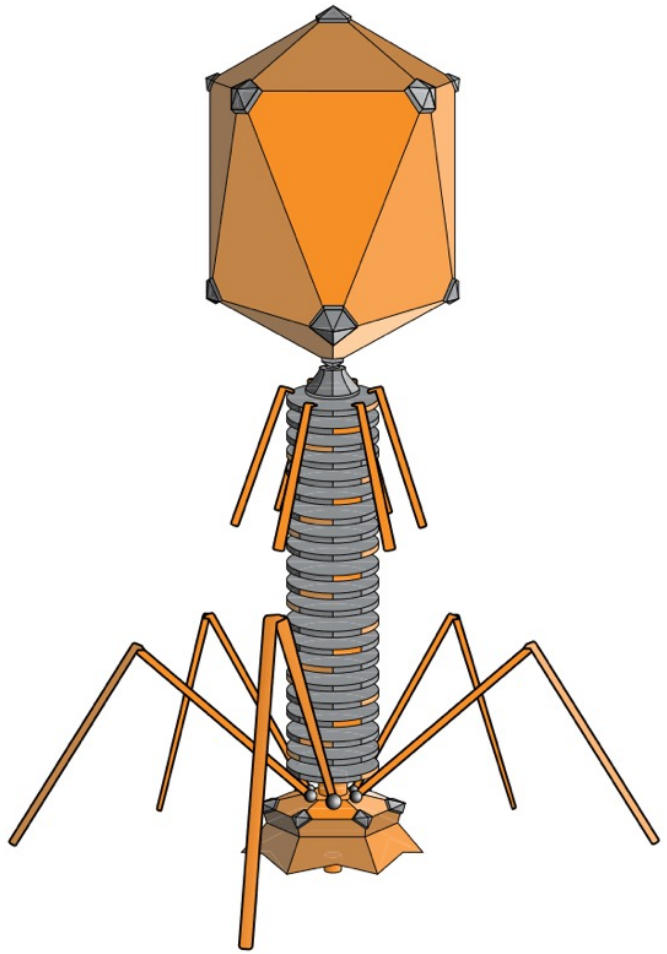
# MESTO BAKTERIOFAGOV PRI ZDRAVLJENJU SEPSE

Doc. Dr. Nina Grasselli Kmet, dr. med.

KIBVS-RC

11.9.2025



# O virusu podobnem povzročitelju z antibakterijskimi lastnostmi je prvi poročal M. E. Hankin leta 1896.

**Značilnosti:**

- temperaturno občutljiv
- sposoben prehajanja skozi porcelanasti filter
- zmanjšal je titer bakterije Vibrio cholerae v laboratorijski kulturi.

- **Hankinovi zaključki:**

"To bi lahko pomagalo zmanjšati pojavnost kolere pri ljudeh, ki uporabljajo vodo iz Gangesa."

Troubled waters? Bathers in the Ganges were thought to be protected from cholera by phage.

# BAKTERIOFAG

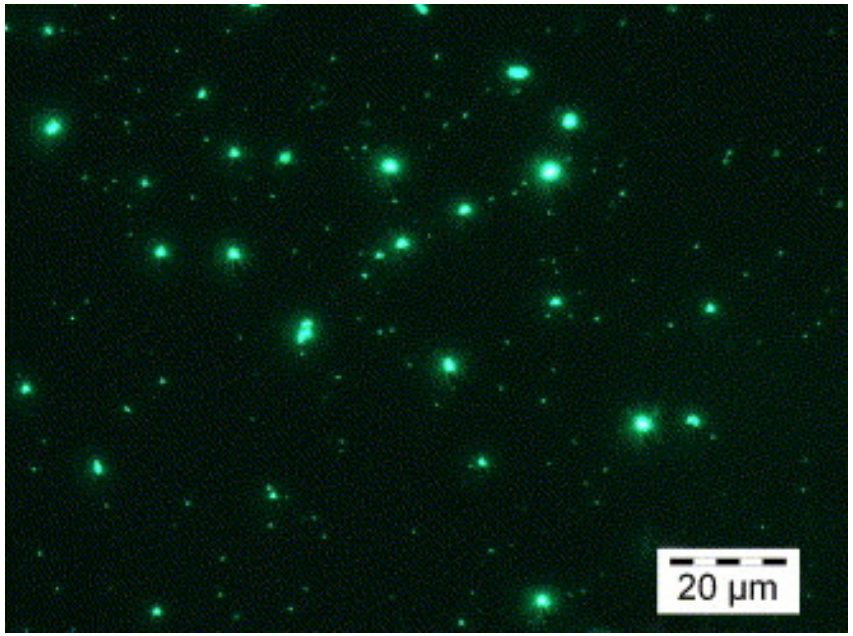
Beseda izvira iz stare grščine

bacteria φαγεῖν (phagein) ‘požreti'

Bakteriofági, ali samo fági (gr. φαγεῖν phagein = žreti), **so virusi, ki zajedajo v bakterijah, in so navadno specifični za vrsto ali sev bakterij**.

!

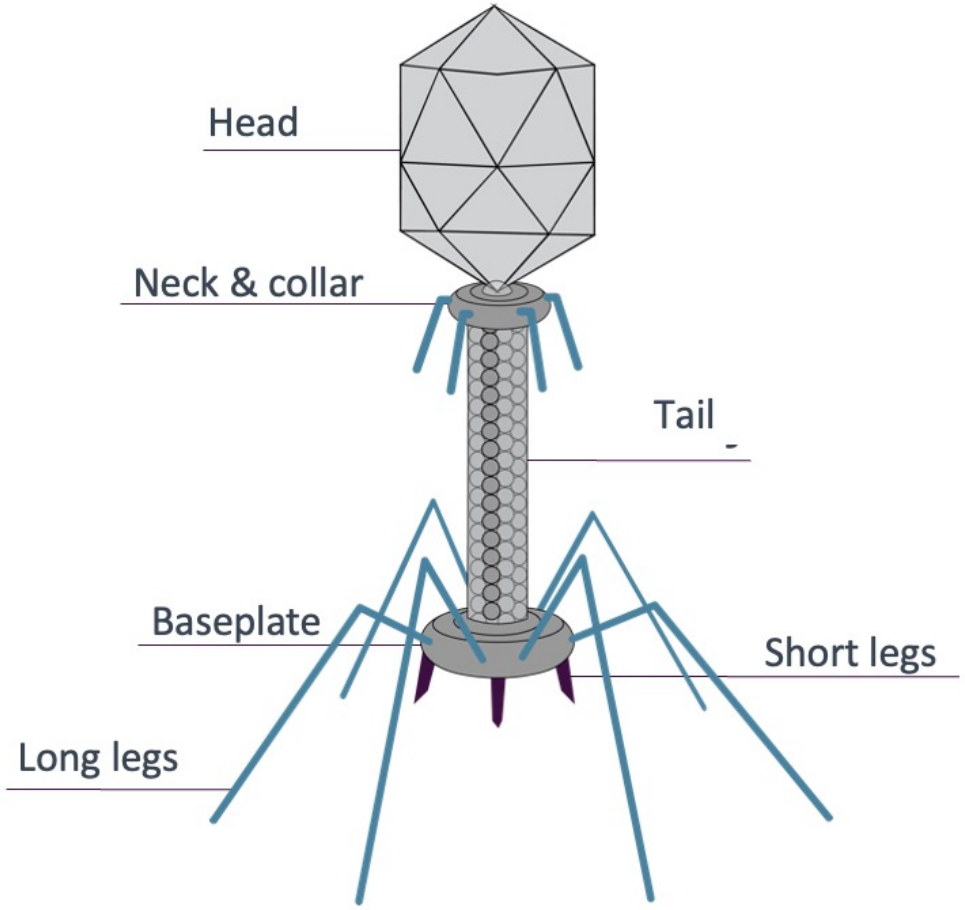
# POJAVNOST




Na planetu je po ocenah $10^{31}$ fagov, ki so vsi potencialno sposobni zdraviti bolezni. Za primerjavo, v nam vidnem delu vesolja je »le« $10^{24}$ zvezd!

Do sedaj je bilo izoliranih in preučenih le 2000–3000 fagov.

# STRUKTURA



# NAČIN DELOVANJA

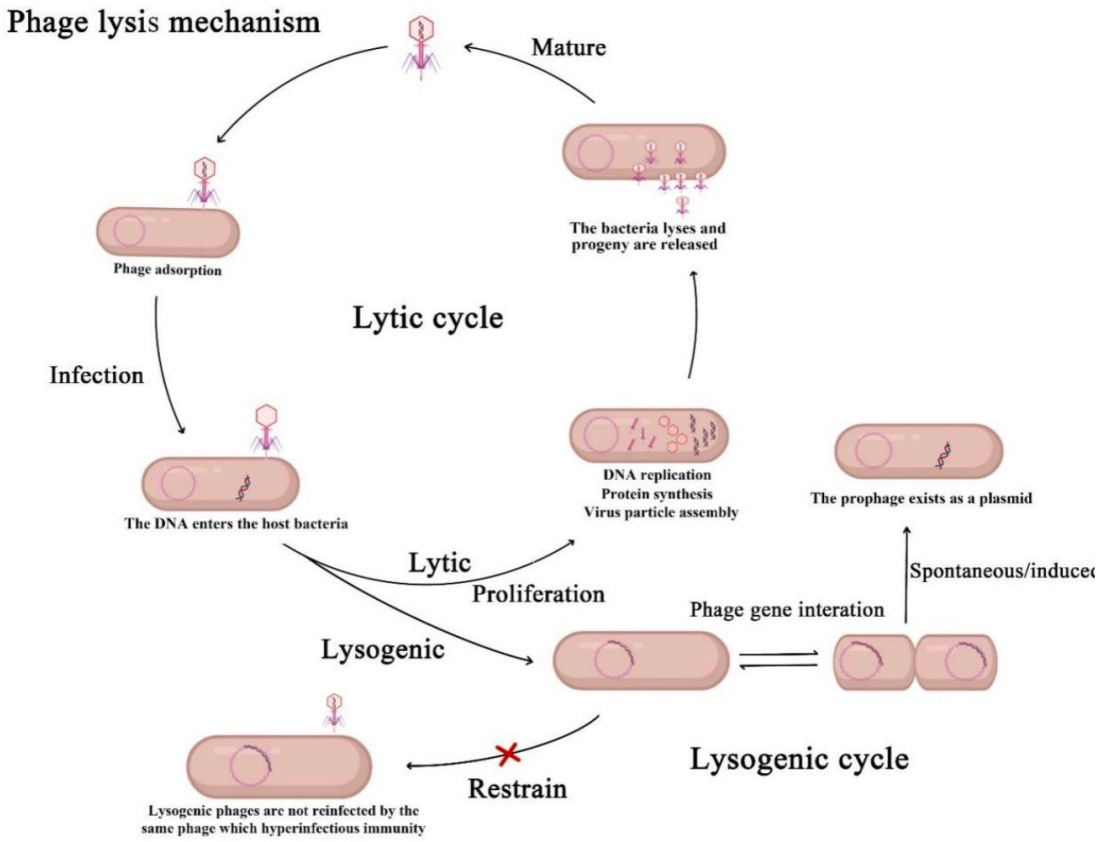



**Figure 1.** Mechanisms of action of lytic phage and lysogenic phage.

## Litični in lizogeni cikel: primerjava

| Značilnost | Litični cikel | Lizogeni cikel |
|---|---|---|
| **Izid za bakterijo** | Bakterija je uničena (lizirana) | Bakterija ostane živa |
| **Integracija DNK faga** | Ne integrira se v bakterijsko DNK | Integrira se v bakterijsko DNK (profag) |
| **Replikacija** | Hitra proizvodnja novih fagov | Fagova DNK se replicira skupaj z bakterijsko DNK |
| **Sprožitev aktivnosti** | Takoj po okužbi | Lahko ostane v mirovanju, aktivira ga stres |

