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Perspective

# Use of AI in Predicting Antibiotic Resistance Patterns: A Systematic Review

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## DESCRIPTION

The global rise in antibiotic resistance presents a mounting challenge to healthcare systems, as traditional surveillance and response methods struggle to keep pace with the rapid evolution of microbial resistance. One emerging solution is the application of Artificial Intelligence (AI) to predict resistance patterns, offering promise for more targeted treatment, earlier intervention, and improved antimicrobial stewardship. Over the past five years, a growing body of research has evaluated AI-driven models for their predictive accuracy and clinical utility in combating Anti-Microbial Resistance (AMR). This article synthesizes recent findings through a systematic review lens and offers a perspective on the potential and limitations of AI in this domain. The review of literature from 2019 to 2024 shows a marked increase in studies employing Machine Learning (ML) and Deep Learning (DL) algorithms to predict antibiotic resistance in both hospital and community settings. These AI models are designed to analyze large datasets including Electronic Health Records (EHRs), genomic sequences, microbiology lab result, and epidemiological trends to forecast resistance to specific antibiotics. Some of the most commonly used algorithms include random forests, support vector machines, convolutional neural networks and recurrent neural networks.

Among these studies, several have demonstrated high predictive accuracy. For instance, ML models trained on EHR and microbiological data have achieved over 85% accuracy in predicting resistance in pathogens such as *Escherichia coli*, *Klebsiella pneumoniae* and *Staphylococcus aureus*. Particularly noteworthy are studies using genomic data, where Whole-Genome Sequencing (WGS) is combined with AI to identify resistance genes and mutations. These approaches not only predict resistance profiles but can also anticipate the emergence of new resistance mechanisms providing a valuable edge for public health preparedness. One of the most cited benefits of AI in this field is its ability to uncover non-obvious patterns in vast and complex datasets. Unlike conventional statistical models, AI systems can adaptively learn from new inputs, meaning that resistance trends can be continuously updated in near real-time.

This feature is especially critical in hospital settings where local antiprograms may become outdated quickly and where timely, evidence-based prescribing can significantly impact patient outcomes.

Another advantage lies in AI's potential integration into Clinical Decision Support Systems (CDSS). Several pilot programs in Europe and North America have explored embedding AI resistance prediction tools into hospital EHR platforms, providing prescribers with real-time understanding into likely resistance profiles before lab results are available. This pre-emptive capability not only supports faster and more appropriate treatment decisions but also reduces the misuse of broad-spectrum antibiotics, a key driver of resistance. However, the implementation of AI-based resistance prediction is not without challenges. One major limitation is the variability and quality of input data. AI models are only as good as the data they are trained on; inconsistent data collection practices, missing values and regional differences in resistance patterns can affect model reliability and generalizability. Moreover, most AI models are trained using retrospective datasets, raising concerns about their prospective performance and clinical utility in dynamic environments.

Another critical issue is interpretability. Many deep learning models function as "black boxes," offering little transparency into how decisions are made. This opacity can hinder clinician trust and limit regulatory approval. In response, a new wave of research is focusing on explainable AI (XAI), which aims to make model outputs more transparent and clinically interpretable. This is a crucial step toward building confidence in AI tools among healthcare providers. Equity is another important consideration. Most AI research in AMR prediction has been conducted in high-income countries using data from well-resourced hospitals. For these tools to benefit global AMR management, they must also be validated in Low- and Middle-Income Countries (LMICs) where resistance burdens are often highest but data availability is limited. Collaborative international efforts are needed to ensure equitable access to AI-driven solutions and avoid further widening global health disparities.

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## CONCLUSION

The application of AI in predicting antibiotic resistance patterns represents a transformative advance in the fight against antimicrobial resistance. With high predictive accuracy, rapid adaptability and integration potential into clinical workflows, AI tools offer a powerful complement to traditional surveillance and diagnostic methods. However, their success depends on addressing key challenges data quality, model transparency, clinical validation and global accessibility.

As healthcare systems become increasingly digitized, the integration of AI into routine clinical practice is no longer a distant possibility but an imminent reality. Future efforts should prioritize explainable models, cross border data sharing and ethical frameworks that promote equitable use. High income countries, with their strong infrastructure and research capacity, must lead in refining and deploying these tools while supporting their adaptation in resource-limited settings. Antibiotic resistance is a global threat requiring innovative and scalable solutions. AI has the potential to be one such solution if we invest wisely, collaborate globally, and implement responsibly.