**Evolution of Molecular Diagnosis in the Detection and Management of Viral Infectious Diseases in Nigeria**

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Coauthors Don Eliseo Lucero-Prisno III and Deborah Oluwaseun Shomuyiwa concurrently hold editorial positions within the journal. Don Eliseo Lucero-Prisno III serves as the Editor-in-Chief, while Deborah Oluwaseun Shomuyiwa is a member of the youth editorial board.

**Abstract**

Molecular diagnostics have revolutionized viral disease diagnosis in clinical settings, offering rapidity, sensitivity, and specificity. Nigeria's diverse burden of viral diseases, coupled with resource limitations and underreporting, underscores the critical need for efficient molecular diagnostics. The article traces the progressive trajectory of molecular diagnostics in Nigeria, including the establishment of Lassa virus detection, containment of the Ebola virus outbreak, and the pivotal role of the Nigeria Center for Disease Control (NCDC). It also highlights the impact of the COVID-19 pandemic on expanding molecular diagnostics infrastructure. Despite these advancements, challenges such as limited testing capacity, skilled personnel shortages, and inadequate funding persist. The article recommends measures to address these challenges, emphasizing the transformative potential of molecular diagnostics in viral surveillance and management. Overall, it underscores the importance of strategic planning and concerted efforts to enhance the utilization of molecular diagnostics in Nigeria's healthcare system.

**Introduction**

Molecular diagnostics has greatly expanded in clinical infectious disease diagnosis, providing benefits in pathogen identification, research, and epidemiological studies [1]. Diagnosing viral infections in clinical settings is challenging due to the initial common fever symptom shared by many diseases. Early detection of pathogens is crucial to prevent transmission and chronic disease progression [2]. Molecular methods allow earlier diagnosis by detecting lower levels of infectious agents in the body without the need for cultivation, reducing turnaround time and enabling detection of difficult-to-culture pathogens [3]. While viral culture and serological techniques are important, their drawbacks, such as cost and time consumption, may hinder timely detection [4]. Molecular diagnostics offer rapidity, sensitivity, and specificity, revolutionizing viral disease diagnosis.

In Nigeria, the need for rapid clinical diagnosis arises from its dense population, low resources and diverse burden of viral diseases. Underreporting of viral infections revealed by multiple studies pose a significant public health concern [2,5,6,7,8]. Hence, efficient molecular diagnostics are vital for pathogen screening, and effective disease management [9]. Since the 2000s, Nigeria has made progress in its molecular capabilities, responding to outbreaks and leveraging vertical disease programs like HIV, Polio and Tuberculosis [10]. This article presents an overview of the progress in molecular diagnostics for viral diseases in Nigeria, identify gaps and propose recommendations to strengthen the molecular diagnostics in Nigeria.

**Progressive Trajectory in the Use of Molecular Diagnostics for Viral Diseases Management in Nigeria over the years.**

Molecular diagnostics, despite their precision and usefulness, faced challenges in resource-limited settings like Nigeria, due to complexity, contamination risks, and high costs [9,11]. Inadequate funding, political will, and poor government health program implementation hindered their adoption. Traditional methods were preferred instead, but had limited impact on patient care and outbreak responses due to long turnaround times and quality issues. Serological methods lacked specificity for emerging viruses [9,12], often leading to misdiagnoses [13,14,15,16]. International collaborations and vertical disease models primarily focused on specific diseases offered limited advantages in combating other viral diseases [10,13,17,18]. As a result, diagnostic testing was often outsourced to established laboratories outside the country [10,12].

**Establishment of Molecular Diagnostics for Lassa Virus Detection**

In 2005, initial progress was made when the University of Lagos, in collaboration with the Bernhard-Nocht Institute (BNI), implemented Lassa virus PCR testing, enabling nationwide retrospective case confirmation and enhancing virus surveillance [19]. This surveillance played a crucial role in tracking a nosocomial outbreak among hospital staff from 2005 to 2008, aided by genome sequencing for strain identification [20]. Further collaboration with BNI led to the development of a PCR assay capable of detecting circulating Lassa Virus strains and related arenaviruses [21].

