Using artificial intelligence to analyse and predict susceptibility to antimicrobials

Guest speakers: Adrian Egli, Javier Fernández Domínguez
Moderator: Margo Diricks
Host: Victor Kouassi

28 October 2025

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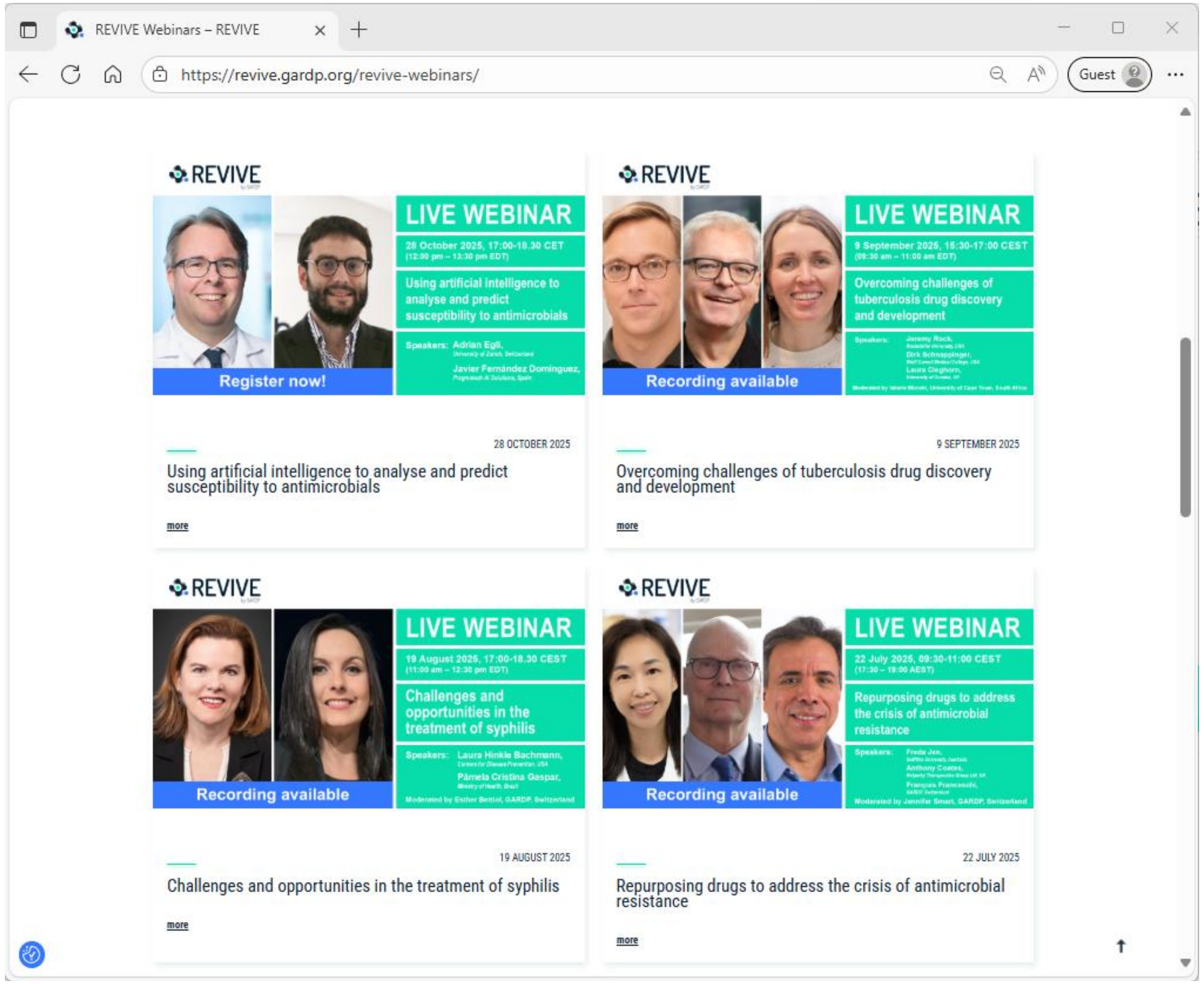

