

Emerging Pathogens and Syndromic Testing: Rapidly Reconfigurable Diagnostics and Surge-Capable Production

Emerging and epidemic pathogens expose structural weaknesses in diagnostic access, surveillance capacity, and manufacturing resilience, particularly in low- and middle-income countries (LMICs). The COVID-19 pandemic demonstrated that delays in decentralized detection amplify transmission and mortality, and inequities in access to testing and reagents can delay effective response.¹ Global health security frameworks, including the International Health Regulations (2005) and recent pandemic preparedness reviews, emphasize the need for scalable diagnostics that can be rapidly deployed, adapted to new threats, and integrated into surveillance systems.^{2,3}

Conventional diagnostic development remains pathogen-specific and laboratory-dependent. While highly accurate, centralized molecular platforms often lack flexibility, rapid scalability, and cost profiles suitable for decentralized LMIC use. During COVID-19, rapid antigen and molecular point-of-care platforms shortened time to detection, but global supply chain constraints and manufacturing bottlenecks limited equitable access.⁴ These challenges highlight the need for rapidly reconfigurable diagnostic architectures capable of adapting to new analytes without full platform redesign and with the capability for automated reporting to public health surveillance systems.

Target product profiles (TPPs) for priority epidemic pathogens outline the required performance and operational characteristics. The World Health Organization's (WHO) R&D Blueprint has issued TPPs for pathogens such as Ebola virus disease, Nipah virus, and other high-consequence threats, emphasizing rapid turnaround, deployability in decentralized settings, minimal infrastructure dependence, and adaptability to outbreak contexts.⁵⁻⁶ Preparedness depends not only on analytical performance but also on scalable manufacturing deployability in low-resource environments.

Surveillance and syndromic diagnostics for undifferentiated febrile illness, respiratory syndromes, and other outbreak-prone clinical presentations represent a critical cross-cutting emerging-pathogen use case. In many endemic settings, febrile patients are initially managed empirically for malaria or common bacterial infections, while viral hemorrhagic fevers, arboviruses, and other outbreak-prone pathogens remain undetected until late in transmission chains. Surveillance studies in sub-Saharan Africa demonstrate substantial diagnostic overlap, frequent co-detections, and a persistent proportion of febrile illness with no pathogen identified, highlighting a surveillance blind spot that single-pathogen testing cannot address.⁷⁻⁹ Field-usable, reconfigurable multiplex or syndromic panels that stratify malaria versus other actionable or outbreak-prone etiologies, support co-infection interpretation, and trigger confirmatory testing and response could improve patient-level management and sentinel surveillance.

This need is particularly salient for pathogens such as Lassa fever and epidemic-prone arboviruses, where delayed suspicion and diagnosis contribute to high case fatality and nosocomial transmission. WHO and partners have emphasized the importance of integrated AFI surveillance approaches that link near-patient diagnostics with confirmatory testing and public-health response, rather than relying on siloed, disease-specific workflows.^{7,10}

The same reconfigurable multiplex architectures used for AFI surveillance are directly applicable to respiratory syndromic testing, where overlapping clinical presentations, co-circulation of pathogens, and seasonal surges complicate case management and outbreak detection. WHO and partners increasingly emphasize integrated surveillance for respiratory pathogens with epidemic and pandemic potential, including influenza A/B, SARS-CoV-2, respiratory syncytial virus (RSV), emerging or zoonotic coronaviruses, and other respiratory viruses of epidemic potential, using flexible platforms capable of adapting to new targets without major redesign.¹¹⁻¹⁴ Field-usable respiratory syndromic panels that

support co-detection, stratify viral versus bacterial etiologies, and link near-patient testing to surveillance systems can strengthen both routine monitoring and early warning for novel threats.

Poliovirus eradication further illustrates the importance of rapid confirmation of circulating virus to trigger vaccination response. Current surveillance relies on stool collection followed by cell culture and molecular characterization at reference laboratories, delaying confirmation and response.^{15,16} Direct (no-culture) detection of live poliovirus from stool, or validated non-stool alternatives that simplify collection and transport, could shorten outbreak confirmation time. WHO guidance also emphasizes environmental surveillance and serologic monitoring to strengthen early warning and identify immunity gaps.^{17,18}

High-order multiplex serosurveillance platforms enable population-level measurement of exposure and immunity across pathogens, supporting vaccine impact evaluation and early detection of emerging threats. WHO guidance on integrated disease surveillance and seroepidemiology underscores the importance of scalable, nationally representative platforms capable of operating at lower cost and higher throughput than legacy systems.⁹

Environmental and wastewater surveillance have also emerged as powerful early-warning tools across multiple pathogens. Wastewater monitoring can detect pathogen circulation prior to widespread clinical reporting, supporting earlier public-health response.¹⁹ WHO guidance highlights the potential for integrated, multiplex platforms capable of detecting priority pathogens in wastewater or environmental samples such as palm sap or milk.¹⁷⁻²¹ Cost-disruptive, modular platforms for multi-pathogen detection in environmental matrices would further strengthen outbreak detection and surveillance integration.

