 2025).

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

Finally, limited interoperability between laboratory information systems and national surveillance platforms, weak linkage between private and public laboratories, and limited integration of human, animal, and environmental laboratories restrict the timely flow and use of laboratory data (Eneh, 2025; Adisasmito et al., 2022).

11. Discussion: Critical Synthesis of the Evidence

11.1 What the Evidence Establishes

Across the sources reviewed, three findings are reasonably well supported for Nigeria. First, in-country diagnostic capacity shortened the time to confirmation during the 2014 Ebola outbreak (Shuaib et al., 2014). Second, the molecular laboratory network could be expanded quickly when an emergency demanded it, from six additional laboratories in April 2020 to 30 by early June 2020 (Nigeria Centre for Disease Control, 2020a, 2020b). Third, turnaround times for Lassa fever confirmation depend strongly on the distance between the state and the testing laboratory (Chandra et al., 2021). What the literature does not establish is whether these gains reflect permanent system capacity or emergency-driven, partner-supported scale-up that recedes between outbreaks.

11.2 Areas of Agreement and Disagreement

Sources agree that laboratories are essential to detection and response, and that quality, workforce, specimen transport, and data systems determine performance (Nkengasong et al., 2010; Alemnji et al., 2014; Wolford et al., 2023). They differ in strength and emphasis. National guidelines and policy documents describe how the system is meant to work (Onduku, 2019; WHO Regional Office for Africa, 2019), whereas the few empirical studies describe how it performs, and these concentrate on Lassa fever and COVID-19. Accounts of the Ebola response credit the combination of laboratory confirmation, contact tracing, and isolation, and differ mainly in how much weight they give to each (Shuaib et al., 2014; Fasina et al., 2014; Otu et al., 2018). Reports on the post-Ebola reforms are largely descriptive and rarely give indicators such as turnaround time, specimen rejection, or reporting completeness, so claims of improvement are difficult to verify.

11.3 Limitations of the Evidence Base and of This Review

The evidence base is limited by its reliance on programme reports, grey literature, and conference abstracts, by the small number of Nigerian empirical studies, and by its concentration on a few outbreaks. This review has its own limitations: as a narrative review it applied no formal quality-appraisal tool, searches were restricted to English-language sources, and selection bias is possible. Conclusions should therefore be read as a synthesis of the available evidence, not as a measure of the true level of laboratory capacity.

11.4 Barriers to Digital Integration and One Health Implementation

Existing capabilities should be distinguished from proposed developments. Existing capabilities include the deployment of the Surveillance Outbreak Response Management and Analysis System in states reporting COVID-19 cases (Nigeria Centre for Disease Control, 2020a) [authors to specify the electronic reporting platforms currently in routine use]. Developments that are proposed rather than established at scale include routine electronic laboratory reporting from laboratory information systems to national platforms, genomic surveillance integrated with epidemiological data (World Health Organization, 2022), and interoperable systems that span public, private, and animal-health laboratories.

ISSN (O) : 3093-4664

Practical barriers include limited interoperability and the absence of common data standards across laboratory information systems; unreliable electricity and internet connectivity at facility level (World Health Organization, n.d.); recurrent costs of licences, hardware, and maintenance that depend on donor funding; data protection obligations under the Nigeria Data Protection Act 2023 (Federal Republic of Nigeria, 2023), which call for lawful bases, security safeguards, and clear data-sharing agreements for health data; limited informatics and bioinformatics skills; and, for genomics, the high cost of sequencing and dependence on external partners (Inzaule et al., 2021; Tessema et al., 2020).

One Health implementation requires coordination between human health (the Nigeria Centre for Disease Control and the Federal Ministry of Health), animal health, and environmental agencies, with shared case definitions, data-sharing agreements, joint training, and laboratories able to test animal and environmental specimens (Adisasmito et al., 2022). Barriers likely to affect Nigeria include fragmented mandates across ministries, separate funding streams and reporting lines, limited interoperability between human and veterinary laboratory systems, and few staff trained in cross-sectoral outbreak investigation. This review did not identify evidence that quantifies how well these arrangements function in Nigeria, so the One Health recommendations describe proposed practice rather than established practice.