In 2008, the establishment of a molecular diagnostics laboratory at the Irrua Specialist Teaching Hospital (ISTH) in Edo state marked significant progress. This facility provided timely and reliable results, becoming the primary testing center for Lassa fever, handling over 90% of cases in endemic areas [12]. The ISTH molecular laboratory played a vital role in containing the 2012 outbreak in Abakaliki, Ebonyi state, by ensuring early detection of the index case [22]. However, the outbreak also highlighted the need for additional molecular laboratories in resource-limited settings to improve outbreak preparedness and timely diagnosis of suspected cases [13,22].

**Ebola Virus Outbreak containment in Nigeria**

During the 2014 Ebola virus outbreak in West Africa, the report of a suspected case in Nigeria raised significant concerns both locally and internationally, so much so that the World Health Organization responded by declaring a public health emergency of international concern due to the emergence of the case in Lagos, the country's most densely populated megacity, and its subsequent transmission to Port Harcourt, another major city, creating a highly volatile situation [13]. The existing molecular laboratory at the University of Lagos, coupled with the swift and coordinated response of the Nigeria Center for Disease Control (NCDC), played a pivotal role in effectively containing the outbreak. The timely diagnosis of the index case at the molecular laboratory in Lagos, achieved within two days of clinical suspicion, proved crucial in containing the spread of the virus [23]. The establishment of the NCDC in 2011, in retrospect, proved to be significant milestone that has in the course of the outbreak provided and still striving to provide opportunities to improve molecular diagnostics across the country. Leveraging on laboratory resources from the Polio Eradication Initiative, and University of Lagos, the NCDC was able to successfully prevent further dissemination and unprecedentedly contain the Ebola virus outbreak in the country [24].

**The Contribution and Influence of NCDC in Enhancing Molecular Diagnostics in Nigeria**

The Ebola outbreak highlighted the insufficient molecular infrastructures for combating viral diseases of public health importance in Nigeria. Previous reliance on facilities from single disease vertical programs funded by international donors had mixed success against emerging threats like Lassa and Ebola viruses [18]. Consequently, the Federal Ministry of Health (FMoH) and the NCDC in particular, prioritized strengthening laboratory diagnostics for active disease surveillance and outbreak preparedness. Collaborations with other African governments unions enabled the establishment of a network of molecular laboratories, supported by multimillion-dollar grants for enhanced disease surveillance [25]. In 2017, the NCDC effectively responded to widespread outbreaks of monkeypox, yellow fever (YF), Lassa fever, and other diseases, showcasing improved integration of active surveillance and laboratory systems [10].

Establishment and partnership with private institutional laboratories like the African Centre of Excellence for Genomics of Infectious Diseases (ACEGID) similar to the University of Lagos Teaching Hospital has also contributed to molecular diagnostics accessibility in the country. For instance, ACEGID's molecular capabilities were instrumental in overcoming challenges encountered during the re-emergence of Yellow Fever in 2018. This enabled early identification of cases and prompt outbreak response and vaccination efforts [26]. By liaising with laboratories equipped with molecular diagnostics capabilities, the NCDC gradually improved the overall access to molecular diagnostics within the country [27].

**COVID-19 Pandemic**

The COVID-19 pandemic greatly accelerated the global advancement of molecular diagnostics, particularly in Low- and Middle-Income Countries (LMICs). With the alarming surge in cases and deaths worldwide, the World Health Organization (WHO) emphasized the criticality of diagnostic testing for COVID-19 to track the virus, understand its spread, and guide interventions. The real-time reverse transcription polymerase chain reaction (RT-PCR) emerged as the gold standard for laboratory confirmation [28]. Nigeria faced the largest outbreak within the West-African sub-region [29]. While progress had been made in developing molecular diagnostics infrastructure prior to the pandemic, increasing evidence of community transmission highlighted the need for further improvements in local accessibility [30]. In response, the government, in collaboration with the private sector, endeavored to enhance the molecular capabilities of various public health institutions and teaching hospitals. As a result, Nigeria expanded its molecular laboratory network from four to 72, leading to a substantial increase in testing capacity and improved outbreak containment capabilities [4,9,31].

