DIGITALIZACIJA U DONOŠENJU ODLUKA O ANTIMIKROBNOJ HEMIOTERAPIJI

Zoran Todorović

Medicinski fakultet, Univerzitet u Beogradu i
KBC „Bežanijska kosa", Beograd

zoran.todorovic@med.bg.ac.rs

Optimalno donošenje odluka u zdravstvenoj zaštiti - ograničenja

- Dostupne informacije - *ograničene* i potencijalno nepouzdane

- Ljudski um ima *ograničen* kapacitet

- Postoji samo *ograničeno* vreme za donošenje odluke

Rawson et al., Nat Hum Behav 2019; 3(6): 543-5; Simon HA. Models of Bounded Rationality. Cambridge, MA: MIT Press., 1985

Digital health technology (DHT)
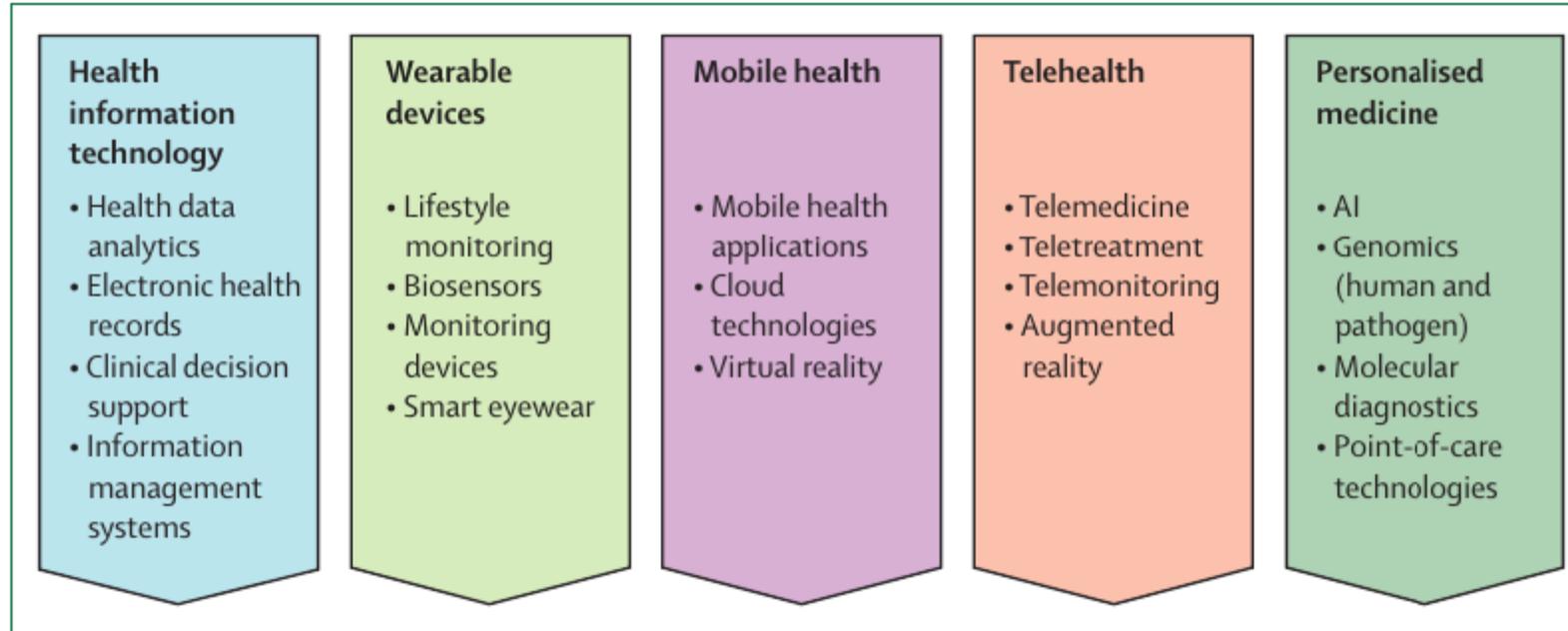# (digitalna zdravstvena tehnologija)