# ODKRITJE BAKTERIOFAGOV


**1898**

**Nnikolai Gamalea**

**Russia**

***Russ Arch Pathol Clin Med Bacteriol 6 (1898), pp. 607–613.***

**1915**

**Frederick Twort**

**UK**

***An investigation on the nature of ultramicroscopic viruses (1915), Lancet 11: 1241***

**1917**

**Felix D'Herelle**

**France**

***Sur un microbe invisible antagoniste des bacilles dysentériques (Comptes rendus de l'Académie des Sciences, Paris, 1917. 165 :p.373-5.***

**1918**

**George Eliava**

**Georgia**

# “THE WINTER WAR” (TALVISOTA)


## 1939-1940

*Experience of phage prophylaxis based on the results of 3 mobile brigades.*

*I brigade applied phages for 2,500 solders, among them gangrene symptoms were revealed in 35 (1,4%) cases. In the control group of 7,918 solders gangrene was registered in 342 (4.3%) cases.*

*II brigade applied phage treatment for 941 solders, only 14 (1,5%) got sick. In the control group 6,8% were infected.*

*III brigade applied phage treatment for 2,584 soders, gangrene was developed in 18 (0,7%) cases, while in the control group incidence of infection was 2,3%*

# BITKA ZA STALINGRAD (1943)

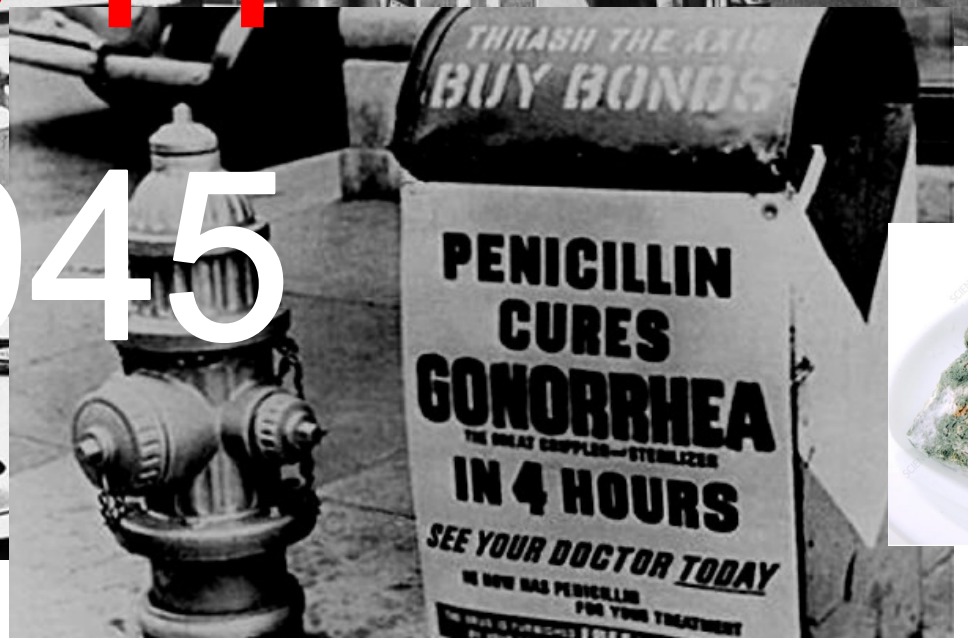
**Zinaida Ermolyeva**


1928


1941

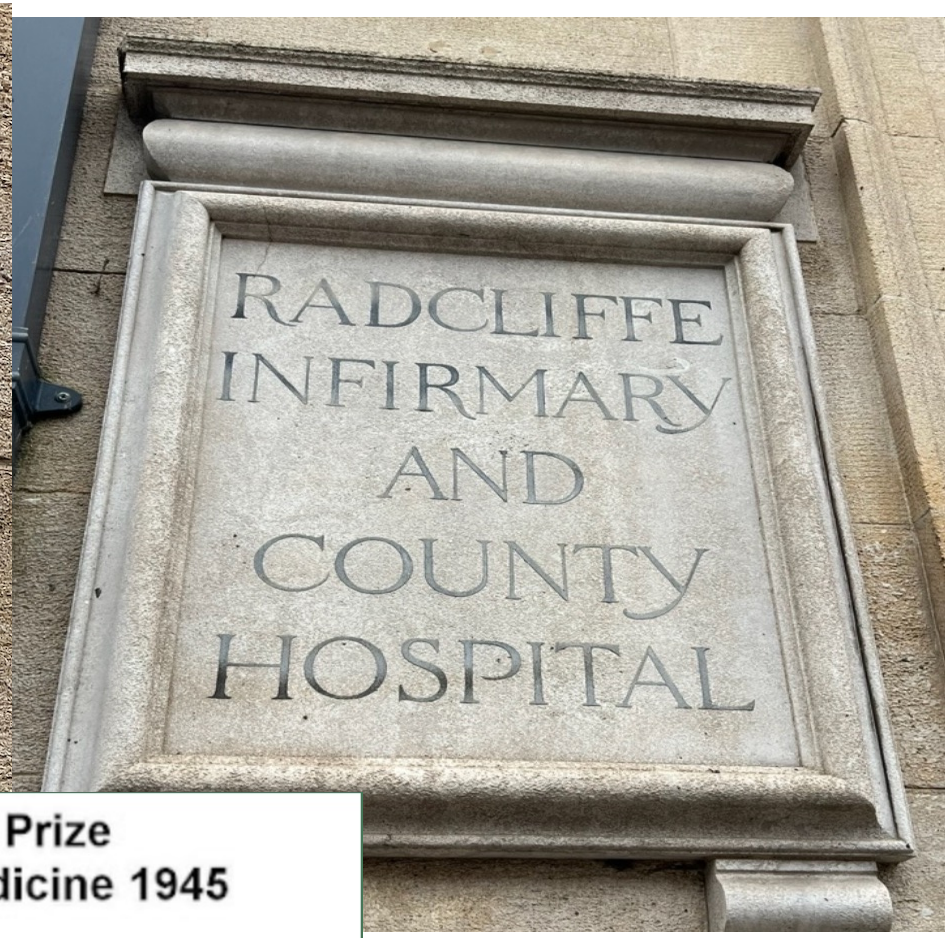


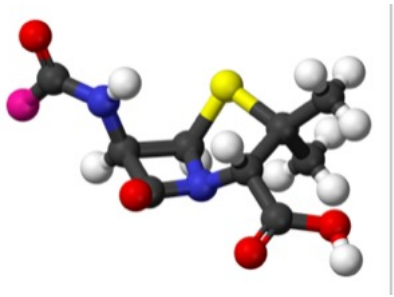
1945

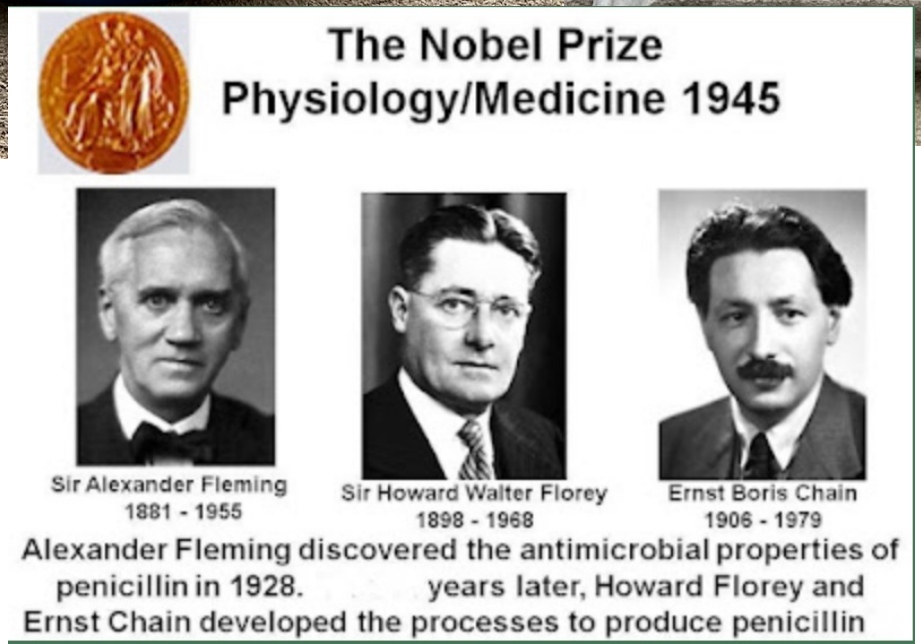


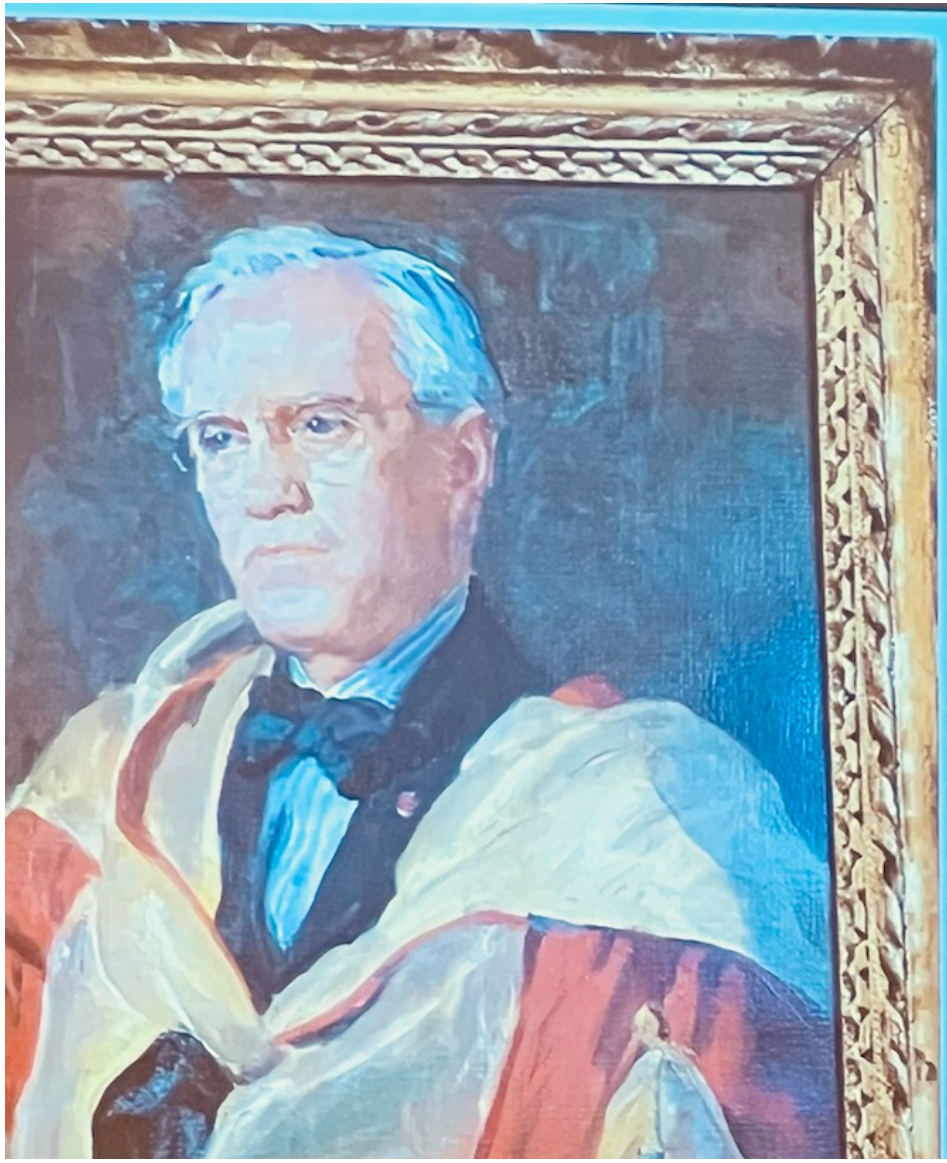


OXFORDSHIRE BLUE PLAQUES BOARD
PENICILLIN
The first antibiotic was
first used to treat infection
here at the Outpatients building
of the former
RADCLIFFE INFIRMARY
on
12 February 1941
NUFFIELD DEPARTMENT OF PRIMARY CARE HEALTH SCIENCES UNIVERSITY OF OXFORD


