OPINION

Reprogramming Bacteriophage Therapy with Artificial Intelligence: The Next Leap in AMR Combat

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Antibiotics are extensively utilized as therapeutic agents, ranging from initial treatment to last-resort medications. Microorganisms have acquired antimicrobial resistance (AMR) as a result of their growing use and abuse. The ability of microorganisms, such as bacteria, fungi, viruses, and parasites, to withstand the effects of antimicrobial medications that were once efficient in treating infections is known as antimicrobial resistance (AMR). A major public health concern marked by higher treatment failures and mortality rates is caused by this phenomenon, which is made worse by variables including the overuse and inappropriate use of antibiotics. An estimated 700,000 fatalities worldwide are due to AMR each year (1) , a surge in resistant infections that is substantial, with resistance rates three to four times greater in low- and middle-income nations than in high-income ones (2).

India confronts major issues with AMR, with large economic expenditures connected with it, totalling to $2.5 billion yearly, according to an examination of AMR in five countries: the USA, India, China, the United Kingdom, and Pakistan(3). Additionally, according to the Global One Health Index (GOHI), Brazil and India exhibit significant shortcomings in their AMR laboratory networks and coordination capabilities, which worsens the AMR problem(4). According to estimations, bacterial AMR caused 4.95 million deaths globally in 2019, and by 2050, it might be the cause of 10 million deaths yearly(5). The crucial link between antimicrobial consumption and resistance is further highlighted by the WHO's Global Antimicrobial Resistance and Use Surveillance System (GLASS), with India's high rates of antimicrobial consumption contributing significantly to the global AMR burden(6).

Effective treatment choices are made more difficult by the formation of resistant strains, which are caused by genetic changes and horizontal gene transfer. This results in higher rates of morbidity and mortality linked to drug-resistant illnesses(7). Additionally, the use of antiquated diagnostic methods makes it difficult to identify resistance in a timely and reliable manner, which leads to incorrect antibiotic use and exacerbates the issue(8). AMR has a significant financial impact; estimates suggest that it costs healthcare systems billions of dollars a year and increases hospital stays and medical expenses(9). Effectively combating AMR is further limited by the absence of strong surveillance and antimicrobial stewardship programs, especially in environments with limited resources(10). Therefore, tackling these complex issues is essential to enhancing treatment results and preserving public health. Phage therapy's tailored approach against antibiotic-resistant bacteria is driving its revival as a tool to tackle antimicrobial resistance (AMR). Using bacteriophages—viruses that selectively infect and lyse bacterial cells—phage treatment provides a targeted substitute for conventional antibiotics without negatively impacting human or animal cells(11). This approach holds great promise for treating diseases such urinary tract infections brought on by resistant Escherichia coli strains, as phages can break down biofilms and work in concert with current antimicrobial therapies(12). Recent developments in phage immunobiology and clinical studies show that, despite regulatory obstacles, phage therapy has the ability to treat infections and alter the microbiome, thereby addressing the wider effects of AMR(13,14).

Phage therapy has considerable limits even though it is successful. One major issue is that bacteriophages only work on certain bacterial strains due to their limited host range, which makes phage cocktails necessary to increase their range of action(15). Furthermore, a significant obstacle is the possibility that bacteria would become resistant to phages since several antiphage defensive systems can reduce the effectiveness of phages(16). The therapeutic application of phage therapy is further complicated by regulatory and production issues, and uneven results are caused by a lack of standardized protocols regarding delivery methods, treatment duration, and phage titers(17). Furthermore, phage therapy's incorporation into standard medical practice is hampered by the lack of thorough pharmacokinetic data and applicable policies(15). Artificial intelligence (AI)-based phage therapy is a novel and promising approach as the global health community searches for workable solutions to the expanding problem of AMR.

AI-powered diagnostic tools are essential for detecting and describing bacterial strains that are amenable to phage therapy, which improves the efficacy of antimicrobial resistance (AMR) treatments. The previously time-consuming matching process can be greatly streamlined by these technologies, especially those that use machine learning (ML), which can analyze large datasets to anticipate phage-host interactions, evaluate phage susceptibility, and optimize phage cocktail formulations(18). For example, ML algorithms can speed up host range detection and phage resistance gene identification, both of which are necessary for customizing phage treatments for each patient(19). Furthermore, by overcoming the drawbacks of traditional optical tests, novel diagnostic techniques such as Phage-layer Interferometry (PLI) allow quantitative screening of phages in complicated media(20). Phage therapy can be tailored by incorporating these cutting-edge diagnostic tools, which will improve treatment results against bacterial illnesses that are resistant to antibiotics and tackle the urgent problem of antimicrobial resistance.

Declaration Of Generative Ai And Ai Assisted Technologies In The Writing Process

We hereby declare that there is no use of Artificial Intelligence (AI) tools in the writing, analysis, or preparation of this research paper. The work submitted is entirely original and prepared by the authors.

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