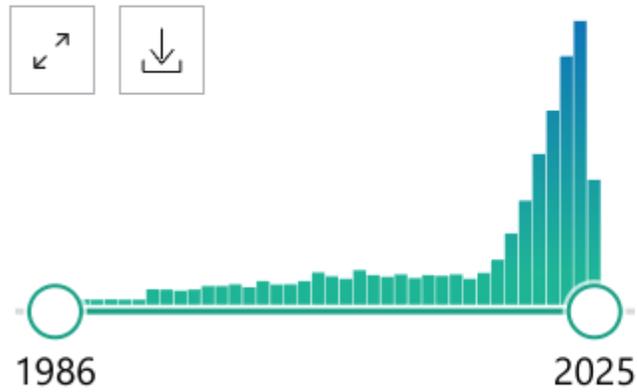**Figure 1: DHT classifications and examples**

DHTs to support optimised antimicrobial use in humans currently focus on supporting routine clinical health-care data gathered at the individual level, from microbiology laboratories, other pathology services, and radiology services. Few tools are available to incorporate population-level data and data on the environment and climate. Wider linkage of DHTs beyond individual tools remains a challenge in both high-income countries and low-income and middle-income countries. AI=artificial intelligence. DHT=digital health technology.

Artificial intelligence - AI

Digitalna zdravstvena tehnologija (DHT)

- U 2022. godini, globalno DHT tržište procenjeno je na 211 milijardi američkih dolara, sa godišnjom stopom rasta (*Compound Annual Growth Rate*, CAGR) od 18,6% godišnje

- Može *značajno poboljšati* efikasnost sistema zdravstvene zaštite

Rawson et al., Lancet Digit Health 2024; 6(12): e914-25

Digital health technology (DHT)
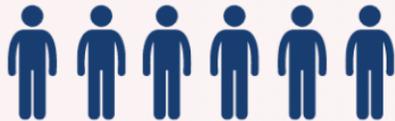
The benefits of digital health tech...

can be used anytime, anywhere

can reduce travel, resulting in benefits to the environment

can reach more people than face-to-face care

often cheaper

can empower people to manage their own conditions

Distributivna pravednost u zdravstvenoj zaštiti

- Princip pravednosti – jedan od osnovnih bioetičkih principa
  - distributivna pravednost - pravedna raspodela resursa među različitim članovima zajednice

- DHT nisu svima dostupne

- **Na međunarodnom nivou -** globalna neravnoteža u dostupnosti DHT u zemljama s niskim i srednjim bruto nacionalnim dohotkom (BND) (DISTRIBUTIVNA PRAVEDNOST)

- **Na nacionalnom nivou -** problem pravedne raspodele resursa i u samim razvijenim zemljama: primer SAD
  - američki sistem zdravstvene zaštite je zasnovan na:
    - širokoj upotrebi tehnologija (*technologically driven*) i
    - negiranju mogućnosti smrtnog ishoda (*death-denying*), odnosno produženju života koliko god je to moguće (Annas, 1993)
  - Zato, stalni pritisak na lekare: oni su između Scile (etički principi) i Haribde (potrebe da se smanje direktni troškovi)

Smith GP II, Distributive Justice and Health Care, CUA Law Scholarship Repository 2002; https://scholarship.law.edu/cgi/viewcontent.cgi?article=1204&context=scholar
Annas GJ. Standard of Care: the Law of American Bioethics. New York: Oxford University Press. 1993: 211; Encyclopedia of Applied Ethics (2nd ed), 2012