RADCLIFFE
INFIRMARY
AND
COUNTY
HOSPITAL




The Nobel Prize
Physiology/Medicine 1945
Sir Alexander Fleming
1881 - 1955
Sir Howard Walter Florey
1898 - 1968
Ernst Boris Chain
1906 - 1979
Alexander Fleming discovered the antimicrobial properties of
penicillin in 1928. years later, Howard Florey and
Ernst Chain developed the processes to produce penicillin



"The thoughtless person playing with penicillin treatment is morally responsible for the death of the man who succumbs to infection with the penicillin-resistant organism."

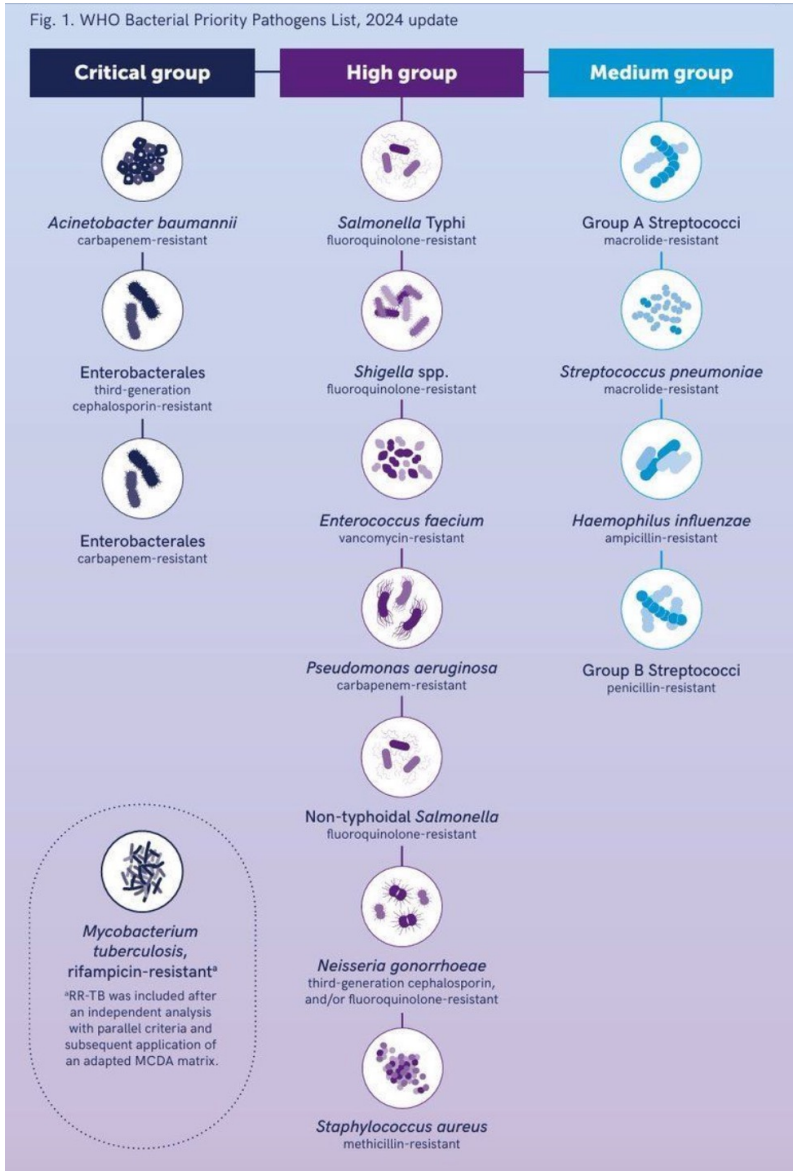
Fleming, 1945

# KAJ JE PROTIMIKROBNA ODPORNOST?

- Protimikrobna odpornost (AMR) je sposobnost mikroorganizmov, da vztrajajo ali rastejo v prisotnosti zdravil, ki so namenjena njihovemu zaviranju ali ubijanju.

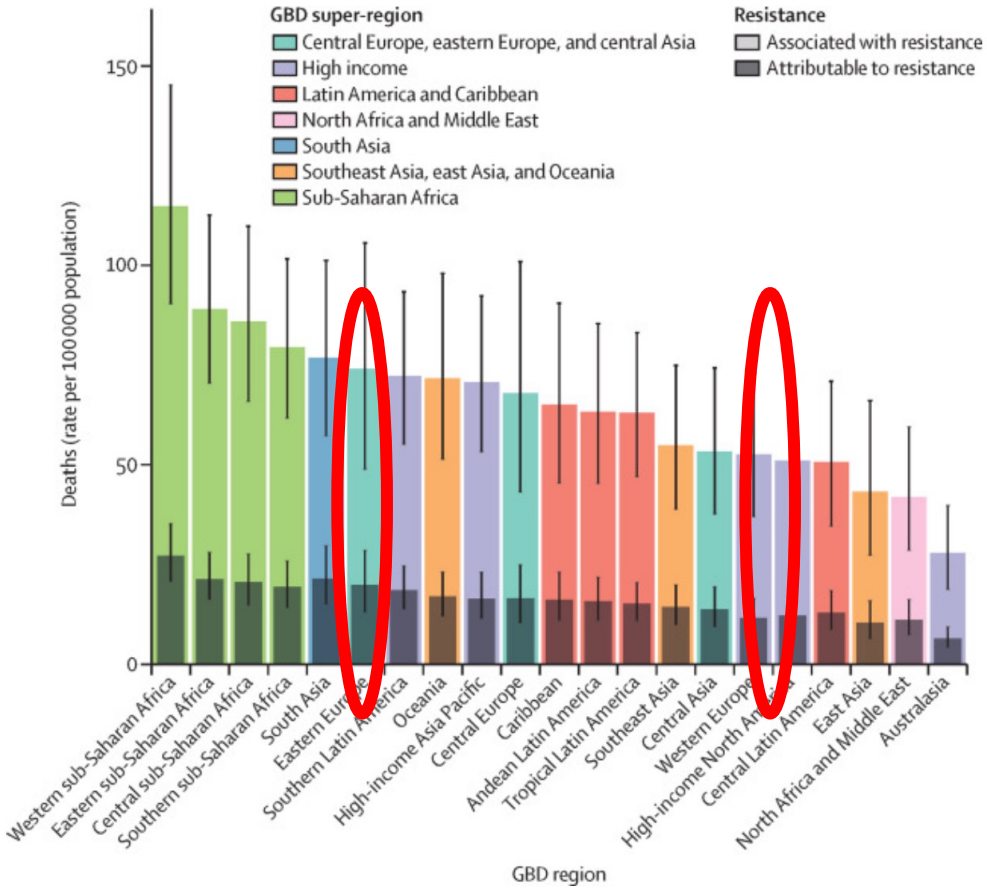
- VOB – vrsta mikroorganizma kaže odpornost na vsaj eno protimikrobno zdravilo v treh ali več protimikrobnih kategorijah

# WHO “PRIORITY” LIST



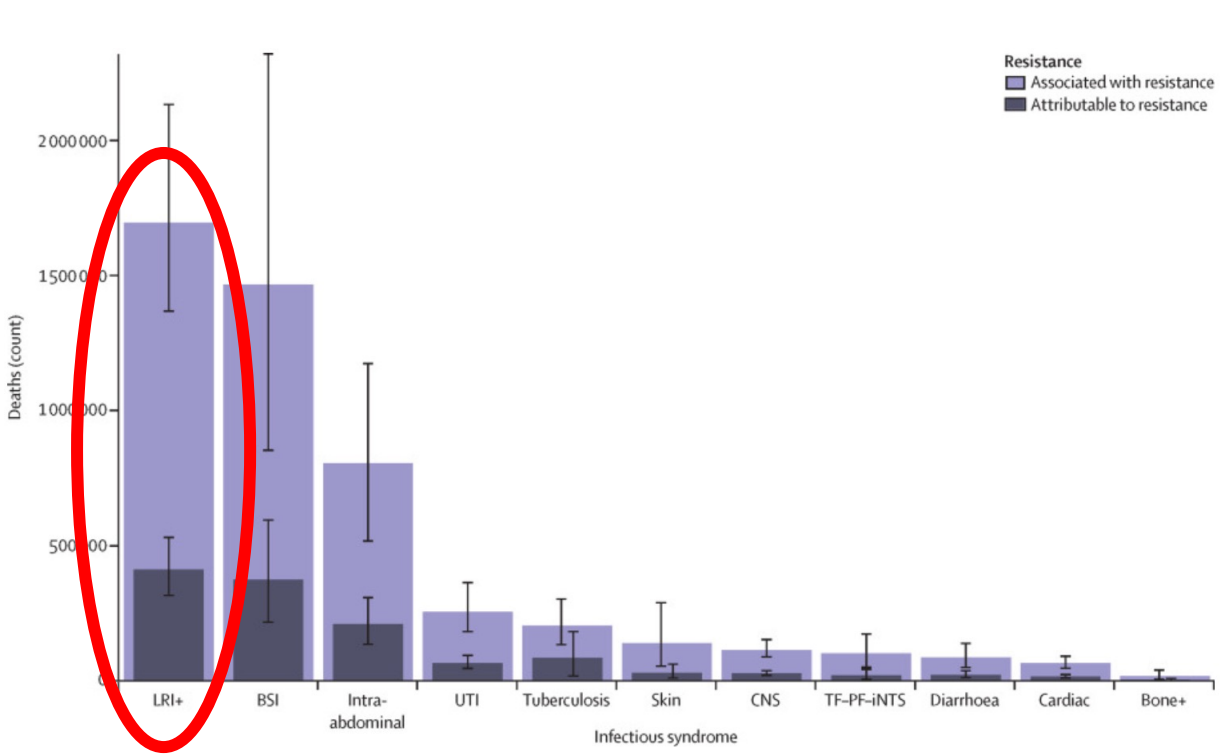
# Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis

