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Perspective

Microbial Assay-Based Strategies for Antimicrobial Resistance Surveillance

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DESCRIPTION

Antimicrobial resistance (AMR) is one of the most important global health threats, as it undermines the effectiveness of antibiotics, antifungals, antivirals and other antimicrobial agents. The rise of resistant pathogens leads to treatment failures, prolonged illnesses, increased healthcare costs and higher mortality rates. A key component in combating AMR is the surveillance of antimicrobial resistance patterns, which allows healthcare providers, researchers and public health authorities to understand the prevalence and spread of resistance. Microbial assays play a central role in this surveillance by providing accurate, reproducible and scalable methods for testing the susceptibility of microorganisms to antimicrobial agents. This article examines microbial assay-based strategies for AMR surveillance, including traditional and novel approaches, challenges and the role of microbial assays in monitoring resistance trends globally.

Microbial assay-based surveillance strategies

National and International AMR Surveillance Networks: Microbial assays are integral to national and international surveillance networks aimed at tracking AMR. For example, the Global Antimicrobial Resistance Surveillance System (GLASS), established by the World Health Organization (WHO), relies on antimicrobial susceptibility testing to monitor resistance trends across different countries and regions. These surveillance systems collect data from clinical and laboratory settings, using microbial assays to track the prevalence of resistance in various pathogens, such as *Escherichia coli*, *Staphylococcus aureus* and *Mycobacterium tuberculosis*. National surveillance programs, such as the National Antimicrobial Resistance Monitoring System (NARMS) in the United States, also use microbial assays to monitor resistance in foodborne pathogens, animals and humans. These programs contribute valuable data that inform public health policies and antimicrobial stewardship programs. Healthcare-Associated Infections (HAIs) are a major concern in the fight against AMR, as hospitals and other healthcare facilities are hotspots for resistant pathogens. Microbial assays are used for targeted surveillance in these settings to identify resistant infections early and guide appropriate treatment strategies. For instance, surveillance of Clostridium difficile infections and Methicillin-Resistant *Staphylococcus aureus* (MRSA) can help prevent outbreaks and control the spread of resistant pathogens within healthcare environments. Antimicrobial resistance is not confined to human health; it also affects animals, particularly in veterinary medicine. Microbial assays are used to monitor resistance in veterinary pathogens and to assess the impact of antimicrobial use in animal husbandry. Resistance patterns in *Escherichia coli*, Salmonella and other zoonotic pathogens can be tracked through microbial assays, providing insights into the transmission of resistance between animals and humans. Surveillance efforts are also extended to the environment, where antimicrobial-resistant microorganisms can persist and contribute to the spread of resistance. Wastewater, agricultural runoff and soil samples are tested using microbial assays to detect resistant bacteria. This type of surveillance is essential for understanding the environmental reservoirs of resistance and developing strategies to mitigate contamination.

Challenges in microbial assay-based AMR surveillance

Variability in Methodology one of the challenges in AMR surveillance is the variability in the methods used for antimicrobial susceptibility testing. Different laboratories may use different assay techniques, reagents and protocols, leading to inconsistent results. Standardized procedures and guidelines, such as those provided by the Clinical and Laboratory Standards Institute (CLSI) and EUCAST (European Committee on Antimicrobial Susceptibility Testing), help mitigate this issue and ensure that results are comparable across different settings. As microorganisms evolve, novel resistance mechanisms emerge, making it more challenging to detect and track AMR using conventional microbial assays. Advanced molecular techniques, such as PCR-based assays and Next-Generation Sequencing (NGS), are increasingly used alongside traditional microbial assays to identify novel resistance genes and mutations. Integrating these technologies into surveillance efforts can improve the accuracy and speed of AMR monitoring. In many low- and middle-income countries, resources for antimicrobial

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resistance surveillance are limited. Microbial assays can be expensive and access to the necessary laboratory infrastructure, reagents and trained personnel may be restricted. To overcome this challenge, affordable and simplified assay methods, as well as international collaborations, are needed to strengthen surveillance efforts globally. The large volume of data generated from microbial assays can be immense and effective data management systems are required to store, analyze and interpret surveillance results. Automated data collection and advanced bioinformatics tools can help streamline this process, but the interpretation of resistance data requires expertise to account for factors such as geographic variations, clinical relevance and epidemiological trends. Microbial assays are indispensable tools in the fight against antimicrobial resistance, providing important data for surveillance, prevention and treatment strategies. By enabling the detection of resistant pathogens and monitoring resistance trends, microbial assays contribute to global efforts to combat AMR. While challenges such as variability in methodology, the emergence of novel resistance mechanisms and resource limitations exist, continued innovation in assay technologies and international collaboration can help strengthen surveillance systems. As antimicrobial resistance continues to threaten public health, microbial assay-based strategies will remain a fundamental in monitoring and controlling this global issue.