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Microbial diagnostics: Bridging the gap between lab and clinic.

Ayenew Negesse*

Department of Veterinary Medicine, University of East London, United Kingdom

Correspondence to: Ayenew Negesse, Department of Veterinary Medicine, University of East London, United Kingdom. E-mail: ayenewnegessa@edi.com

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Introduction

For instance, machine learning models can predict bloodstream infections based on vital signs and lab parameters, prompting early diagnostic testing and intervention. Telemedicine and cloud-based diagnostics also enable remote access to expert interpretation, expanding diagnostic reach in underserved areas. Microbial diagnostics are central to combating antimicrobial resistance (AMR). Rapid identification of resistant strains allows for targeted therapy, reducing unnecessary antibiotic use. Tools like MALDI-TOF mass spectrometry and whole-genome sequencing can detect resistance genes and track their spread across populations. Surveillance networks such as GLASS (Global Antimicrobial Resistance Surveillance System) rely on diagnostic data to inform public health strategies. Microbial diagnostics play a pivotal role in identifying infectious agents, guiding treatment decisions, and controlling disease outbreaks. Yet, despite remarkable advances in laboratory technologies, a persistent gap remains between bench-side innovation and bedside application. Bridging this divide is essential to ensure timely, accurate, and actionable diagnostic insights that improve patient outcomes and public health. Microbial diagnostics encompass a range of techniques used to detect and characterize bacteria, viruses, fungi, and parasites. These tools are critical for: Identifying causative pathogens in infections. Determining antimicrobial susceptibility. Monitoring disease outbreaks and resistance trends [1].

In clinical settings, rapid and reliable diagnostics can mean the difference between life and death—especially in cases of sepsis, meningitis, or multidrug-resistant infections. Conventional diagnostic methods include culture-based techniques, microscopy, and biochemical assays. While these remain the gold standard for many pathogens, they suffer from several limitations: Cultures may take days to yield results. Some pathogens are fastidious or present in low abundance [2].

For example, syndromic panels for respiratory or gastrointestinal infections can identify dozens of pathogens in a single test, streamlining diagnosis and treatment. NGS, in particular, enables metagenomic analysis of clinical samples, uncovering rare, novel, or unexpected microbes without prior assumptions. This has proven invaluable in diagnosing encephalitis, sepsis, and unexplained febrile illnesses. The advent of molecular diagnostics has revolutionized microbial detection. Techniques such as polymerase chain reaction (PCR), loop-mediated isothermal amplification (LAMP), and next-generation sequencing (NGS) offer: Multiplexing capabilities to detect multiple pathogens simultaneously [3].

Point-of-care (POC) diagnostics are designed for use at or near the patient, offering immediate results without the need for centralized laboratories. Examples include lateral flow assays, portable PCR devices, and smartphone-based readers. POC tests are especially beneficial in resource-limited settings, emergency departments, and outbreak scenarios. They empower clinicians to make informed decisions quickly, reducing diagnostic delays and improving antimicrobial stewardship. However, challenges remain in ensuring the accuracy, affordability, and regulatory approval of POC technologies [4].

Despite technological advances, several barriers hinder the seamless integration of microbial diagnostics into clinical workflows: Complex results from molecular or genomic tests require expert analysis, which may not be readily available in all healthcare settings. Transporting samples to centralized labs and relaying results back to clinicians can introduce delays. Advanced diagnostics may be expensive and not covered by insurance, limiting accessibility. Clinicians may lack familiarity with newer diagnostic platforms, leading to underutilization or misinterpretation. Bridging these gaps requires collaboration between microbiologists, clinicians, informaticians, and policymakers. Automating image analysis (e.g., Gram stains, culture plates) [5].

Conclusion

Microbial diagnostics are the linchpin of effective infectious disease management. While laboratory innovations have surged ahead, translating these advances into clinical impact requires systemic change. By aligning technology, training, policy, and patient care, we can bridge the gap between lab and clinic—ushering in a new era of precision diagnostics and improved health outcomes. Emerging diagnostics are enabling personalized approaches to infectious disease management. Host-pathogen interaction profiling, immune response biomarkers, and microbiome analysis offer nuanced insights into disease susceptibility and treatment response. For example, gut microbiome composition can influence the efficacy of antibiotics and vaccines. Diagnostic tools that assess microbial diversity and dysbiosis are opening new avenues in precision medicine.

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