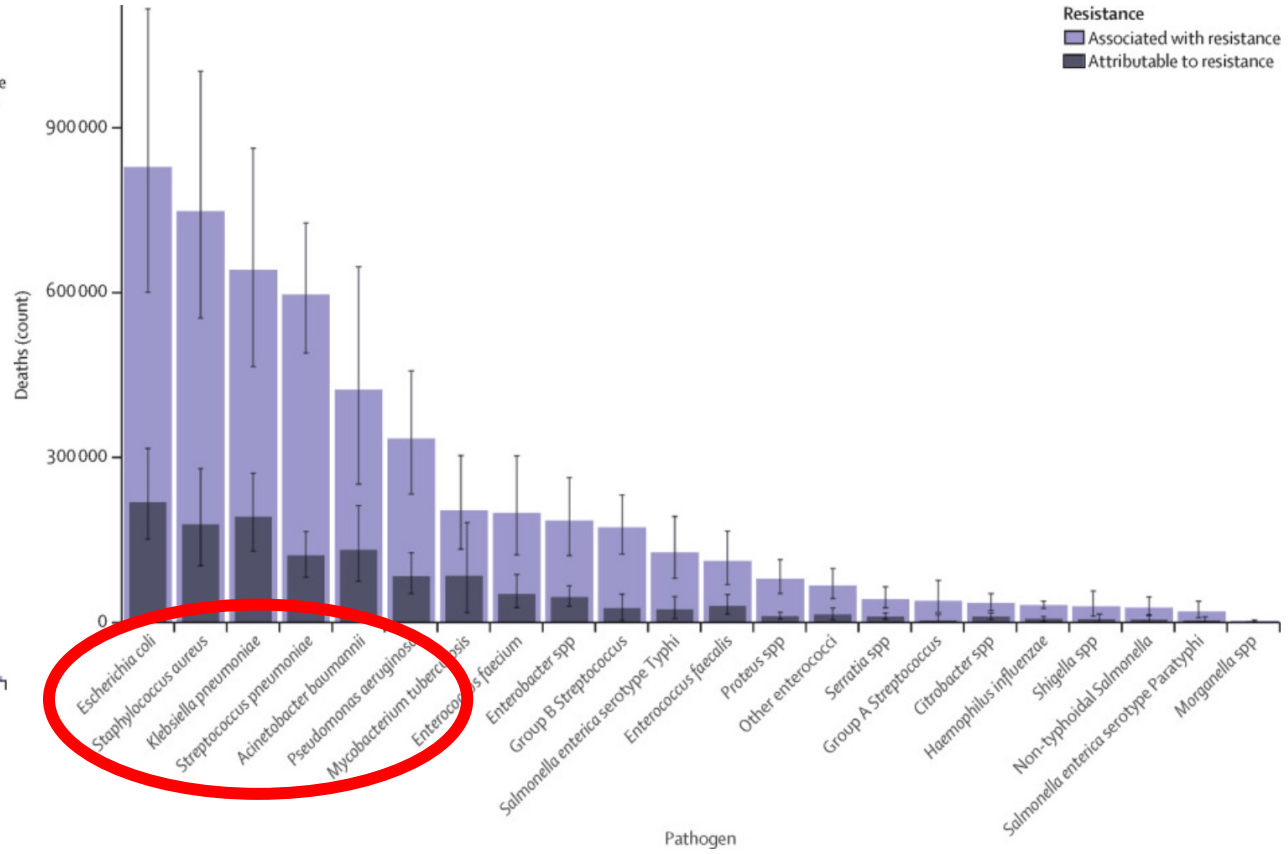
*Antimicrobial Resistance Collaborators**

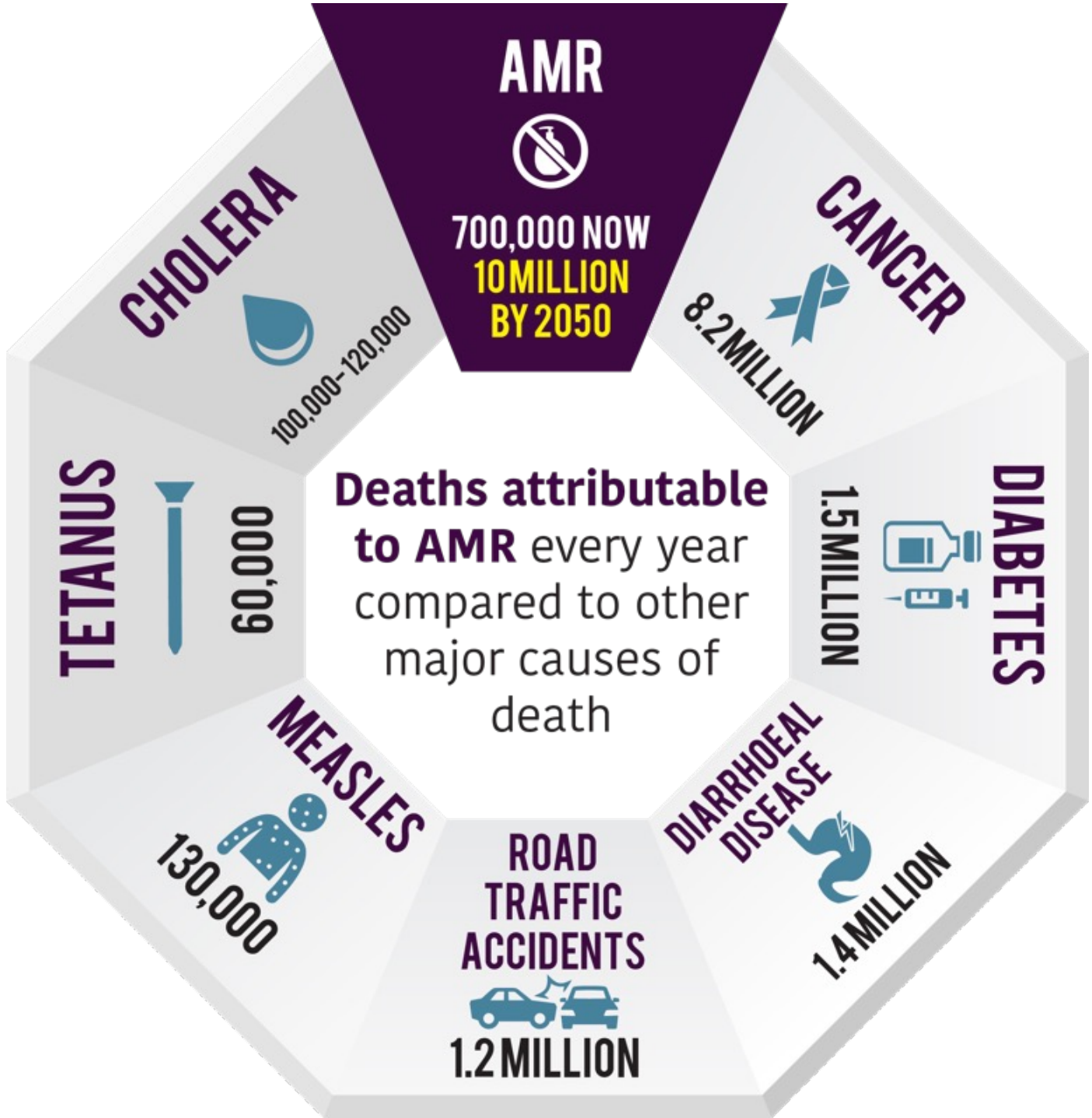


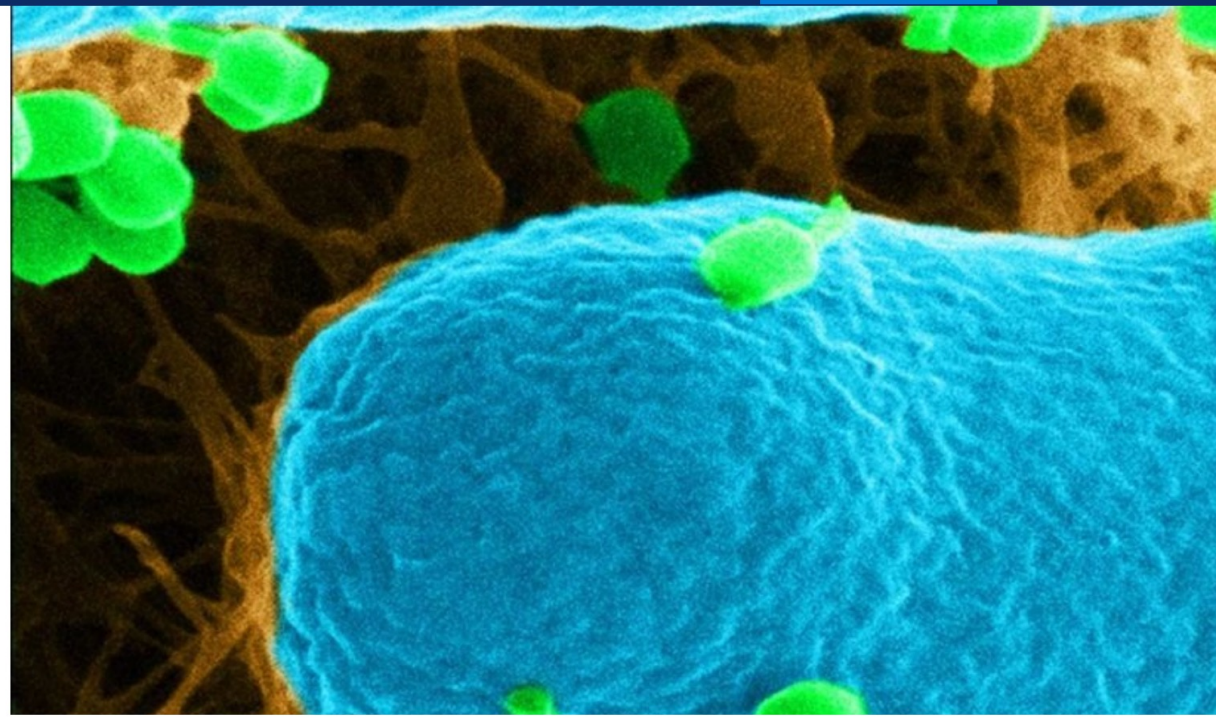
# Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis

*Antimicrobial Resistance Collaborators**




AMR
700,000 NOW
10 MILLION
BY 2050
CHOLERA
100,000–120,000
CANCER
8.2 MILLION
TETANUS
60,000
DIABETES
1.5 MILLION
Deaths attributable to AMR every year compared to other major causes of death
MEASLES
130,000
DIARRHOEAL DISEASE
1.4 MILLION
ROAD TRAFFIC ACCIDENTS
1.2 MILLION



# Bacteriophages and their use in combating antimicrobial resistance

17 February 2025

## Key facts

- Bacteriophages (phages) are viruses that selectively target and kill bacteria. They are the most abundant commonly occurring natural entities, playing crucial roles in regulating bacterial populations and influencing microbial ecosystems.
- Phages are useful as they can destroy bacteria resistant to drugs such as antibiotics. Phages infect their bacterial hosts with great specificity. They do not infect human cells.
- Antimicrobial resistance (AMR) poses a serious global threat to our ability to treat bacterial infections. New antibiotics have often proved difficult and expensive to develop. This has led to an interest in an older approach to treating microbial infections by using phages. Phage therapy can be a promising tool for controlling AMR, which is one of the top global public health and development threats.
- In the WHO European Region, AMR is directly responsible for 133 000 deaths each year and indirectly linked to 541 000 deaths. Estimates show that AMR costs the European Union and European Economic Area about €11.7 billion each year due to health expenditure and workforce productivity losses.
- Addressing AMR requires a multifaceted approach that considers the interconnectedness of human, animal, and environmental health – known as the One Health approach. Phages provide biologically innovative approaches to addressing the challenge of AMR across sectors, ranging from therapeutic use in humans and animals to potentially replacing antibiotic use in the agricultural sector.
- Currently, phages are primarily used on compassionate grounds, in life-threatening situations, when all other treatments have been exhausted.

