

# Cholera Phages: A Journey from Bacterial Typing and Surveillance to Phage-Based Antimicrobial Resistance Interventions

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Bacteriophages have played a foundational role in cholera research and surveillance for over eight decades, reflecting a sustained effort to adapt classical microbiology to evolving public health challenges. Since the 1950s, researchers have utilized phages as precise biological tools to understand the epidemiology of *Vibrio cholerae*. In Kolkata, India, early isolation of cholera phages enabled phage typing to differentiate *V. cholerae* strains at a time when molecular methods were absolutely unavailable, providing a critical framework for outbreak investigation and disease tracking.

A landmark advancement was the phage typing scheme developed by Basu and Mukerjee in 1968, which standardized strain discrimination and significantly strengthened epidemiological investigations both nationally and internationally, establishing India as a key contributor to global cholera research. In subsequent decades, the National Institute of Cholera and Enteric Diseases (NICED), Kolkata, emerged as a central hub for phage-based studies. During the 1990s, NICED scientists developed and standardized phage typing schemes for *V. cholerae* O1 and O139, which proved indispensable during periods of high cholera incidence and supported effective public health responses.

The current scenario of bacterial infections has shifted dramatically due to rapid emergence and spread of multidrug-resistant *V. cholerae* and other pathogens, severely limiting antibiotic effectiveness. This escalating AMR crisis has renewed interest in bacteriophages as alternative or complementary therapeutic strategies. Building on decades of foundational work, we have isolated and purified a panel of lytic phages targeting *V. cholerae*, characterized their biological and genomic properties, and evaluated their therapeutic potential in preclinical models. Animal experiments demonstrated significant protection against cholera infection with favourable safety profiles.

Our work illustrates a remarkable translational journey—from classical phage typing to modern phage therapy—underscoring the continued relevance of bacteriophages in addressing cholera and the growing challenge of antimicrobial resistance.