Primer korišćenja DHT u istraživanjima: facijalna ekspresija (*Impala*)
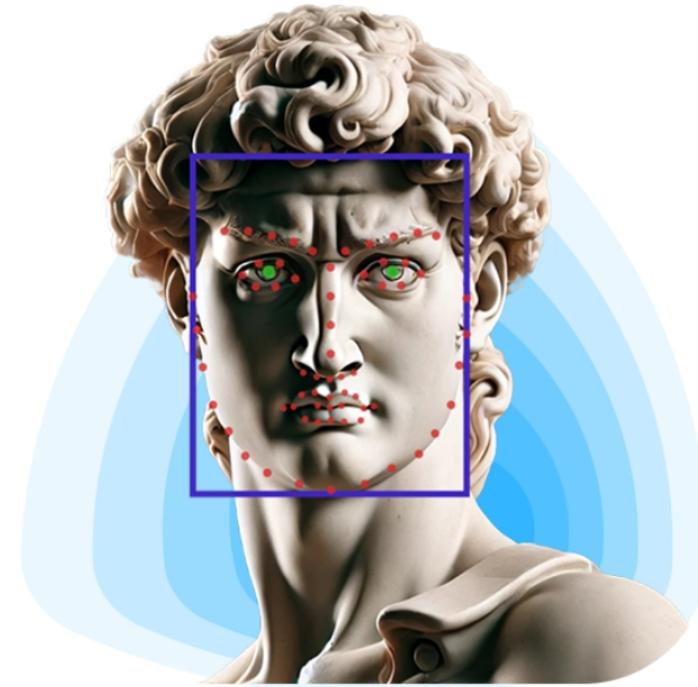
Primer korišćenja DHT u istraživanjima: lekovi

MedMine: Examining Pre-trained Language Models on Medication Mining

Haifa Alrdahi [1*], Lifeng Han [1*], Hendrik Šuvalov [2*], and Goran Nenadic[1]

[1] The University of Manchester, UK
[2] The University of Tartu, Estonia
* co-first authors

firstname.lastname @ {manchester.ac.uk | ut.ee}

Abstract

Automatic medication mining from clinical and biomedical text has become a popular topic due to its real impact on healthcare applications and the recent development of powerful language models (LMs). However, fully-automatic extraction models still face obstacles to be overcome such that they can be deployed directly into clinical future optimised and personalised treatments. Medication extraction itself can also be beneficial to epidemiological studies and term management (Ananiadou and Nenadic, 2006), e.g. to rheumatologists, and the extracted medical terminologies and concepts can be useful for knowledge transformation (Han et al., 2023; Han et al., 2022).

Medication extraction has been an application field of NLP models for decades across statistical and neural NLP methods (Spasić et al., 2010;

Prof. Goran Nenadić
Univ. of Manchester

https://arxiv.org/pdf/2308.03629v2

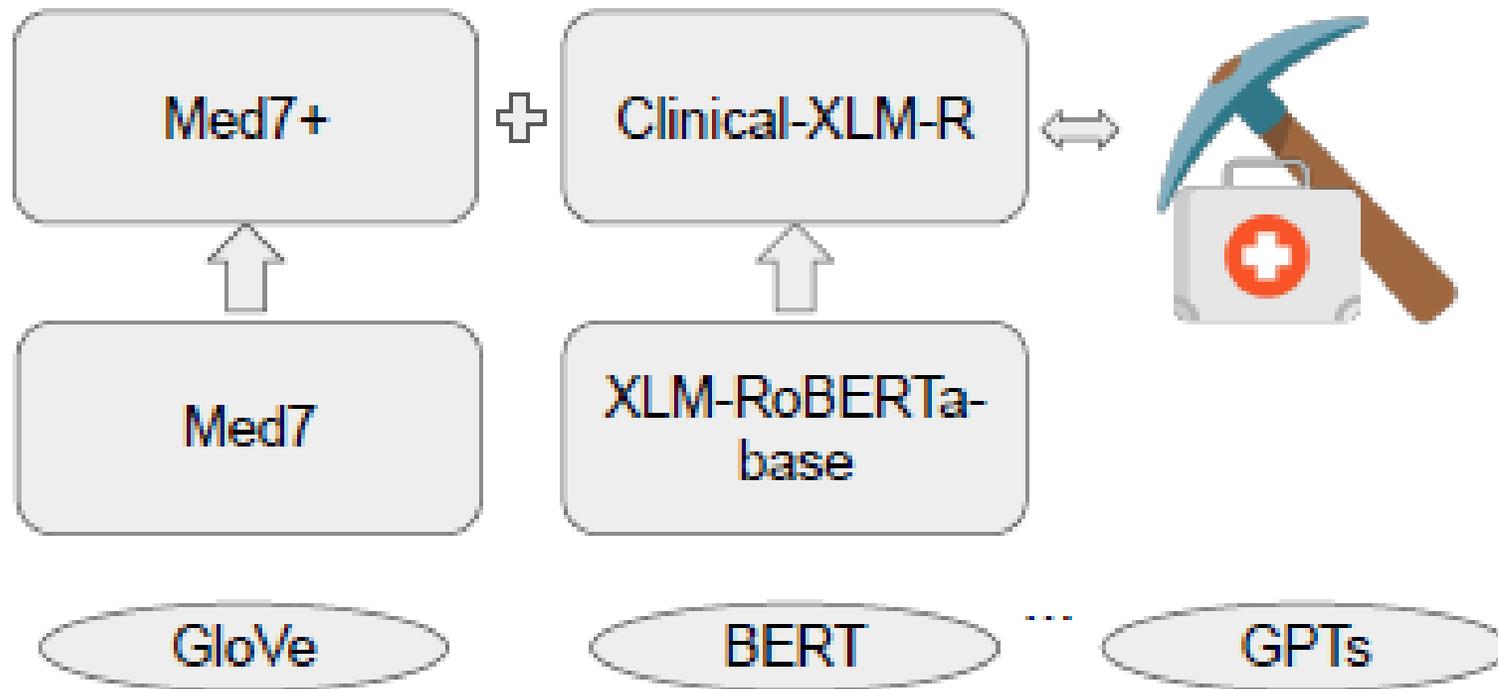# Primer korišćenja DHT u istraživanjima: lekovi