# FAGI vs. ANTIBIOTIKI

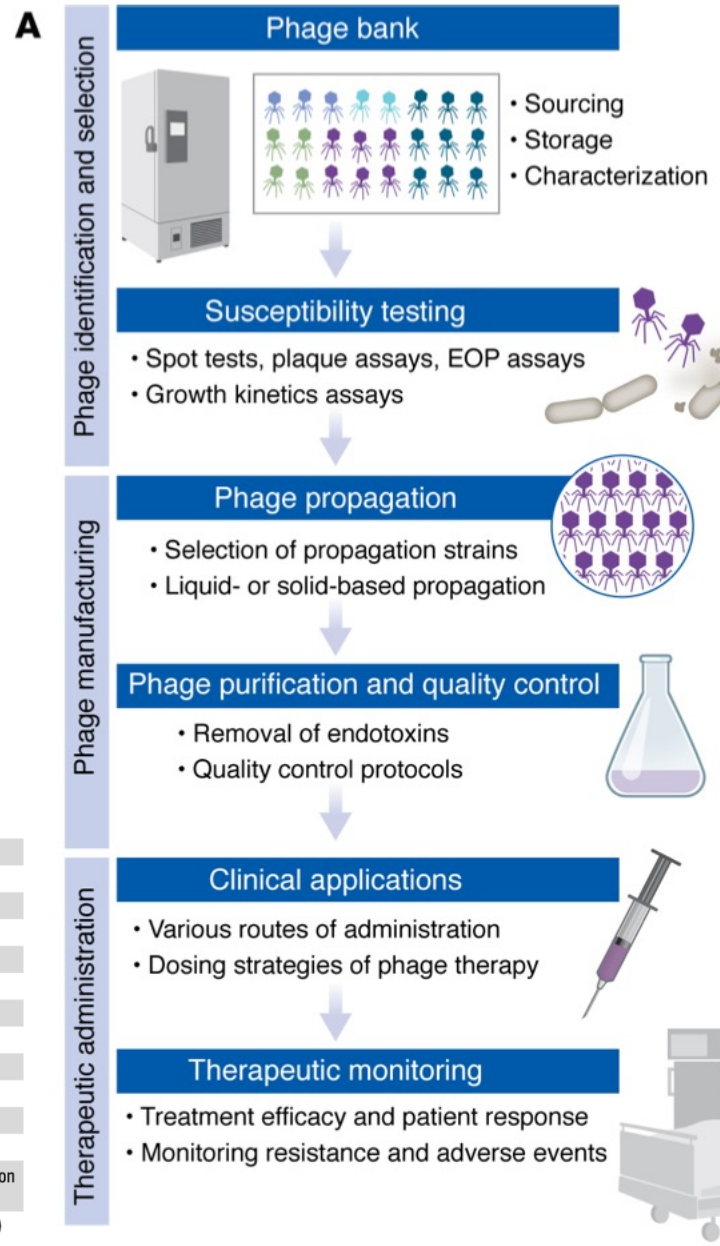
- delujejo specifično na eno klico – ni stranskih učinkov na telesno mikrobioto
- se samoreproducirajo
- s proizvodnjo so povezani nižji stroški v primerjavi z antibiotiki
- učinkoviti so tudi proti večkratno odpornim bakterijam
- redke interakcije in neželeni učinki

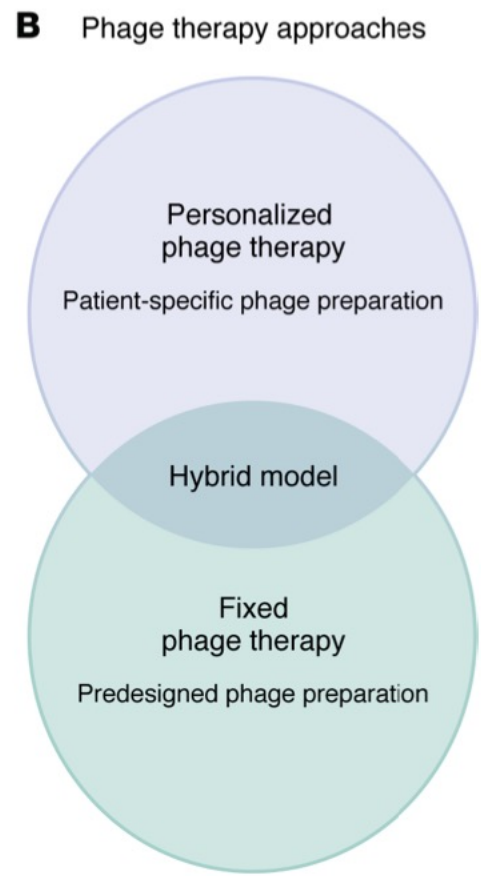
# NAČINI UPORABE

- Magistralni pripravki
- Sočutna raba/ personaliziran pristop (EU, ZDA)

RCT raziskave

| Parameter | Personalized phage therapy | Fixed phage therapy |
|---|---|---|
| Phages isolated in advance? | Variable | Yes |
| Phages characterized in advance? | Variable | Yes |
| Phage-phage interactions known? | Variable | Yes |
| Cocktail defined in advance? | No (customized per patient) | Yes |
| Phagogram done before treatment? | Yes | Variable |
| Therapeutic monitoring during therapy? | Variable | Variable |
| GMP production required for compassionate use? | Not currently | Not currently |
| GMP production required for scaled-up product? | Yes | Yes |
| Cost per patient for compassionate use? | Low if non-GMP | Low if non-GMP |
| Cost per patient at scale? | High | Low (Economies of scale) |
| Controlled clinical trials completed? | No | Yes (114) |
| Success in case reports? | Yes (9) | Yes (10, 111) |
| Straightforward regulatory pathway for compassionate use? | Yes, in most countries (eIND in USA, Helsinki Declaration in Europe; SAS in Australia) | Yes, in most countries (eIND in USA, Helsinki Declaration in Europe; SAS in Australia) |
| Defined regulatory pathway for scaled up drug? | No (allowed in Georgia; allowed through magistral phage in Belgium; unclear in other countries) | Yes (traditional biologic drug development pathway) |
| Potential for rapid availability for acute infections? | Unlikely | Yes |



# MAGISTRALNI PRIPRAVKI


**PHAGE BANK**
Seed lot

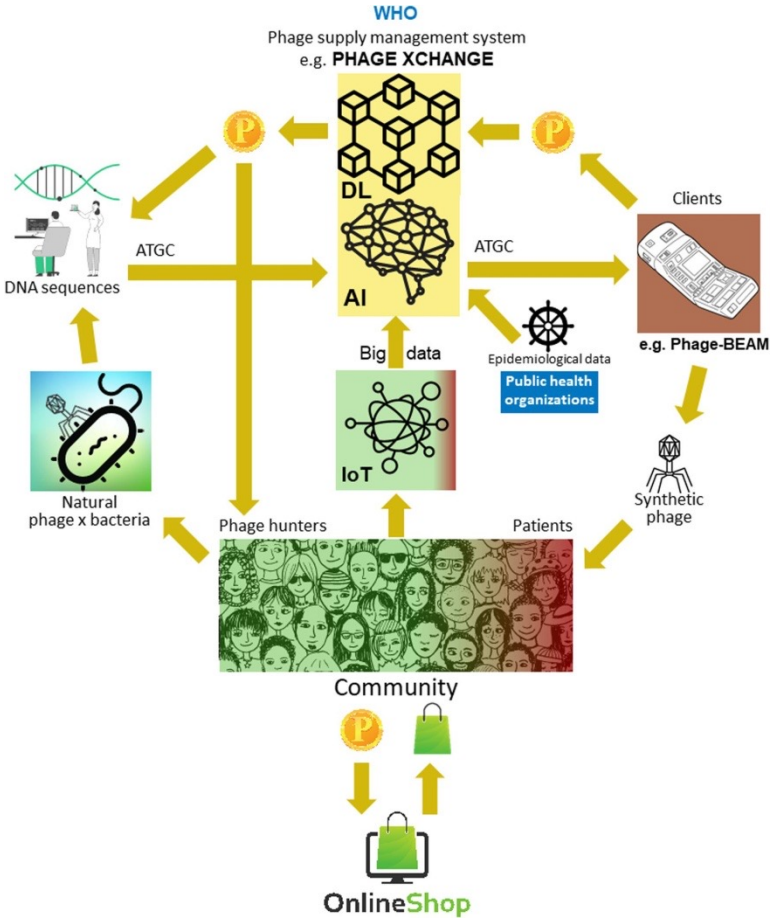
- Characterized phages
- Stored using a (tiered) banking system

**CONTROLLED ENVIRONMENT**
Active Pharmaceutical Ingredient (API)

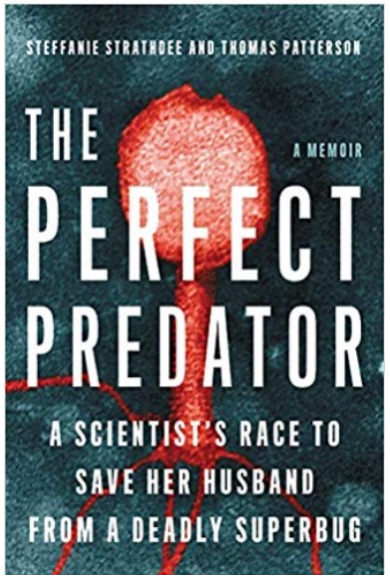
- A phage API (single phage) is produced using a suitable host
- Produced according to a monograph
- External quality testing based on a monograph, performed by a "Belgian Approved Laboratory"

**HOSPITAL PHARMACY**
Magistral preparation

- Upon prescription
- One or more phage APIs are selected (phagogram)
- Phage APIs are mixed with a carrier (e.g. a hydrogel)

# PERSONALIZIRANA (SOČUTNA) RABA




Antimicrobial Agents and Chemotherapy

| Research Article | 22 September 2017

## Development and Use of Personalized Bacteriophage-Based Therapeutic Cocktails To Treat a Patient with a Disseminated Resistant *Acinetobacter baumannii* Infection

This article has been corrected. VIEW CORRECTION

**Authors**: Robert T. Schooley, Biswajit Biswas, Jason J. Gill, Adriana Hernandez-Morales, Jacob Lancaster, Lauren Lessor, Jeremy J. Barr, SHOW ALL (34 AUTHORS) , Theron Hamilton | AUTHORS INFO & AFFILIATIONS

https://doi.org/10.1128/aac.00954-17 • Check for updates

# PERSONALIZIRANA (SOČUTNA) RABA

nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-021-27656-z OPEN

## Combination of pre-adapted bacteriophage therapy and antibiotics for treatment of fracture-related infection due to pandrug-resistant *Klebsiella pneumoniae*