**Limitations and Challenges of Molecular Diagnostics in Nigeria**

In the wake of the COVID-19 pandemic, Nigeria faces the ongoing challenge of limited testing capacity, exacerbated by its dense population, hindering efficient sample collection and timely results generation [31]. This was evident during the peak of the pandemic, as reflected in the low ratio of tested individuals to the estimated total population in each of the 36 states. The NCDC activated additional testing sites, but optimizing early case detection, especially in rural settlements, requires further measures [32]. A crucial factor affecting testing capacity is the scarcity of skilled laboratory professionals in molecular diagnostic labs, leading to longer turnaround times and test result inaccuracies during outbreaks [22,33,34,35]. Inadequate government funding results in poor working conditions, hindering the development of skilled personnel and leading to professionals seeking opportunities abroad or in the private sector [25,31]. Additionally, the limited power supply poses a significant challenge, impacting laboratory operations and making them costlier [28]. Addressing these challenges and finding sustainable solutions are essential to improve molecular diagnostics in Nigeria.

**Recommendations and Future Prospect**

Molecular diagnostics hold immense potential for enhancing viral surveillance, especially in resource-constrained settings, enabling the targeting of transmission hotspots and vaccine campaigns [10]. These diagnostics offer cost-effectiveness over time, despite initial high costs, and adaptability to emerging threats. Advanced techniques such as Next Generation Sequencing (NGS) provide comprehensive viral genomic information, valuable for surveillance, epidemiological research, and understanding viral evolution [9,31].

To harness this potential, expanding national testing capacity is paramount. This involves enlarging the NCDC molecular laboratory network, prioritizing safety, continuous training of healthcare professionals, and ensuring quality assurance [36]. National health institutes should provide governance and support for the expansion of public health diagnostics. Establishing robust procurement and waste disposal systems, coupled with backup power solutions like solar technology and 'smart' machines, can overcome power interruptions [36]. Moreover, improving payment structures and hazard allowances for personnel is essential to boost confidence and enhance work quality.

**Conclusion**

Molecular diagnostics in Nigeria have made significant strides, but new challenges must be overcome for more effective utilization. It is imperative that concerted efforts and strategic planning are undertaken to ensure the widespread implementation of molecular diagnostics, empowering Nigeria's healthcare system to respond proactively and decisively to future viral threats.