Figure 1: MedMine Illustration: Models already included Glove and RoBERTa embeddings, clinical domain fine-tuning for medication mining.

Antimikrobna rezistencija (AMR)

- Tokom poslednjih četvrt veka, skoro 1,1 milion smrtnih slučajeva godišnje su direktni rezultat AMR

- Skoro 90% smrtnih slučajeva zbog AMR godišnje dešava se u zemljama sa niskim ili srednjim BND (*low-income, middle-income*)

- Na primer, u zemljama s niskim i srednjim BND postoji ogroman jaz u lečenju: samo 6,9% karbapenem-rezistentnih G- bakterijskih infekcija bilo je odgovarajuće lečeno 2019. godine

- Neadekvantna primena antibiotika je jedan od glavnih pokretača nastanka AMR

- Strategija SZO: *Jedno zdravlje*

TRACE

Mere za štedljivu primenu antibiotika

Edukacija/vodiči
Restriktivna distribucija lekova
Kontrola na dnevnoj bazi
Kompjuterski sistemi
Ciklična promena antibiotika

Pregled pacijenata
Izbor antibiotika
Nabavka antibiotika
Raspodela antibiotika
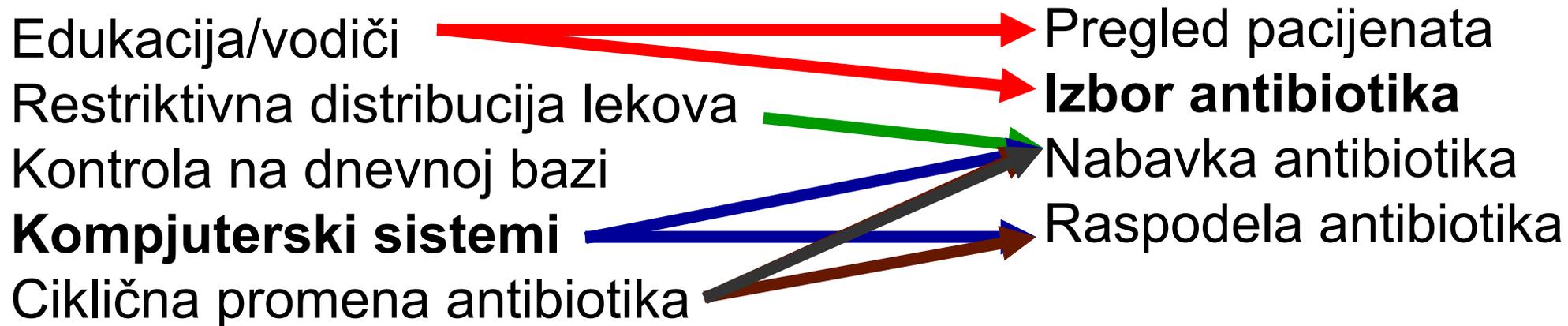
... ali često loša adherencija u svakodnevnoj kliničkoj praksi