Anaïs Eskenazi[1,9✉], Cédric Lood[2,3], Julia Wubbolts[4], Maya Hites[1], Nana Balarjishvili[5], Lika Leshkasheli[5], Lia Askilashvili[5], Leila Kvachadze[5], Vera van Noort[3,6], Jeroen Wagemans[2], Marc Jayankura[7], Nina Chanishvili[5], Mark de Boer[4], Peter Nibbering[4], Mzia Kutateladze[5], Rob Lavigne[2], Maya Merabishvili[8] & Jean-Paul Pirnay[8]

nature microbiology

Article https://doi.org/10.1038/s41564-024-01705-x

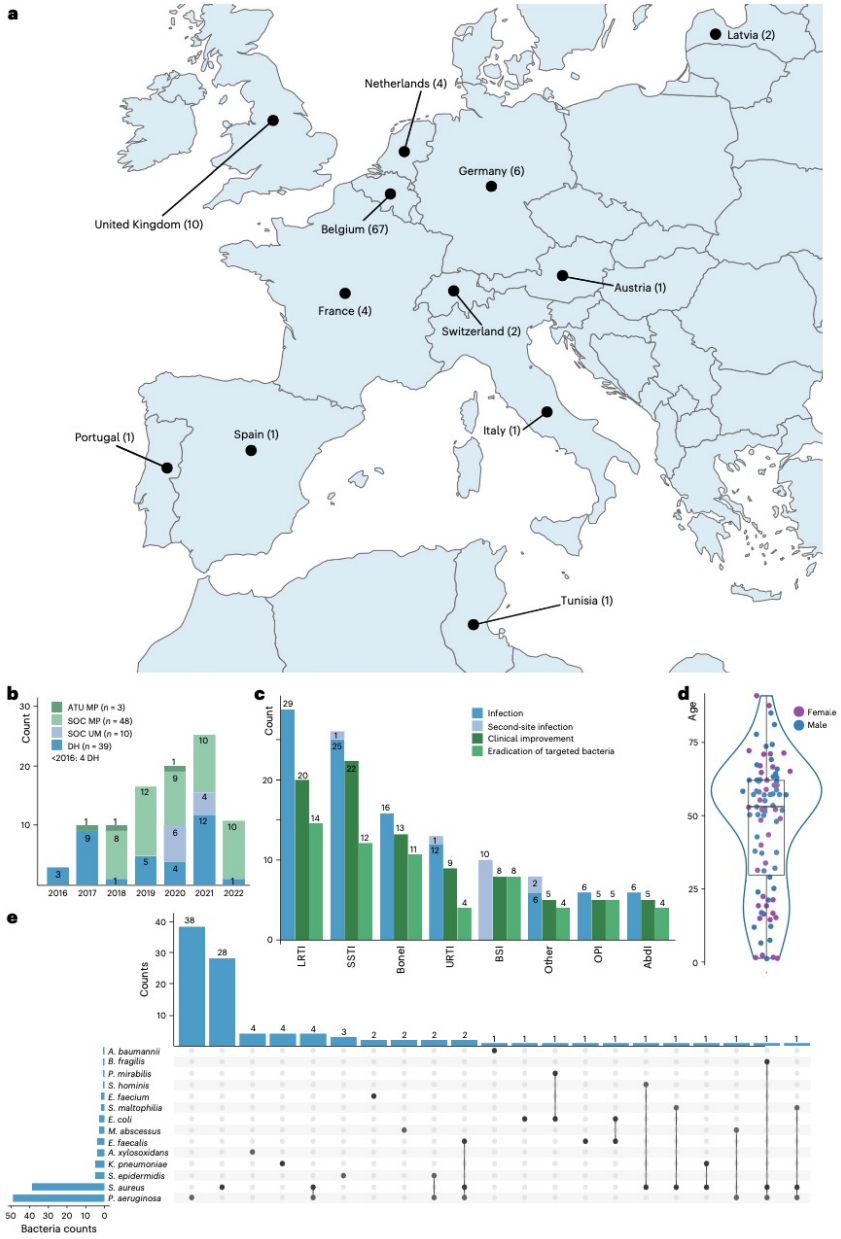
# Personalized bacteriophage therapy outcomes for 100 consecutive cases: a multicentre, multinational, retrospective observational study

- Objavljeno 2024 (2008-2022)
- 100 primerov personalizirane uporabe v Evropi
- **77.2% ozdravitev oz. 61.3% eradikacija**
- **sinergizem z antibiotiki!**

**Table 1 | General overview of bacteriophage therapy protocols according to the main infection types**

| Infection type | Application route | Bacteriophage carrier | Volume (ml) | Concentration (p.f.u.sml$^{-1}$) | Dose | Duration |
|---|---|---|---|---|---|---|
| Lower respiratory tract infections | Nebulization | NaCl 0.9% | 2–4 | $10^7$–$10^8$ | q6h | 5 days–6 weeks |
| Bone and orthopaedic prostheses infections | Intralesional | NaCl 0.9% | 2–70 | $10^7$–$10^8$ | q24h | 5 days–3 weeks |
| Skin and soft tissue infections | Topical | NaCl 0.9% or Flaminal Hydro | In excess | $10^7$–$10^9$ | q24h | 5 days–3 weeks |
| Upper respiratory tract infections | Nasal spray | NaCl 0.9% | 1–15 | $10^7$ | q8h | 1–3 weeks |
| Bloodstream infections or other infection types[a] | Intravenous | NaCl 0.9% | 50–100 | $10^6$–$10^7$ | q24h | 5–10 days |

[a]When the treating physician considered it was necessary to apply bacteriophages systemically. p.f.u.s, plaque forming units; q, every.



# SOČUTNA RABA

| Organization/company | Country | Study | Year | Refs. |
|---|---|---|---|---|
| Baylor college of medicine (TAILΦR) | USA | A retrospective, observational study. Device-related or systemic infections, 12 patients<br>• Evaluated 12 cases of customized phage therapy, showing a 66% favorable response rate, with 42% bacterial eradication<br>• Phage therapy was safe, though immunological neutralization occurred in some cases | 2023 | [20] |
| Belgian Consortium Study | Belgium | A multicenter, multinational, retrospective observational study. Individualized phage therapy<br>• Analyzed 100 cases of individualized phage therapy across 12 countries<br>• Showed clinical improvement in 77.2% of cases and bacterial eradication in 61.3%<br>• The use of antibiotics alongside phage therapy increased the likelihood of success | 2024 | [21] |
| Prosthetic joint infections | Italy | A case report. Pa53 (anti-*P. aeruginosa* phage)<br>• A 62-year-old patient with chronic *P. aeruginosa* infection was successfully treated with customized phage therapy and meropenem, showing no infection recurrence over 2 years | 2023 | [22] |
| Diabetic foot infection | UK | A case series. Anti-*S. aureus* therapy<br>• Tested anti-*S. aureus* phage therapy on 10 patients at high risk of amputation<br>• Nine out of 10 patients benefited, though one patient showed no response to treatment | 2023 | [23] |
| LVAD infection study | Israel/ USA | A case series. Anti-*P. aeruginosa* therapy<br>• Phage therapy in combination with antibiotics for LVAD-related *P. aeruginosa* infections had limited success, with breakthrough bacteremia and immune reactions hindering effectiveness | 2023 | [24] |

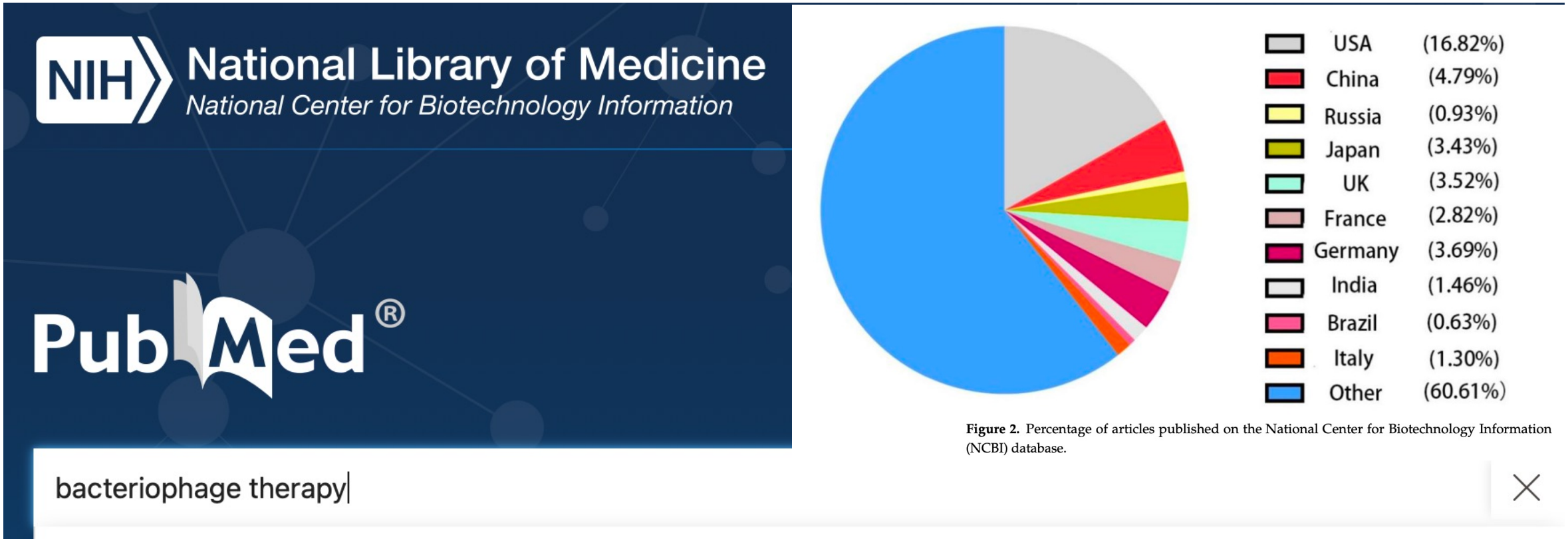






**Figure 2.** Percentage of articles published on the National Center for Biotechnology Information (NCBI) database.

frontiers in Pharmacology

ORIGINAL RESEARCH
published: 07 February 2022
doi: 10.3389/fphar.2022.778676

# Evaluation of Bacteriophage Cocktail on Septicemia Caused by Colistin-Resistant *Klebsiella pneumoniae* in Mice Model

*Aprajita Singh[1†], Alakh Narayan Singh[1†], Nisha Rathor[2], Rama Chaudhry, Sudhir Kumar Singh[1] and Gopal Nath[1*]*

**Conclusion:** Our study showed that the optimized relatively lower and multiple dosages of phage cocktails with the strict monitoring of vitals in clinical settings might cure septicemia caused by MDR bacteria with different severity of infection.

