World Journal of
Experimental Biosciences

Volume 14, Number 02: 71 – 72
P-ISSN: 2313-3937, e-ISSN: 3070-0647
2026

Editorial

Leveraging Artificial Intelligence (AI) to Optimize Phage Therapy: A Perspective.

Sonia Bhonchal Bhardwaj[1] Sanjay Chhibber[2]*

Phage therapy has its origin around 100 years back as phages were used to treat various infections. However, improper storage, purification methods and treating bacterial infections not specific to the therapeutic phage led to its downfall in the west except in Eastern European countries where it is still being practiced. With the emergence of antimicrobial resistance, the phage therapy once again has attracted the attention of scientists as a promising strategy. According to a 2024 global analysis, antimicrobial resistance (AMR) will be responsible for 39 million deaths by the year 2050 [1]. This observation further rekindles interest in phages due to their specificity for a particular bacterial strain; making it an attractive alternative to antibiotics to manage multi-drug-resistant bacteria. Traditionally, phage therapy involves isolation of lytic phage against bacterial strains isolated from patients. In the previous year's phage therapy has primarily focused on phage stability, novel formulations and biocompatibility. Various animal models have been employed to assess disease treatment, synergy with antibiotics and biomaterial modification. To further improve phage delivery and stability, different nanocarriers have also been evaluated [2,3]. In spite of significant progress and growing interest in the field, further refinement in the technology is being attempted.

In a commentary published in the journal "Frontiers of Microbiology" in the year 2020 Jean Paul Pirnay mentioned use of AI algorithms and generating phages based on genetic sequences of host bacteria as an upcoming technology to combat AMR more effectively [4]. The recently concluded Stanford experiment showed that computers are beginning to move from analyzing biological information to making biological designs. Scientists at Stanford and the Arc Institute used AI to design complete genomes of 285 phages.

Out of them, 16 were functional phages that could overcome bacterial resistance of original E. coli phage ΦX174. The scientist's used Evo 1 and Evo 2 language models which were capable of generating new genetic sequences. It showed AI is capable of designing biological information [5]. In the last few years, AI-driven tools have now been extensively used to identify phage genetic sequences. These novel phage gene sequences are used to design and engineer therapeutic phages. The AI algorithms can identify the most suitable therapeutic phages from the vast phage library, enabling rapid phage selection. The AI-driven physics has confirmed that neural networks (PINNs) simulate the phage -host bacteria interaction, optimizing personalized dose for efficient therapeutic outcome [6]. Further, bacterial resistance can be overcome by designing an optimum phage cocktail formulation using AI algorithms [7]. Phages have been combined with antibiotics to increase the efficiency of treatment. These phage -antibiotic interactions could be synergistic, neutral or antagonistic. AI based Machine learning systems enable phage -antibiotic optimization through pharmacokinetic and pharmacodynamic datasets [8]. To prevent therapeutic failure by AMR, AI assisted CRISPR phages have been designed to deliver CRISPR-Cas system into host bacteria to specifically target AMR genes. This could eliminate multi -drug resistant pathogens more effectively. Another use of AI is in development of phage libraries for rapid phage selection. Algorithms like natural language processing (NLP) can be used to cluster phages based on genetic homology and host specificity. In this way large datasets of available phage genomes have been extracted through AI/ML and phage therapeutic potential evaluated. The AI-integrated workflow and tools potentially decrease the diagnostic and treatment process from days to hours.

In spite of many advantages certain limitations of AI in phage therapy are being considered. Many regulatory, ethical and practical barriers encompass the AI driven phage therapy. The bacterial resistance against the AI designed phage's can still occur through CRISPR-Cas defense mechanism. Another issue is the phage standardization for dosing; is limited by batch consistency and quality control as phage's are strain specific biological entities. The AI-designed phage's may be rapidly neutralized in the host compared to their "in vitro" stability, thereby reducing therapeutic efficacy. In addition, AI-assisted phage systems increase the complexity of the ethical and legal framework. Any computational error in the algorithm could lead to a false-positive host outcome, particularly in patients with mul-

* Correspondence: **Professor (Emeritus Scientist), Dr. Sanjay Chhibber.** E-mail: sanjaychhibber8@gmail.com .
Department of Microbiology, Panjab University, Chandigarh, India.
Full list of author information is available at the end of the article.