	Potential drivers of AMR	Data required	Impact
International and national	Travel; trade; climate change; agriculture; conflict; health inequalities; access to therapeutics; health literacy and socioeconomics; antimicrobial consumption	Standardised, aggregated data that are fair, representative, and allow for geographical variations; identification and reporting of key factors identified as drivers of AMR	Supports targeted policy interventions, which allows for the monitoring of the impact of these drivers on AMR over time
Community and local networks	Cultural and contextual factors; health inequalities; socioeconomic factors; access to diagnostics and treatments; infection control measures; access to immunisation; local rates of AMR; resources available; antimicrobial consumption; access to water, sanitation, and hygiene	Standardised, individual-level data incorporating measures of key variables that influence AMR at the population level; agreement on value-based measurements of interventions (eg, at the individual, societal, or economic level)	Allows for equitable implementation and monitoring of policy to optimise antimicrobial prescribing and minimise the impact of antimicrobial use on AMR in the local network and environment; standardised methods of aggregating and reporting data to allow benchmarking against other areas or networks
Prescriber	Education and training; experience; resources available; context; communication with patient; competing interests; personality and world view; access to diagnostics, therapeutics, and expert support	Real-time, evidence-based data to support individualised decision making; support for a holistic approach to decision making, focused on objective and individual patient outcomes (eg, mortality, morbidity, length of stay, health-care costs for the patient or prescriber)	Supports individualised treatment decisions that aim to maximise treatment efficacy while minimising the risk of toxicity, side-effects, and AMR on the individual
Patient	Knowledge and beliefs; socioeconomic status; demographics; comorbidities; nutritional status; polypharmacy; severity of infection	Personalised data to enhance knowledge and understanding of infection and its management; support for the contextualisation of antimicrobial decisions into the patient's wider health-care journey	Improves antimicrobial-seeking behaviour, compliance, and awareness of AMR

AMR=antimicrobial resistance.

Table 1: Data requirements for and from digital health technologies to optimise antimicrobial use and address the potential drivers of AMR at different levels

	High-income countries	Low-income and middle-income countries
Technical		
Expertise	Rapidly evolving expertise within industry with poor oversight of training and curriculum requirements; the requirement for broader cross-disciplinary expertise to guide intervention development	An absence of trained technicians to support maintenance in implementation; low capacity for development and manufacture
Network connectivity	Complex networks, with challenges harmonising data	Low access to cloud-based applications and networks; limited data linkage between networks
Infrastructure	Variation in digital health technology procurement between centres, networks, and countries	Unstable electricity and internet; limited supply infrastructure; variable laboratory infrastructure
Data security	Privacy concerns and data governance requirements limit data linkage	Outdated cybersecurity protocols
Regulatory		
National regulation	Evolving regulatory positions by national agencies; international harmonisation of regulatory status under way; an absence of clear classifications, safety evaluations, and low standards of evidence required	Disorganised regulatory responsibilities; a paucity of expertise within regulatory agencies in digital health development
Insurance	Organisational liability limits deviation from rule-based approaches	High insurance costs make access unequitable and inaccessible to many
Legislation	Rapidly evolving technological landscape is difficult for legislators to keep up with	Absence of clear legislation for digital health technologies; poor classification of medical devices

Table developed from data from Al Meslamani,[69] Mumtaz and colleagues,[70] Colloud and colleagues,[71] and Iqbal and colleagues.[72]

Table 2: Technical and regulatory challenges for global digital health technology to support optimised antimicrobial use

AI i AMR

- AI može <u>da poveća preciznost, pouzdanost i fleksibilnost</u> donošenja odluke o upotrebi antimikrobnih lekova analizom kompleksnih podataka i otkrivanjem modela koji se ne opaze uvek u kliničkoj praksi

- U ranim 2000-tim razvijena je mogućnost donošenja odluke uz pomoć neuronskih mreža koja je unapredila propisivanje antibiotika i <u>smanjivala je 180-dnevni mortalitet</u> u randomizovanom kontrolisanom kliničkom ispitivanju