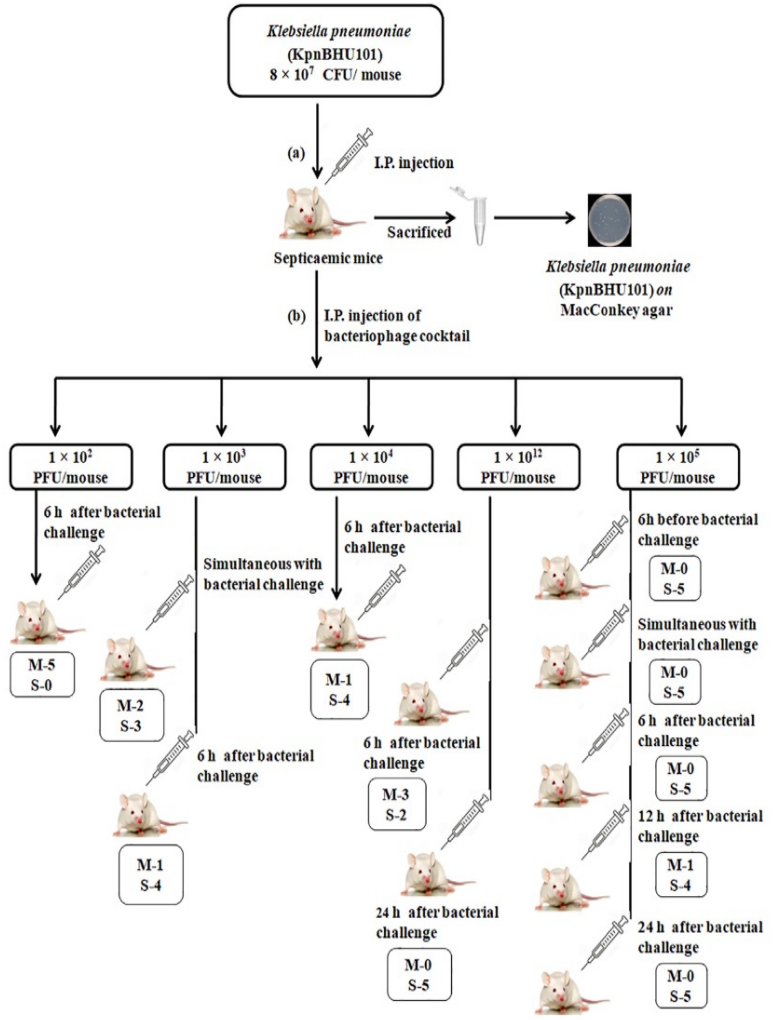



**FIGURE 4 |** Mouse experiment flowchart **(A)** Depicts the induction of septicemia through intraperitoneal route with *K. pneumoniae* at the dose of 8 × $10^7$ CFU/ mouse of KpnBHU101. After 24 h, mice were killed, and organs were homogenized and cultured on MacConkey plates to see the presence of bacteria. **(B)** Outline of the efficacy of the bacteriophage cocktail dosage with varying concentrations at a different time point after the initial bacterial challenge. Each group has 5 mice; (M) depicts the number of dead mice and (S) depicts the number of mice surviving.

PNAS RESEARCH ARTICLE | MICROBIOLOGY OPEN ACCESS Check for updates

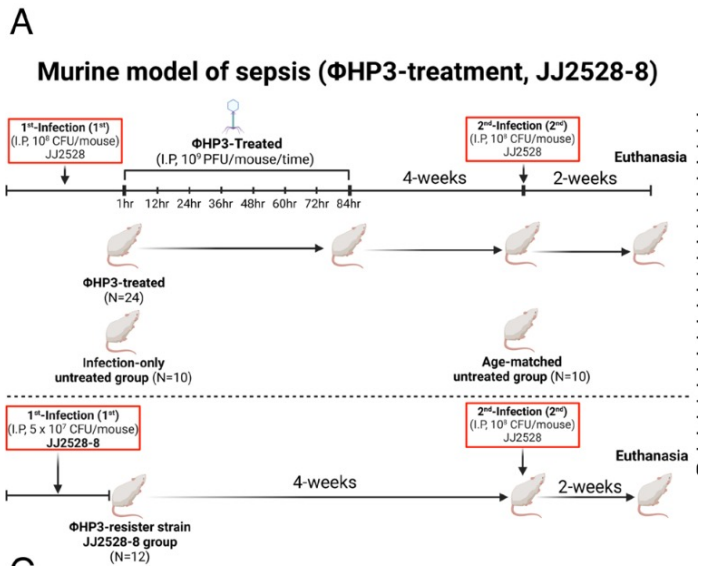
# Phage-induced protection against lethal bacterial reinfection

Yikun Xing[a,b,1], Haroldo J. Hernandez Santos[a,b,1], Ling Qiu[b], Samantha R. Ritter[a,b], Jacob J. Zulk[a,b], Rachel Lahowetz[b], Kathryn A. Patras[b,c], Austen L. Terwilliger[a,b], and Anthony W. Maresso[a,b,2]

Affiliations are included on p. 9.

Edited by Bruce Levin, Emory University, Atlanta, GA; received November 8, 2024; accepted April 1, 2025

- Študija na miših
- Poleg lize bakterijskih celic – dolgotrajna zaščita pred ponovno okužbo
- Terapevtsko – vakcinacijski učinek



Microbial Pathogenesis
Volume 148, November 2020, 104447


# New Phage cocktail against infantile Sepsis bacteria

Sadeq Abdulridha Gatea Kaabi, Hadeel Kareem Musafer

Show more



- In vitro raziskava (2020)
- 54 kliničnih izolatov (HK) pediatričnih bolnikov s sepso: *E. coli, K. pneumoniae, H. influenze, P. aeruginosa, C. freundii, M. catarrhalis*
- Fagi izolirani iz odpadnih vod
- Fagni cocatail – in vitro 100 % aktivnost proti izolatom

Łusiak-Szelachowska *et al.*
*Journal of Biomedical Science* (2022) 29:23
https://doi.org/10.1186/s12929-022-00806-1

MOST 科技部 Ministry of Science and Technology
The cost of publication in *Journal of Biomedical Science* is borne by the Ministry of Science and Technology, Taiwan.
Journal of Biomedical Science

REVIEW Open Access

# Bacteriophages and antibiotic interactions in clinical practice: what we have learned so far

Marzanna Łusiak-Szelachowska[1*], Ryszard Międzybrodzki[1,2,3], Zuzanna Drulis-Kawa[4], Kathryn Cater[5], Petar Knežević[6], Cyprian Winogradow[7], Karolina Amaro[8], Ewa Jończyk-Matysiak[1], Beata Weber-Dąbrowska[1,2], Justyna Rękas[1] and Andrzej Górski[1,2,9]

- Biofilmi – fagno–antibiotični sinergizem (PAS)
- Fagno-antibiotični antagonizem -

v nekaterih primerih lahko opazimo tudi kot zmanjšano učinkovitost zdravljenja v primerjavi z enim od posameznih zdravljenj

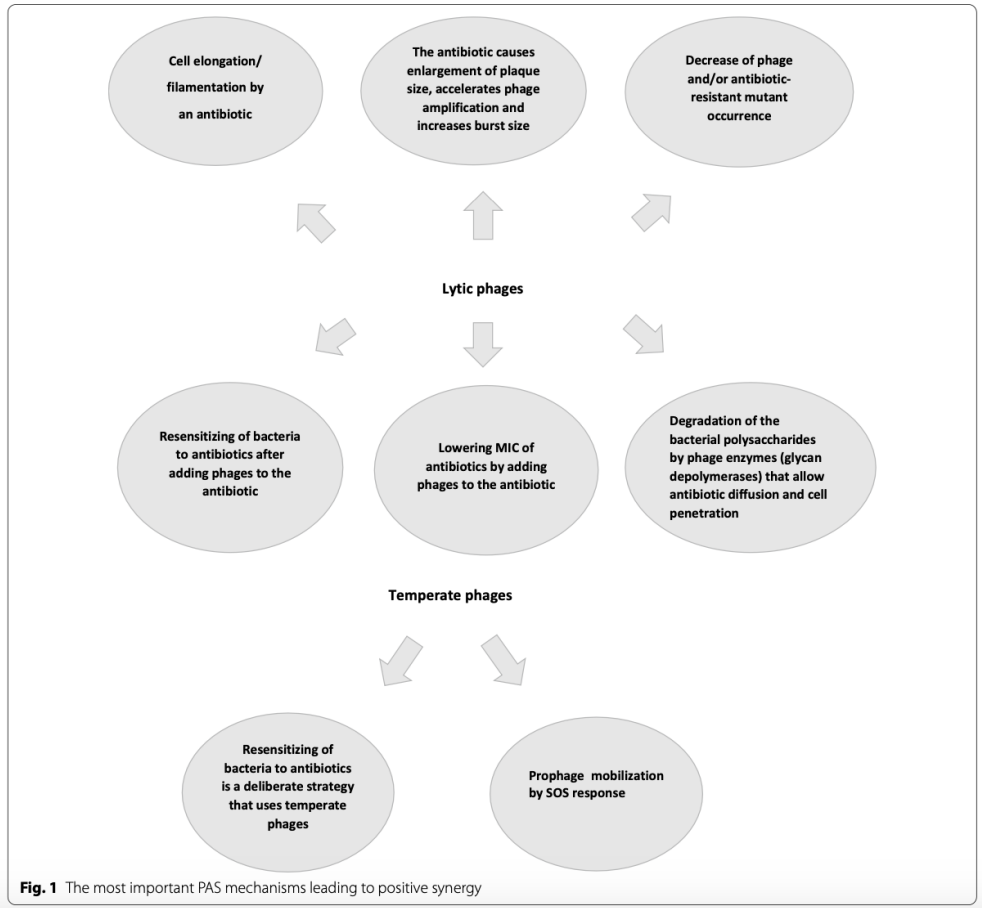



**Fig. 1** The most important PAS mechanisms leading to positive synergy

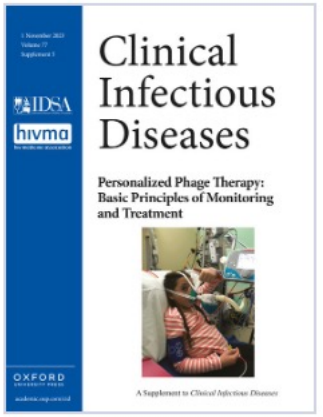
*Clinical Infectious Diseases*

SUPPLEMENT ARTICLE

# Phage Therapy as a Novel Therapeutic for the Treatment of Bone and Joint Infections

**Gina A. Suh,[1] Tristan Ferry,[2] and Matthew P. Abdel[3]**

[1]Division of Infectious Diseases, Department of Medicine, Mayo Clinic, Rochester Minnesota, USA; [2]Department of Infectious and Tropical Diseases, Hospital de la Croix-Rousse, Hospices Civils de Lyon, Lyon, France; and [3]Department of Orthopedic Surgery, Mayo Clinic, Rochester Minnesota, USA




Volume 77, Issue Supplement_5
1 November 2023

- 2010-2023: 33 opisov uporabe pri okužbah kosti in sklepov
- Sistemska in lokalna aplikacija
- **87 % ozdravitev**
- 24 % - blagi neželeni učinki (najpogosteje povišani jetrni testi!)

EFORT open reviews

*EFORT Open Reviews* (2024) **9** 339–348
https://doi.org/10.1530/EOR-24-0042

INSTRUCTIONAL LECTURE: GENERAL ORTHOPAEDICS

# Bacteriophage therapy in musculoskeletal infections: from basic science to clinical application

Tristan Ferry[1,2,3,4,5], Jolien Onsea[6,7], Tiphaine Roussel-Gaillard[8], Cécile Batailler[9], Thomas Fintan Moriarty[10] and Willem-Jan Metsemakers[6,7]

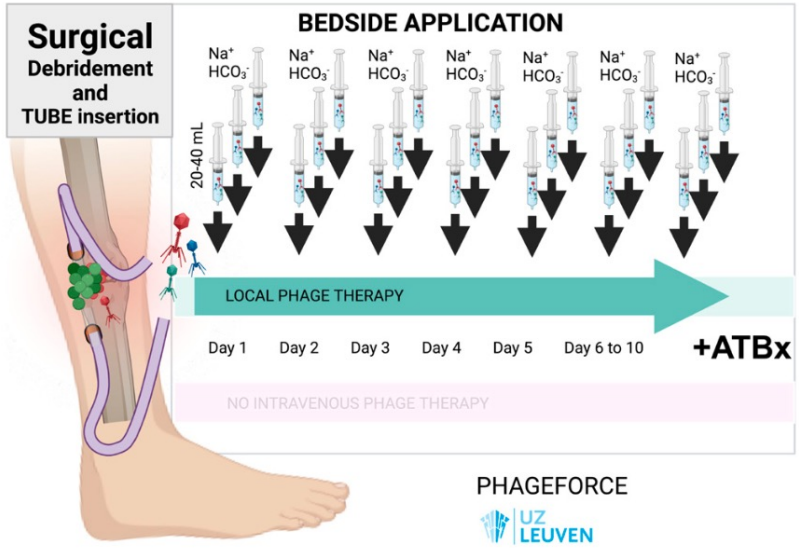



**Figure 2**

Typical phage treatment course in patients with FRI included in the PHAGEFORCE study, with surgical debridement, surgical tube (drain) insertion, and then administration of 20–40 mL of active phages three times per day for 7–10 days. Prior to each phage application, the drain is rinsed with sodium bicarbonate (NaHCO3) 1.4%. All patients receive concomitant antibiotics.