12. Knowledge Gaps and Directions for Future Research

Several gaps limit the evidence base on laboratory systems in Nigeria. First, there appear to be few published studies that systematically measure laboratory performance indicators such as specimen referral and turnaround times, the proportion of suspected cases tested, and equipment downtime across states. Second, the costs and cost-effectiveness of decentralised molecular and genomic capacity, and the sustainability of laboratories established with donor funding once external support ends, are poorly documented. Third, the role of private, academic, and veterinary laboratories in national surveillance is rarely evaluated, and standards for sharing their data with public health authorities are inconsistent. Fourth, evidence on how electronic laboratory reporting and interoperable laboratory information systems affect timeliness and data quality in Nigeria is limited. Fifth, the integration of antimicrobial resistance, environmental and wastewater surveillance, and One Health laboratory networks into routine surveillance has received little evaluation. Finally, research on laboratory workforce retention and biosafety compliance is sparse. Future studies should combine laboratory network assessments, mixed-methods evaluations, and economic analyses to guide investment.

13. Recommendations

The recommendations are prioritised in Table 2, which links each challenge to an intervention, responsible stakeholders, and a measurable indicator.

1. **Provide Adequate Personal Protective Equipment (PPE)**: Ensure a consistent, reliable, and sufficient supply of appropriate personal protective equipment for the continual safety and protection of laboratory staff, especially when handling highly infectious agents or specimens from patients with unknown infections. Laboratory safety must be treated as a non-negotiable priority that protects the health of workers who are at the frontline of disease detection. Regular training on proper PPE use and regular assessment of safety practices should accompany provision of equipment.

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

2. **Establish a Proper Communication System**: Institute formal, reliable, and bidirectional communication channels between clinicians, Medical Laboratory Scientists, and public health authorities to ensure the provision of relevant clinical information, provisional diagnoses, and epidemiological context alongside specimens submitted for testing. This communication infrastructure should include standardised requisition forms that capture essential clinical and epidemiological information, secure electronic messaging systems for urgent results, regular liaison meetings between laboratory and clinical staff, and feedback mechanisms so that laboratory personnel understand the clinical and public health impact of their work

4. **Engage in Consistent Training and Capacity Building**: Implement comprehensive and ongoing continuous professional development programmes designed to keep laboratory staff updated with the latest diagnostic techniques, information about emerging pathogens and their laboratory characteristics, advances in quality management systems and accreditation standards, developments in laboratory information systems and electronic reporting, and leadership and management skills necessary for effective laboratory administration.

5. **Advocate for Active Integration**: Actively integrate Medical Laboratory Scientists into public health planning processes, surveillance teams, outbreak investigation units, and emergency response teams to leverage their unique expertise in real-time decision-making rather than treating them solely as technical service providers. Laboratory scientists possess deep understanding of pathogen biology, transmission dynamics, diagnostic limitations, and data interpretation that is invaluable for designing effective surveillance systems and response strategies.

6. **Increase and Sustain Domestic Financing**: Allocate dedicated, predictable budget lines for laboratory infrastructure, reagents, maintenance, and personnel at federal and state levels, with transition plans that reduce dependence on donor funding, so that gains made after the Ebola response are not lost between outbreaks.

7. **Strengthen Specimen Referral and Supply Chains**: Establish a functional, funded specimen referral and transport network with standardised packaging, cold chain, tracking, and agreed turnaround times, together with forecasting and procurement systems that prevent reagent stock-outs.

8. **Expand Quality Management, Accreditation, and Biosafety**: Support laboratories at all tiers to progress through SLIPTA toward ISO 15189 accreditation, to participate in external quality assessment, and to implement biosafety and biosecurity programmes proportionate to the pathogens they handle.

9. **Digitise and Integrate Laboratory Data**: Deploy interoperable laboratory information systems and electronic laboratory reporting linked to national surveillance and health information platforms, with agreed data standards, data protection safeguards, and feedback of results to clinicians and surveillance officers.

10. **Adopt a One Health Approach and Build Genomic Capacity**: Link human, animal, and environmental laboratories through shared protocols and data-sharing agreements, and expand sequencing capacity with matched investment in bioinformatics training and equitable data access.

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

11. **Retain the Workforce and Engage Private Laboratories**: Improve incentives, career structures, and leadership training to retain laboratory scientists, and create mechanisms to accredit and integrate private laboratories into national surveillance and reporting networks.