Across emerging pathogen priorities, diagnostics must be adaptable to new pathogens, decentralized, integrated with data systems, and supported by manufacturing pathways that support surge at scale. An additional enabling requirement is data traceability, ensuring that results generated at the point of care are structured, transmitted, and retained within national and global surveillance systems, rather than lost in disconnected workflows. Cost-disruptive innovations that combine technical agility, syndromic surveillance capability, surge-ready production, and integrated reporting can shorten the time from pathogen emergence to population-level action and strengthen global health security.

References

1. World Health Organization. WHO Policy Brief: COVID-19 surveillance. Geneva: WHO; 2024. https://www.who.int/docs/default-source/coronaviruse/policy-briefs/policy-brief_covid-19_surveillance.pdf
2. World Health Organization. International Health Regulations (2005), Third Edition. Geneva: WHO; 2016 (Amended 2024). https://apps.who.int/gb/bd/pdf_files/IHR_2014-2022-2024-en.pdf
3. Independent Panel for Pandemic Preparedness & Response. COVID-19: Make it the Last Pandemic. 2021. Available from: <https://theindependentpanel.org/mainreport/>
4. Ruhwald M, et al. Learning from COVID-19 to reimagine tuberculosis diagnosis. *Lancet Microbe*. 2021; Volume 2, Issue 5, e169 - e170.
5. World Health Organization. Pathogens prioritization: a scientific framework for epidemic and pandemic research preparedness. Geneva: WHO; 2024. <https://www.who.int/publications/m/item/pathogens-prioritization-a-scientific-framework-for-epidemic-and-pandemic-research-preparedness>
6. World Health Organization — R&D Blueprint. Geneva: WHO. Available from: <https://www.who.int/teams/blueprint>

7. Prasad N, et al. Etiology of severe febrile illness in low- and middle-income countries: a systematic review. *PLoS One*. 2015;10(6):e0127962. doi:10.1371/journal.pone.0127962
8. Wainaina M, et al. A systematic review and meta-analysis of the aetiological agents of non-malarial febrile illnesses in Africa. *PLoS Negl Trop Dis*. 2022;16(1):e0010144.
9. World Health Organization. Technical guidelines for integrated disease surveillance and response in the African Region. 3rd ed. Brazzaville: WHO Regional Office for Africa; 2019. <https://www.afro.who.int/publications/technical-guidelines-integrated-disease-surveillance-and-response-african-region-third>
10. World Health Organization. Lassa Fever R&D Roadmap. Geneva: WHO; 2019. [https://www.who.int/publications/m/item/lassa-fever-research-and-development-\(r-d\)-roadmap](https://www.who.int/publications/m/item/lassa-fever-research-and-development-(r-d)-roadmap)
11. World Health Organization. “Crafting the mosaic”: a framework for resilient surveillance for respiratory viruses of epidemic and pandemic potential. Geneva: WHO; 2023. <https://www.who.int/initiatives/mosaic-respiratory-surveillance-framework/>
12. World Health Organization. Implementing integrated sentinel surveillance of influenza and other respiratory viruses of epidemic and pandemic potential by the Global Influenza Surveillance and Response System. Geneva: WHO; 2024. <https://reliefweb.int/report/world/implementing-integrated-sentinel-surveillance-influenza-and-other-respiratory-viruses-epidemic-and-pandemic-potential-global-influenza-surveillance-and-response-system>
13. World Health Organization. Global Influenza Surveillance and Response System (GISRS). Geneva: WHO. <https://www.who.int/initiatives/global-influenza-surveillance-and-response-system>
14. World Health Organization. Prioritizing diseases for research and development in emergency contexts. Geneva: WHO; 2024. <https://www.who.int/activities/prioritizing-diseases-for-research-and-development-in-emergency-contexts>
15. World Health Organization. Poliovirus laboratory manual, 4th ed. Geneva: WHO; 2004. https://polioeradication.org/wp-content/uploads/2024/05/Polio_Lab_Manual04.pdf
16. McKinlay MA, Orenstein WA, editors. *Human Poliovirus*. Basel & Beijing: MDPI AG; 2025.
17. World Health Organization. Field guidance for the implementation of environmental surveillance for poliovirus. Geneva: WHO; 2023. Available from: <https://www.who.int/publications/b/58136>
18. World Health Organization. Polio: Vaccine Preventable Diseases Surveillance Standards. Geneva: WHO; 2018. <https://www.who.int/publications/m/item/vaccine-preventable-diseases-surveillance-standards-polio>
19. Medema G, et al. Implementation of environmental surveillance for SARS-CoV-2 to support public health decisions: opportunities and challenges. *Curr Opin Environ Sci Health*. 2020;17:49–71.
20. World Health Organization. Wastewater and environmental surveillance. Geneva: WHO; c2026. Available from: <https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/sanitation-safety/wastewater>
21. WaSPP – Wastewater Surveillance for Pandemic Prevention [Internet]. London: Waspp.org; c2025 [cited 2026 Mar 6]. Available from: <https://www.waspp.org/>