AI i AMR

- Poboljšanja uz pomoć AI:
  - ukazuju na prelazak sa intravenske na oralnu primenu (*optimalan način*)
  - obustavljanje primene antibiotika (*optimalno trajanje*)
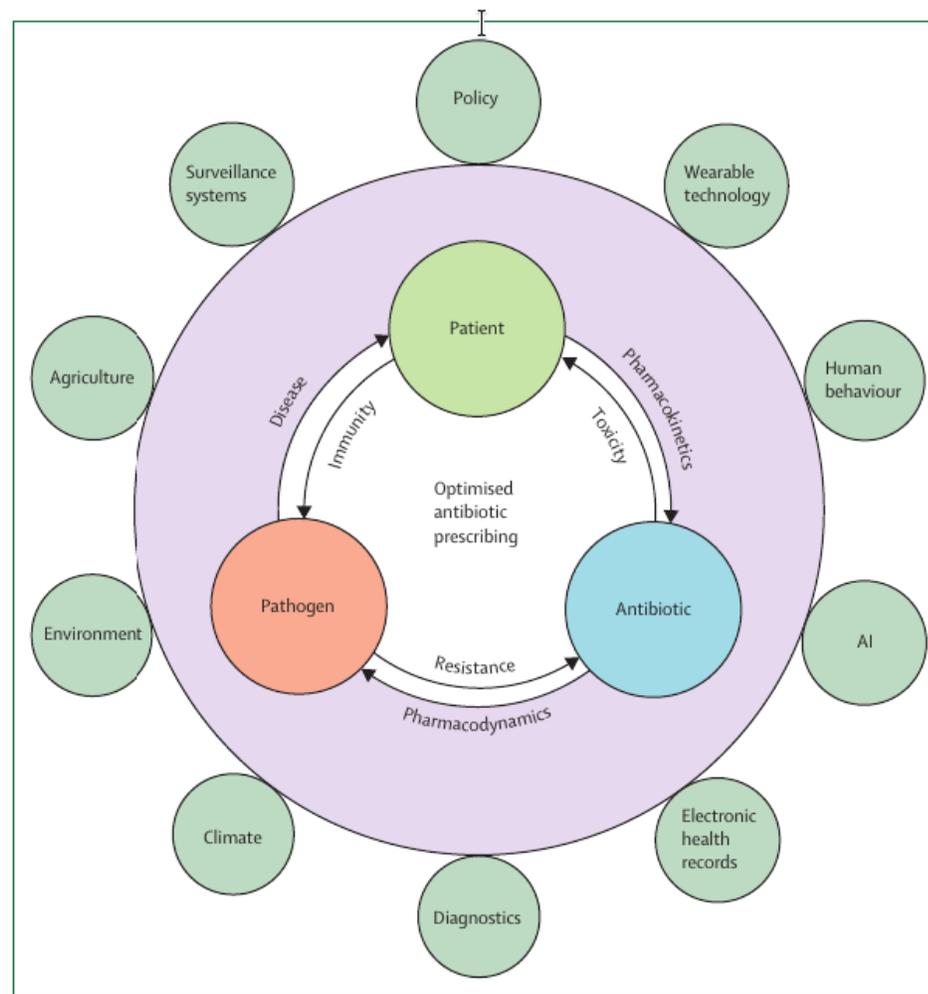 - predikcija osetljivosti mikroorganizama (optimalni izbor)

Figure 2: Factors influencing antimicrobial treatment outcome within the individual and associated data sources that DHTs can provide to support optimisation of prescribing and address AMR