Priorities in Table 2 were assigned qualitatively by the authors using three criteria: urgency (risk of missed or delayed detection during outbreaks), feasibility (cost and existing structures), and expected public health benefit. They are not the result of a formal prioritisation exercise, and the indicators are suggested measures for which targets should be set by the NCDC and state authorities.

Table 2. Prioritised recommendations, responsible stakeholders, and indicators

Priority	Challenge	Intervention	Responsible stakeholders	Indicator
High	Specimen transport delays; reagent stock-outs	Funded referral network with standard packaging, cold chain, and tracking; forecasting and procurement system	NCDC; state ministries of health; logistics partners	% of priority-disease specimens reaching the laboratory within the agreed time and condition; stock-out days per quarter
High	Unpredictable funding and donor dependence	Dedicated federal and state laboratory budget lines with donor transition plans	Federal Ministry of Health and Social Welfare; Ministry of Finance; state governments	Share of laboratory budget financed domestically; funds released against approved
High	Biosafety and personal protective equipment gaps	Sustainable PPE supply; biosafety training and risk assessment	NCDC; hospital management; Medical Laboratory Science Council of Nigeria	% of laboratories with trained biosafety officer; PPE stock-outs recorded
Medium	Variable quality of testing	Stepwise progression through SLIPTA to ISO 15189; external quality assessment	National Reference Laboratory; Medical Laboratory Science Council; accrediting bodies	Number of laboratories enrolled or accredited; external quality assessment pass rate
Medium	Poor communication and fragmented data	Interoperable laboratory information systems and electronic reporting; feedback to clinicians	NCDC; state surveillance officers; laboratories; ICT partners	Completeness and timeliness of laboratory reporting; % of results reported electronically
Medium	Workforce attrition and	Retention incentives, continuing professional	Medical Laboratory Science Council;	Staff turnover; % of staff with annual CPD;

https://doi.org/10.64261/7dyamb87

ISSN (O) : 3093-4664

	limited advanced skills	development, bioinformatics training	Federal Ministry of Health; teaching hospitals; universities	number trained in bioinformatics
Longer term	Fragmented human, animal, and environmental laboratories; limited genomic capacity	One Health protocols and data sharing; sustained sequencing capacity	NCDC; agriculture and environment ministries; academia; Africa CDC	Number of joint investigations; % of priority pathogens sequenced within target time
Longer term	Limited integration of private laboratories	Accreditation and reporting requirements for private laboratories	NCDC; Medical Laboratory Science Council; private laboratory associations	% of private laboratories reporting notifiable results

14. Conclusion

The central role of laboratories in public health cannot be overstated: they serve as the diagnostic foundation upon which all other surveillance and response activities are built. Without strong, well-functioning laboratory systems operating at all levels of the healthcare infrastructure, public health efforts inevitably become delayed, potentially misinformed by inaccurate information, or rendered completely ineffective due to lack of the objective data necessary for sound decision-making.

Addressing the existing and well-documented gaps in laboratory capacity including limited physical infrastructure, unreliable supply chains, insufficient numbers of trained personnel, inadequate quality management systems, and weak information systems through sustained and adequate financial investment, comprehensive workforce training and retention programmes, and strengthening of partnerships across sectors is not merely a technical necessity or a desirable improvement (Wolford *et al*., 2023)

Funding

This study did not receive any specific grant from any funding institution

Data Availability

Not Applicable

Declarations

Ethics approval and consent to participate

Not Applicable

ISSN (O) : 3093-4664

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

References

Abubakar, I., Dalglish, S. L., Angell, B., et al. (2022). The Lancet Nigeria Commission: Investing in health and the future of the nation. The Lancet, 399(10330), 1155–1200.

Adisasmito, W. B., Almuhairi, S., Behravesh, C. B., et al. (2022). One Health: A new definition for a sustainable and healthy future. PLoS Pathogens, 18(6), e1010537.

Alemnji, G. A., Zeh, C., Yao, K., & Fonjungo, P. N. (2014). Strengthening national health laboratories in sub-Saharan Africa: A decade of remarkable progress. Tropical Medicine & International Health, 19(4), 450–458.

APHL. (n.d.). *Core functions of public health laboratories*. Association of Public Health Laboratories.