Citation: **Bhardwaj SB, Chhibber S.** (2026) Leveraging artificial intelligence (AI) to optimize phage therapy: A perspective. *World J Exp Biosci* **14**:71-72. doi: 10.65329/wjeb.v14.02.01

tidrug-resistant infections. It is being said that governance systems for operating phage therapy based on AI should rigorously rely on data use agreements, accountabilities and responsibilities shared by clinicians, microbiologists, legal experts, data analysts and patients. The answer is that beneficial science should progress with increasing safeguards in AI systems, DNA synthesis, laboratories and institutional biosafety.

In conclusion, AI-driven phage therapy, if supported by efficient validation and appropriate regulatory guidelines, has a promising future in the management of the increasingly prevalent AMR. The development of phage therapy guided by AI and coupled with increased funding and clinical trials could help prevent deaths due to AMR. AI-driven phage therapy is the next-generation therapeutic to address the global AMR concern in the 21st century.

Funding information

This work received no specific grant from any funding agency.

Conflict of interest

The authors declare that they have no conflicts of interest.

Ethical Approval

Not applicable

CRediT authorship contribution statement

Bhardwaj SB, Chhibber S: Conceptualization, writing of the original draft and writing, review and editing. Both authors contributed to the preparation of this editorial, read, and approved the final version of the manuscript.

Availability of data and materials

All information used is available in the cited literature, & Data will be made available on request.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

AI declaration

The author(s) declare that no Generative AI was used in the creation of this manuscript.

REFERENCES

[1] **Naghavi M, Vollset SE, Ikuta KS, Swetschinski LR, Gray AP, Wool EE, et al.** (2024). Global burden of bacterial antimicrobial resistance 1990–2021: a systematic analysis with forecasts to 2050. Lancet (2024) **404:**1199–1226. doi: 10.1016/S0140-6736(24)01867-1. PMID: 39299261.

[2] **Singla, S., Harjai, K., Katare, O. P., & Chhibber, S.** (2015). Bacteriophage-loaded nanostructured lipid carrier: improved pharmacokinetics mediates effective resolution of Klebsiella pneumoniae-induced lobar pneumonia. *J Infect Dis* **212:**325–334. doi: 10.1093/infdis/jiv029. PMID: 25605867.

[3] **Chhibber S, Kaur J, Kaur S.** (2018) Liposome Entrapment of Bacteriophages Improves Wound Healing in a Diabetic Mouse MRSA Infection. *Front Microbiol* **9**:561. doi: 10.3389/fmicb.2018.00561. PMID: 29651276.

[4] **Pirnay JP.** (2020) Phage Therapy in the Year 2035. *Front Microbiol* **11**:1171. doi: 10.3389/fmicb.2020.01171. PMID: 32582107.

[5] **King SH, Driscoll CL, Li DB, Guo D, Merchant AT, et al.** (2026) Generative design of bacteriophages with genome language models. *Science* **393**:eaec2657. doi: 10.1126/science.aec2657. PMID: 42561074.

[6] **Rahimian M, Mohammadi E, Aghazadeh-Soltan-Ahmadi M, Samari A, Zarghami N.** (2026) An update on experimental to large-**scale production of bacteriophages against superbugs: a review. Crit Rev Biotechnol 46: 25–44. doi:** 10.1080/07388551.2025.2531446. PMID: 40759559.

[7] **Xu S, Yang S, Jiao X, Cai J, Wu J, Qiao J.** (2026) From structure to design: experimental and AI-driven approaches in receptor-binding protein engineering for reprogramming phage host range. *Arch Microbiol* **208**:269. doi: 10.1007/s00203-026-04830-9. PMID: 41843138.

[8] **Galgat H, Pouya N, Tam VH, Nikolaou M.** (2026) Using Machine Learning to Design Effective Antimicrobial Dosing Regimens. *Comput Chem Eng* **210**:109645. doi: 10.1016/j.compchemeng.2026.109645. PMID: 42022206.

Author affiliation

1. Department of Microbiology, Dr Harvansh Singh Judge Institute of Dental Sciences and Hospital, Panjab University, Chandigarh, India.
2. Department of Microbiology, Panjab University, Chandigarh, India.

ORCID:
Bhardwaj SB: https://orcid.org/0000-0003-0650-2813
Chhibber S: https://orcid.org/0000-0003-2600-1450

Published online: September 05, 2026