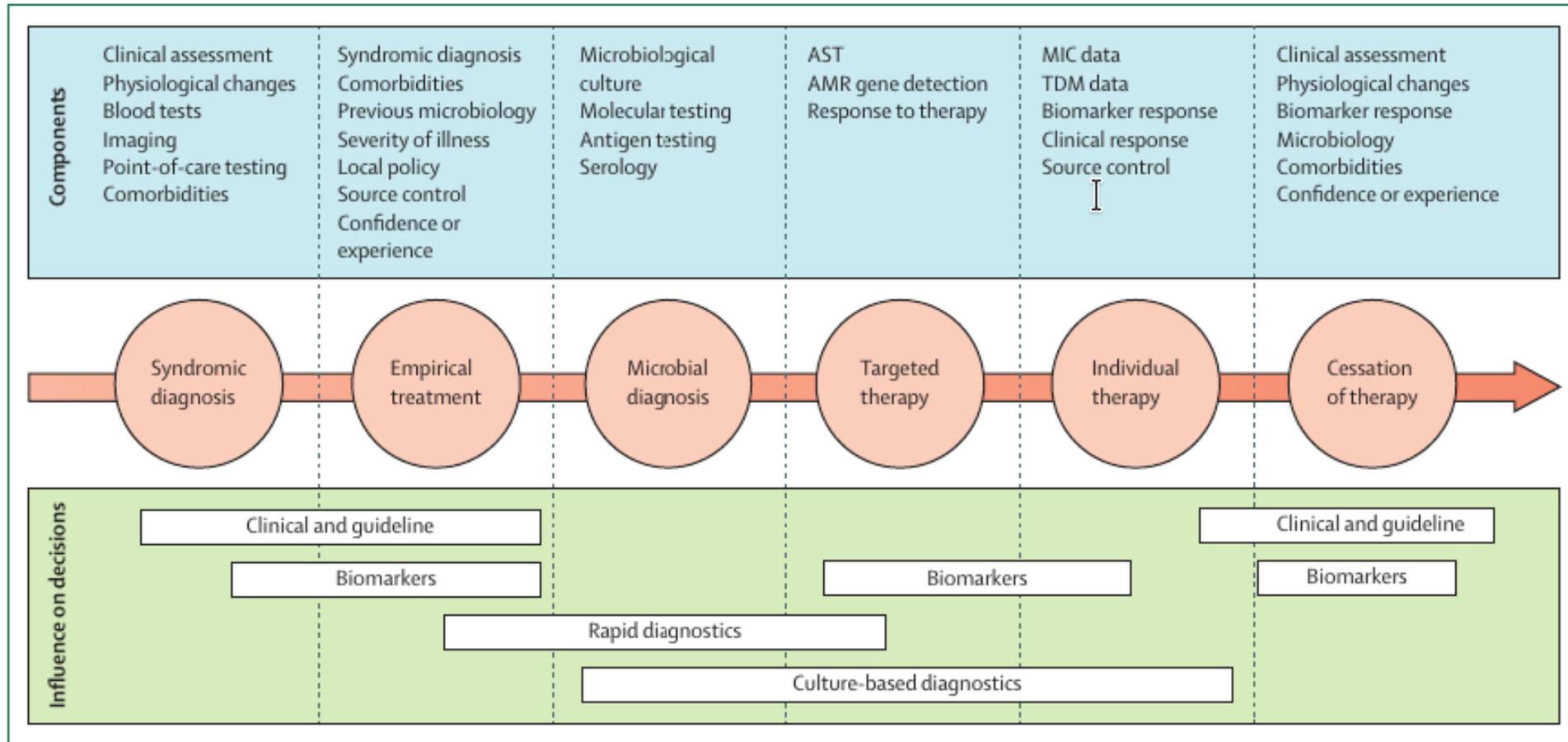Rawson et al., Nat Hum Behav 2019; 3(6): 543-5; Rawson et al., Lancet Digit Health 2024; 6(12): e914-25

AI i AMR

Figure 3: Core decision nodes associated with antimicrobial use in individual patients
Figure from Rawson and colleagues.[45,73] Core components and factors that influence each step of the antimicrobial use decision-making pathway are highlighted. AST=antimicrobial susceptibility testing. AMR=antimicrobial resistance. MIC=minimum inhibitory concentration. TDM=therapeutic drug monitoring.

Zaključci

- AI može pomoći u može pomoći u upravljanju antimikrobnom terapijom i primenom antibiotika, ali...

- ...još uvek je u povoju (zabrinutost zbog tačnosti)

- Prepreke: na mikro i makro nivou sistema zdravstvene zaštite
  - složeni i promenljivi inputi (patogeni, humani faktori)
  - potreba za edukacijom
  - transparentnost