Association of Health Care Journalists. (2025). *Active vs. passive surveillance*. Centre for Excellence in Health Care Journalism.

Bayot, M. L., Lopes, J. E., Zubair, M., & others. (2024, January 26). Clinical laboratory. In *StatPearls*. StatPearls Publishing.

Cantón, R. (2005). Role of the microbiology laboratory in infectious disease surveillance, alert and response. *Clinical Microbiology and Infection*, *11*(Suppl 1), 3–8.

CDC. (2024). *Electronic Laboratory Reporting (ELR)*. Centers for Disease Control and Prevention.

Chandra, N. L., Bolt, H., Dan-Nwafor, C., et al. (2021). Factors associated with delayed presentation to healthcare facilities for Lassa fever cases, Nigeria 2019: A retrospective cohort study. BMC Infectious Diseases, 21(1). https://doi.org/10.1186/s12879-021-05822-4

Dairo, M. D. (2018). Awareness and reporting of notifiable diseases among health workers in a tertiary health institution in South West Nigeria. *Pagepress Journals*.

Eneh, S. C. (2025). Implementation of integrated disease surveillance and response in Nigeria: A review. *PMC*.

Fasina, F. O., Shittu, A., Lazarus, D., Tomori, O., Simonsen, L., Viboud, C., & Chowell, G. (2014). Transmission dynamics and control of Ebola virus disease outbreak in Nigeria, July to September 2014. Eurosurveillance, 19(40), 20920.

Federal Republic of Nigeria. (2018). Nigeria Centre for Disease Control (Establishment) Act, 2018.

Federal Republic of Nigeria. (2023). Nigeria Data Protection Act, 2023.

Hallworth, M. J. (2011). The '70% claim': What is the evidence base? Annals of Clinical Biochemistry, 48(6), 487–488.

Ibeh, I. N., Enitan, S. S., Akele, R. Y., & Isitua, C. C. (2020). A review of the COVID-19 pandemic and the role of medical laboratory scientists in containment. *Journal of Medical Laboratory Science*.

ISSN (O) : 3093-4664

Ibrahim, N. K. (2020). Epidemiologic surveillance for controlling COVID-19 pandemic: Types, challenges and implications. Journal of Infection and Public Health, 13(11), 1630–1638.

Ihekweazu, C., & Agogo, E. (2020). Africa's response to COVID-19. BMC Medicine, 18, 151.

International Organization for Standardization. (2022). ISO 15189:2022 Medical laboratories: Requirements for quality and competence (4th ed.). Geneva: ISO.

Inzaule, S. C., Tessema, S. K., Kebede, Y., Ogwell Ouma, A. E., & Nkengasong, J. N. (2021). Genomic-informed pathogen surveillance in Africa: Opportunities and challenges. The Lancet Infectious Diseases, 21(9), e281–e289.

Isere, E. E., Fatiregun, A. A., & Ajayi, I. O. (2015). An overview of disease surveillance and notification system in Nigeria and the roles of clinicians in disease outbreak prevention and control. *Nigerian Medical Journal*, *56*(3), 161–168. https://doi.org/10.4103/0300-1652.160347

Kan, B. (2022). Performing laboratory network surveillance to monitor the spread of pathogens. *PMC*, 9005488.

Keusch, G. T. (2009). The role of the laboratory in global health. *Clinical Chemistry*, *55*(10), 1804–1813.

Makata, V. C. (2023). Role of medical laboratory scientists in the COVID-19 pandemic response. *Journal of Global Biosecurity*.

McNabb, S. J., Chungong, S., Ryan, M., Wuhib, T., Nsubuga, P., Alemu, W., Carande-Kulis, V., & Rodier, G. (2002). Conceptual framework of public health surveillance and action and its application in health sector reform. BMC Public Health, 2(1), 2. https://doi.org/10.1186/1471-2458-2-2

Medical Laboratory Science Council of Nigeria [MLSCN]. (2012). *Guidelines for medical laboratory practice in Nigeria*. MLSCN.

Meierkord, A., Körner-Nahodilová, L., Gotsche, C. I., *et al*. (2024). Strengthening disease surveillance capacity at national level across five countries: A qualitative study. *Public Health*, *234*, 45–53.