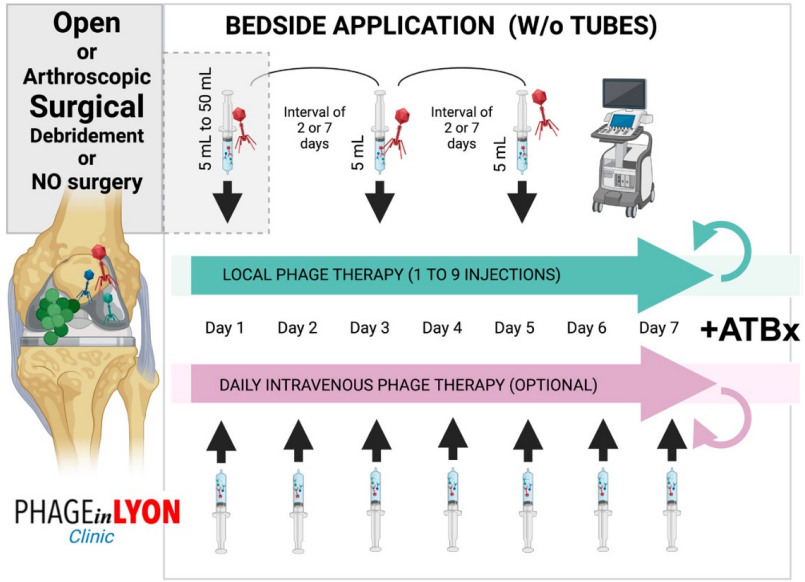
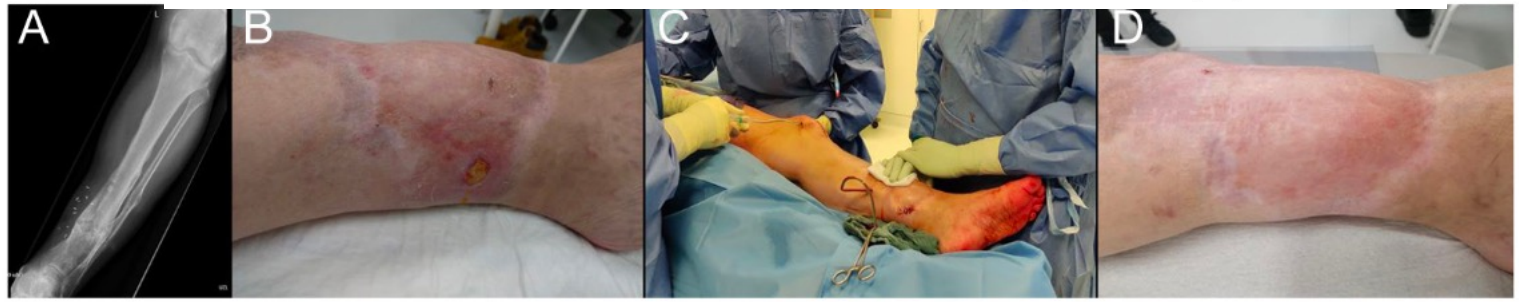



**Figure 4**

Typical phage treatment course in patients with PJI included in the PHAGE*in*LYON *Clinic* programme. As adjuvant treatment to antibiotics, based on susceptibility testing, the patient received a first local injection of phages in the joint cavity during surgery (volume 30–50 mL) or after the surgery under sonography (5 mL), and then subsequent injections under sonography exclusively (5 mL), without using tubes. The number of injections and the time interval between each injection are depending on the clinical presentation. Daily intravenous injections of phages could be prescribed in non-surgical patients.



frontiers | Frontiers in Cellular and Infection Microbiology

TYPE Original Research
PUBLISHED 23 May 2025
DOI 10.3389/fcimb.2025.1597009



OPEN ACCESS

EDITED BY
Mercedes Gonzalez Moreno,
Leibniz Institute for Natural Product Research and Infection Biology, Hans Knoll Institute, Germany

REVIEWED BY
Yunxue Guo,
Chinese Academy of Sciences (CAS), China
Robert Ramirez-Garcia,
Imperial College London, United Kingdom

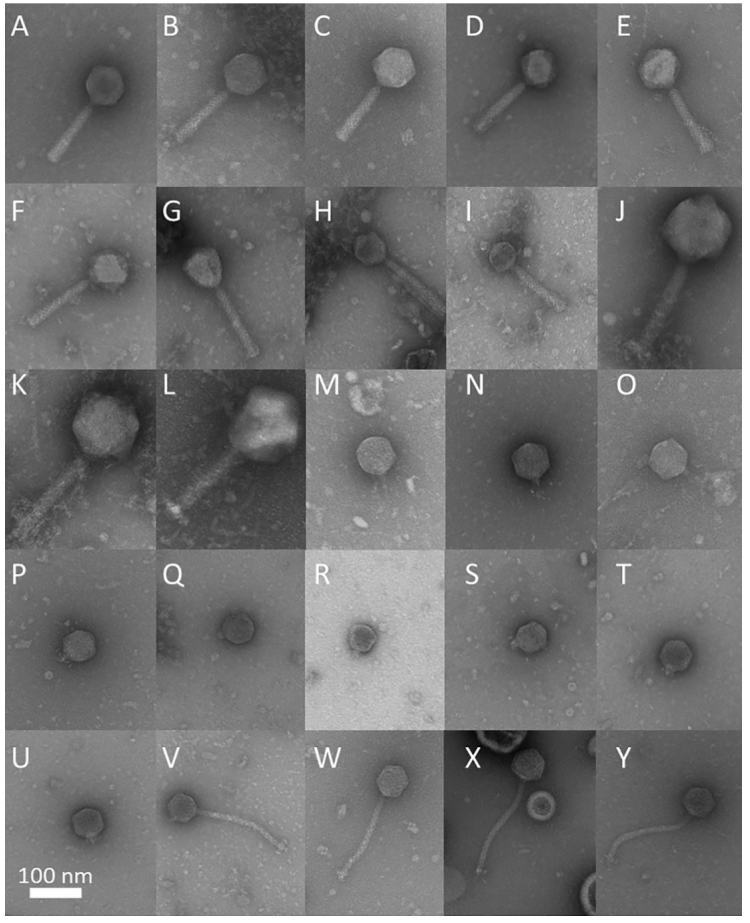
# Systematic bacteriophage selection for the lysis of multiple *Pseudomonas aeruginosa* strains

Finja Rieper[1,2], Johannes Wittmann[3], Boyke Bunk[3], Cathrin Spröer[3], Melanie Häfner[4], Christian Willy[4], Mathias Müsken[5], Holger Ziehr[1], Imke H.E. Korf[1*†] and Dieter Jahn[2,6*†]

- 6 fagov
- testirana učinkovitost na 141 izolatih (klinični vzorci od bolnikov) – liza pri 92 % vzorcih

## 5 Conclusion

25 *P. aeruginosa* phages were characterized and compared showning a great diversity within all morphotypes. A combination of six phages could theoretically lyse 92% of clinical *P. aeruginosa* strains. Further, we showed that especially *Pakpunavirus*, *Pbunavirus*, *Pawinskivirus*, *Elvirus* (all myoviruses), *Litunavirus* and *Bruynoghevirus* (all podoviruses) showed the greatest potential in the proposed ranking and should be employed with priority, as they have already been used for phage therapy. Siphoviruses were less suitable. Phages with a lysogenic cycle also have less potential due to their narrow host range and efficiency (low vp value), as well as safety concerns regarding phage therapy.



# TRENUTNO POTEKAJOČE RCT

| Organization/company | Country | Study | | Year | Refs. |
|---|---|---|---|---|---|
| Pherecydes Pharma (Phaxiam Therapeutics) | France | A randomized, controlled, double-blind phase 1/2 trial<br>• PhagoBurn *E.coli*, and *P aeruginosa* infections | NCT02116010 | 2019 | [25, 26] |
| Armata Pharmaceuticals | USA | A multi-center, double-blind, randomized, placebo-controlled, single and multiple ascending dose phase 1/ 2 trial<br>• AP-PA02, *P. aeruginosa* for severe respiratory infections<br>• Evaluating safety and tolerability of inhaled AP-PA02 in chronic lung infections and cystic fibrosis (SWARM-Pa) | NCT04596319 | 2024– | [27] |
| Adaptive phage therapeutics | USA | A randomized, parallel, double-blind, placebo-controlled, repeat dose, multi-site phase 1/2 trial<br>• DANCE™; diabetic foot osteomyelitis | NCT05177107 | 2022– | [28] |
| Israeli phage therapy center | Israel | A pre-phase-1 cohorts trial<br>• PASA16;*P. aeruginosa* infection | – | 2023 | [29] |
| TechnoPhage | Portugal | A randomized, parallel, open label, phase 1/2a trial<br>• TP-122A, ventilator-associated pneumonia<br>• Assess safety and tolerability | NCT06370598 | 2024– | [30] |
| MB pharma | Czech Republic | A randomized, double-blind, placebo-controlled phase 1/2a trial<br>• DUOFAG®; phage cocktail against *S. aureus* and *P. aeruginosa* for surgical wound infection | NCT06319235 | 2022– | [31] |
| Locus biosciences | USA | A double-blind, randomized, active-controlled phase 2/3 trial<br>• LBP-EC01; *E. coli*-induced UTIs<br>• Treatment of acute uncomplicated UTI caused by drug-resistant *E. coli* (ELIMINATE Trial) | NCT05488340 | 2024 | [32] |

# UPORABA V SLOVENIJI

- Zaenkrat še ne
- Ortopedska bolnišnica Valdortra – in vitro študije
- Pomlad 2025; PeK
- Raziskovalno (TP v UKC)

# ZANIMIVOST


JAFRAL is **world's biggest phage manufacturer (CDMO)**, which primary focus is development and production of phage-based products for various (GMP and non-GMP) applications:

- **Human therapeutics**
- **Food industry**
- **Cosmetics**
- **Veterinary**
- **Agriculture**

Other biomolecules: pDNA, mRNA, OMVs, rProteins, Fill & Finish

JAFRAL
passion for biosolutions

# SKLEPI

- “Virusi, ki uničujejo bakterije” (tudi VOB)
- Selektivno delovanje, ni vpliva na normalno mikrobioto
- Relativno poceni proizvodnja
- Redki stranski učinki
- Primerni za zdravljenje bakterijskih okužb, tudi sepse in tistih povzročenih z VOB
- Sinergizem z antibiotiki, prodor v biofilm
- Zaenkrat pomanjkanje RCT – možna je sočutna raba

# HVALA ZA POZORNOST