**References**

1. Morgan, M., Kalantri, S., Flores, L., & Pai, M. (2005). A commercial line probe assay for the rapid detection of rifampicin resistance in Mycobacterium tuberculosis: A systematic review and meta-analysis. *BMC Infectious Diseases*, *5*(1), 1–9.
2. Souf, S. (2016). Recent advances in diagnostic testing for viral infections. Bioscience Horizons: The International Journal of Student Research, 9.
3. M, D., A.S, S. G., & D, E. (2020). Molecular Diagnostic Methods For Viral Infections. *European Journal of Molecular & Clinical Medicine*, *7*(1), 2595–2605.
4. Sboui, S., & Tabbabi, A. (n.d.). *Importance of Molecular Diagnostic Methods for infectious Diseases*.
5. Kayem, N. D., Okogbenin, S., Okoeguale, J., Momoh, M., Njoku, A., Eifediyi, R., & Horby, P. (2023). Seroepidemiology of Lassa virus in pregnant women in Southern Nigeria: A prospective hospital-based cohort study. *PLOS Neglected Tropical Diseases*, *17*(5), e0011354.
6. Tizhe, D. T., Kwaga, J. K. P., & Nok Kia, G. S. (2022). Serological and Molecular Survey for Dengue Virus Infection in Suspected Febrile Patients in Selected Local Government Areas in Adamawa State, Nigeria. *Vaccines*, *10*(9), 1407.
7. Ozer, E. A., Simons, L. M., Adewumi, O. M., Fowotade, A. A., Omoruyi, E. C., Adeniji, J. A., and Lorenzo-Redondo, R. (2021). High prevalence of SARS-CoV-2 B. 1.1. 7 (UK variant) and the novel B. 1.5. 2.5 lineage in Oyo State, Nigeria. *Medrxiv*, *4*(09), 21255206.
8. Aniche, O. M. C., Orabueze, I. N., Nwafia, I. N., Ihezuo, J. U., Chinaka, C. B., Egbe, K. A., and Ike, A. C. (2022). Prevalence of Hepatitis B Virus Seromarkers in Female Sex Workers in Enugu State, Nigeria. *Venereology*, *1*(1), 124-134.
9. Okeke, I. N., & Ihekweazu, C. (2021). The importance of molecular diagnostics for infectious diseases in low-resource settings. *Nature Reviews Microbiology*, *19*(9), 547–548. <https://doi.org/10.1038/s41579-021-00598-5>
10. Naidoo, D., & Ihekweazu, C. (2020). Nigeria’s efforts to strengthen laboratory diagnostics – Why access to reliable and affordable diagnostics is key to building resilient laboratory systems. *African Journal of Laboratory Medicine*, *9*(2). <https://doi.org/10.4102/ajlm.v9i2.1019>
11. Ombelet, S., Ronat, J. B., Walsh, T., Yansouni, C. P., Cox, J., Vlieghe, E., Martiny, D., Semret, M., Vandenberg, O., Jacobs, J., & Bacteriology in Low Resource Settings working group (2018). Clinical bacteriology in low-resource settings: today's solutions. *The Lancet. Infectious diseases*, *18*(8), e248–e258. <https://doi.org/10.1016/S1473-3099(18)30093-8>
12. Asogun, D. A., Adomeh, D. I., Ehimuan, J., Odia, I., Hass, M., Gabriel, M., Ölschläger, S., Becker-Ziaja, B., Folarin, O., Phelan, E., Ehiane, P. E., Ifeh, V. E., Uyigue, E. A., Oladapo, Y. T., Muoebonam, E. B., Osunde, O., Dongo, A., Okokhere, P. O., Okogbenin, S. A., … Günther, S. (2012). Molecular Diagnostics for Lassa Fever at Irrua Specialist Teaching Hospital, Nigeria: Lessons Learnt from Two Years of Laboratory Operation. *PLoS Neglected Tropical Diseases*, *6*(9), e1839. <https://doi.org/10.1371/journal.pntd.0001839>
13. Olumade, T. J., Adesanya, O. A., Fred-Akintunwa, I. J., Babalola, D. O., Oguzie, J. U., Ogunsanya, O. A., ... & Osasona, D. G. (2020). Infectious disease outbreak preparedness and response in Nigeria: history, limitations and recommendations for global health policy and practice. *AIMS Public Health*, *7*(4), 736.
14. Achinge, G. I., Kur, J. T., and Gyoh, S. K. (2013). Lassa fever outbreak in Makurdi, North Central Nigeria: what you need to know. *IOSR J Dent Med Sci*, *7*, 42-46.
15. Tomori, O., El-Bayoumi, S. M., & Fabiyi, A. (1976). Virological and serological studies of a suspected yellow fever virus outbreak in Mabudi area of Benue Plateau State of Nigeria. *Nigerian Medical Journal: Journal of the Nigeria Medical Association*, *6*(2), 135-143.
16. Moore, D. Á., Causey, O. R., Carey, D. E., Reddy, S., Cooke, A. R., Akinkugbe, F. M., ... & Kemp, G. E. (1975). Arthropod-borne viral infections of man in Nigeria, 1964–1970. *Annals of Tropical Medicine & Parasitology*, *69*(1), 49-64.
17. Federal Ministry of Health Nigeria (FMOH) and National Tuberculosis and Leprosy Control Programme (NTBLCP). Workers Manual. Revised 5th Edition. Abuja: Federal Ministry of Health Nigeria, 2010.