Murray, J., & Cohen, A. L. (2017). Infectious disease surveillance. In *International encyclopedia of public health* (2nd ed., pp. 222–229). Academic Press.

Musa, K., Okoliegbe, I., Abdalaziz, T., Aboushady, A. T., Stelling, J., & Gould, I. M. (2023). Laboratory surveillance, quality management, and its role in addressing antimicrobial resistance in Africa: A narrative review. Antibiotics, 12(8), 1313. https://doi.org/10.3390/antibiotics12081313

Nigeria Centre for Disease Control. (2018). National action plan for health security 2018–2022. Abuja: NCDC.

Nigeria Centre for Disease Control. (2020a). Optimising diagnostic capacity for COVID-19 testing in Nigeria [Editorial]. Weekly Epidemiological Report, 2020(13). Abuja: NCDC. https://ncdc.gov.ng/reports/weekly/2020/3/13

Nigeria Centre for Disease Control. (2020b). Coronavirus – Nigeria: Inclusion of lab for COVID-19 testing capacity (3 June 2020) [Press release]. Abuja: NCDC.

Nkengasong, J. N., & Mankoula, W. (2020). Looming threat of COVID-19 infection in Africa: Act collectively, and fast. The Lancet, 395(10227), 841–842.

Nkengasong, J. N., Nsubuga, P., Nwanyanwu, O., et al. (2010). Laboratory systems and services are critical in global health: Time to end the neglect? American Journal of Clinical Pathology, 134(3), 368–373.

Nomhwange, T. (2021). The resurgence of yellow fever outbreaks in Nigeria: A review. *Springer Link*.

ISSN (O) : 3093-4664

Odelola, O. I. (2025). Knowledge and practice of disease surveillance among healthcare workers. *PMC*.

Ogunsola, F. T. (2015). The role of medical microbiology laboratories in disease control and prevention. *Nigerian Medical Journal*, *56*(2), 77–82.

Onduku, B. (2019). National technical guidelines for integrated disease surveillance and response (3rd ed.). https://ncdc.gov.ng/themes/common/docs/protocols/242_1601639437.pdf

Osterholm, M. T., & Hedberg, C. W. (2015). Epidemiologic principles. In *Mandell, Douglas, and Bennett's principles and practice of infectious diseases* (8th ed., pp. 158–167). Elsevier.

Otu, A., Ameh, S., Osifo-Dawodu, E., Okcut, H., Akhtar, Z., Almasri, I., & Yeboah-Manu, D. (2018). An account of the Ebola virus disease outbreak in Nigeria: Implications and lessons learnt. *BMC Public Health*, *18*(1), 3.

Sakwa, Y., et al. (2025). A multi-quarter assessment of sample rejection and cold chain deviations in Lassa fever surveillance in Nigeria, 2024–2025 [Conference abstract ELIC2025266]. Proceedings of the ECOWAS 2nd Lassa Fever International Conference, Abidjan, 8–11 September 2025.

Shuaib, F., Gunnala, R., Musa, E. O., et al. (2014). Ebola virus disease outbreak: Nigeria, July–September 2014. Morbidity and Mortality Weekly Report, 63(39), 867–872.

Tessema, S. K., Inzaule, S. C., Christoffels, A., et al. (2020). Accelerating genomics-based surveillance for COVID-19 response in Africa. The Lancet Microbe, 1(7), e227–e228.

WHO Regional Office for Africa. (2019). Technical guidelines for Integrated Disease Surveillance and Response in the African Region (3rd ed.). Brazzaville: WHO.

WHO. (n.d.). *Strengthening public health laboratory services*. World Health Organization.

Wolford, T., Sutton, J., & Mangal, C. N. (2023). Laboratory response to pandemic threats: Challenges, needs, and solutions. *Health Security*, *21*(3), 234–245.

World Health Organization. (2017). Joint external evaluation of IHR core capacities of the Federal Republic of Nigeria: Mission report, June 2017. Geneva: WHO.

World Health Organization. (2020). Laboratory biosafety manual (4th ed.). Geneva: WHO.

World Health Organization. (2022). Global genomic surveillance strategy for pathogens with pandemic and epidemic potential, 2022–2032. Geneva: WHO.

https://doi.org/10.64261/7dyamb87