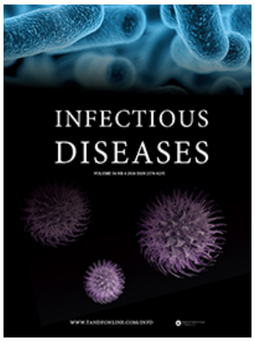

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The impact of artificial intelligence in the fight against antimicrobial resistance

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COMMENT

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The impact of artificial intelligence in the fight against antimicrobial resistance

Artificial intelligence (AI) and antimicrobial resistance (AMR) represent two crucial and interconnected challenges in the global health landscape. On the one hand, AI offers tremendous opportunities in the field of disease diagnosis, treatment and prevention, while, on the other hand, growing AMR threatens our ability to effectively treat infections. Overuse and misuse of antibiotics have contributed to the global emergence of bacterial resistance, making it increasingly difficult to treat common infections. The lack of new antibiotics and slow adoption of effective strategies further increase the risk of a future where common infections could become potentially fatal. Standard methods to diagnose antibiotic resistance are neither fast nor intuitive. The Antimicrobial resistance in the EU/EEA (EARS-Net) – Annual Epidemiological Report for 2022 [1], published in November 2023 on the occasion of European Antibiotic Awareness Day, reported a significant increase in the total number of reported isolates from 366,794 (2021) to 392,602 (2022). The most reported bacterial species in 2022 were *Escherichia coli* [2] (39.2%), followed by *Staphylococcus aureus* [3] (22.1%), *Klebsiella pneumoniae* [4] (12.3%), *Enterococcus faecalis* [5] (8.2%), *Pseudomonas aeruginosa* [6] (6.1%), *Enterococcus faecium* [7] (5.9%), *Streptococcus pneumoniae* [8] (3.7%) and *Acinetobacter spp* [9] (2.5%).

Advanced algorithms can analyze huge amounts of clinical data, diagnose diseases more accurately, and predict treatment outcomes [10]. These tools can be particularly useful in the fight against AMR infections, where timeliness and accuracy are essential. Considering that conventional antimicrobial susceptibility testing exceeds 24 h, while whole genome sequencing requires the expertise of a bioinformatician and the processing of a large amount of data, the implementation of AI algorithms could significantly reduce diagnostic time, for example, by applying antimicrobial susceptibility testing to flow cytometry and supervised machine learning [11] or by improving the handling of genome data in a more efficient and easily interpretable way [12]. Another promising application of AI is the design of new drugs. The discovery of new antibiotics has been limited in recent decades, but AI can speed up the process of identifying promising compounds [13]. By simulating complex molecular interactions, algorithms can identify drug candidates more efficiently than conventional methods [14].

A key aspect of AI in infection management is the ability to rapidly analyze emerging patterns in epidemiological data. By constantly monitoring the spread of AMR bacterial strains, AI can identify trends and predict potential outbreaks. For example, AI has been recently harnessed in response to the water crisis [15]. This effort aims to ensure universal access to uncontaminated water and adequate sanitation, which are critical to reducing the prevalence of infectious diseases and the spread of antibiotic-resistant bacteria. Key areas where AI has proven useful include watershed management, pollutant identification, effluent quality improvement and comprehensive data surveillance. In particular, integrating AI into wastewater solutions has the potential to reduce the occurrence of infections, thereby decreasing antibiotic use and mitigating the emergence of AMR. This ability to anticipate threats allows preventive measures to be implemented and therapeutic strategies to be adapted in real time. This innovative approach could lead to the creation of more potent and targeted antibiotics, helping to combat bacterial resistance.

In addition, AI can greatly improve the diagnosis of infections. Through detailed analysis of data from laboratory tests, diagnostic images and patient history, algorithms can detect the presence of antibiotic-resistant pathogens early. This enables clinicians to select targeted therapies and reduce the misuse of antibiotics, a key factor in the spread of resistance.

While AI has the potential to help improve the quality of care and reduce antibiotic resistance, it also poses a wide range of challenges for individual health care providers and the entire healthcare system. It should be emphasized that understanding patient needs cannot be based solely on an algorithm. It requires physician experience and insight, as well as patient trust, which are still traits built on the human relationship between patient and physician. One major challenge is related to training AI with the limited data available. For predictions to be accurate, the underlying data must be of good quality. For example, data from monitoring and surveillance systems could benefit greatly from an AI approach, including global antibiotic resistance databases such as The Global Antimicrobial Resistance and Use Surveillance System (GLASS), The National DB of Antibiotic-Resistant Organisms, and The Antimicrobial DB for High-Throughput Sequencing.

Additional challenges include limited cooperation between academic institutions and drug-developing industries, as well as the need for a broader concept of 'open science' that includes algorithm sharing. Given the required infrastructure and data needs, most AI initiatives are currently limited to high-income countries (especially the United States and Europe), leaving a huge gap in low- and middle-income countries. Given the current frameworks, implementing AI in low-resource settings is a major systematic challenge. Other country-dependent challenges have been identified, such as transparency in data acquisition, confidentiality and accountability.

Successfully addressing these challenges implies widespread awareness of the need to preserve the efficacy of antibiotics and to adopt sustainable health care practices. Only with a joint and collaborative effort that actively involves health care professionals, researchers, pharmaceutical industries and global institutions and long-term vision will it be possible to achieve significant progress in safeguarding global health and managing medical resources responsibly. Optimizing the use of antibiotics through advanced algorithms, facilitating epidemiological surveillance and timely response to emerging threats are crucial aspects that AI can play in mitigating the spread of AMR and in shaping a more resilient and safer future for everyone's health.

Author contributions

Conception and design, investigations, data analysis, writing – original, and writing – revision: F.B.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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