18. Ihekweazu, C. (2022). Lessons from Nigeria’s adaptation of global health initiatives during the COVID-19 pandemic. *Emerging Infectious Diseases*, *28*(Suppl 1), S299.
19. Omilabu, S. A., Badaru, S. O., Okokhere, P., 1, D., Drosten, C., Emmerich, P., Becker-Ziaja, B., Schmitz, H., & Günther, S. (2005). Lassa Fever, Nigeria, 2003 and 2004. *Emerging Infectious Diseases*, *11*(10), 1642–1644. <https://doi.org/10.3201/eid1110.041343>
20. Ehichioya, D. U., Hass, M., Ölschläger, S., Becker-Ziaja, B., Chukwu, C. O. O., Coker, J., and Omilabu, S. A. (2010). Lassa fever, Nigeria, 2005–2008.
21. Vieth, S., Drosten, C., Lenz, O., Vincent, M., Omilabu, S., Hass, M., and Günther, S. (2007). RT-PCR assay for detection of Lassa virus and related Old World arenaviruses targeting the L gene. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *101*(12), 1253-1264.
22. Ajayi, N. A., Nwigwe, C. G., Azuogu, B. N., Onyire, B. N., Nwonwu, E. U., Ogbonnaya, L. U., ... and Ukwaja, K. N. (2013). Containing a Lassa fever epidemic in a resource-limited setting: outbreak description and lessons learned from Abakaliki, Nigeria (January–March 2012). *International Journal of Infectious Diseases*, *17*(11), e1011-e1016.
23. Salu, O. B., James, A. B., Oke, B. O., Orenolu, M. R., Ogunsola, F. T., Omilabu, S. A., Anyanwu, R. A., Happi, C., Abdus-Salam, I. A., & Abdul-Salam, N. (2016). Biosafety level-2 laboratory diagnosis of Zaire Ebola virus disease imported from Liberia to Nigeria: Case studies. *African Journal of Laboratory Medicine*, *5*(1), 1–5.
24. Vaz, R. G., Mkanda, P., Banda, R., Komkech, W., Ekundare-Famiyesin, O. O., Onyibe, R., and Tegegne, S. G. (2016). The role of the polio program infrastructure in response to Ebola virus disease outbreak in Nigeria 2014. *The Journal of infectious diseases*, *213*(suppl\_3), S140-S146.
25. Maxmen, A. (2019). Nigeria’s disease detective. *Nature*, *566*(7744), 310-313. {29}
26. *Nigeria Centre for Disease Control and Prevention*. Retrieved May 5, 2023, from https://ncdc.gov.ng/news/157/response-to-yellow-fever-cases-in-edo-state
27. Osaigbovo, I. I., Igbarumah, I. O., Muoebonam, E. B., & Obaseki, D. E. (2021). Setting up a molecular diagnostic laboratory for SARS-CoV-2 testing: Experience of a single centre in a resource-constrained setting. *African Journal of Laboratory Medicine*, *10*(1), 1-7.
28. World Health Organization (WHO) Coronavirus disease (COVID-19) technical guidance: Laboratory testing for 2019- nCoV in humans. March 22, 2020. Retrieved from https:// www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/laboratory-guidance
29. WHO. (2023). *COVID-19 weekly epidemiological update, edition 134, 16 March 2023*.
30. Adesanya O. A. (2020). Government preparedness and response towards COVID-19 outbreak in Nigeria: A retrospective analysis of the last 6 months. *Journal of global health*, *10*(2), 020382. <https://doi.org/10.7189/jogh.10.020382>
31. Enita, S. S., Richard, Y. A., Chioma, J. A., Kayode, A. O., Amarachi, J. N., Adeolu, S. O., Chukwudi, A. O., Ayodeji, O. O., Ovye, E. G. A., & Comfort, B. E. (2020). Molecular Diagnosis of COVID-19 in Nigeria: Current Practices, Challenges and Opportunities. *Journal of Infectious Diseases & Case Reports*, 1–11. <https://doi.org/10.47363/JIDSCR/2020(1)117>
32. Abdullahi, I. N., Emeribe, A. U., Ghamba, P. E., & Sani, M. (2020). Public health, socioeconomic responses, and associated challenges against coronavirus disease 2019 pandemic in nigeria. *Open Access Macedonian Journal of Medical Sciences*, *8*(T1), 122-125.
33. Okeke, I. N., Feasey, N., Parkhill, J., Turner, P., Limmathurotsakul, D., Georgiou, P., and Peacock, S. J. (2020). Leapfrogging laboratories: the promise and pitfalls of high-tech solutions for antimicrobial resistance surveillance in low-income settings. *BMJ global health*, *5*(12), e003622.
34. Adebisi, Y. A., Oke, G. I., Ademola, P. S., Chinemelum, I. G., Ogunkola, I. O., & Lucero-Prisno III, D. E. (2020). SARS-CoV-2 diagnostic testing in Africa: needs and challenges. *The Pan African Medical Journal*, *35*(Suppl 2).
35. Musa, E., Nasidi, A., Shuaib, F., Nguku, P. M., & Vaz, R. G. (2016). Nigeria’s Ebola outbreak response: lessons for future epidemic preparedness. *Arch Med*, *8*(6).
36. Okeke, I. N., & Ihekweazu, C. (2021). The importance of molecular diagnostics for infectious diseases in low-resource settings. *Nature Reviews Microbiology*, *19*(9), 547–548. <https://doi.org/10.1038/s41579-021-00598-5>