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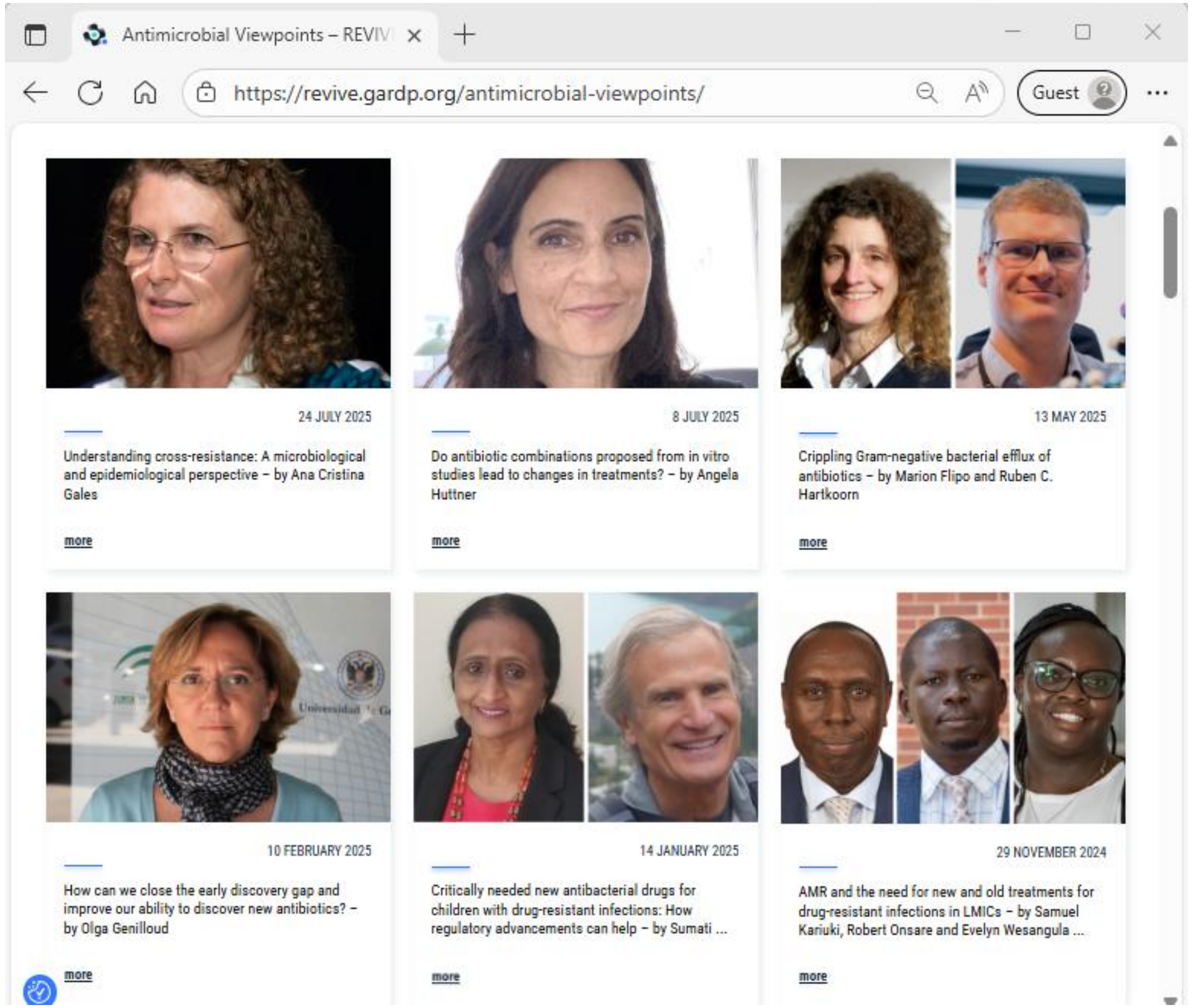

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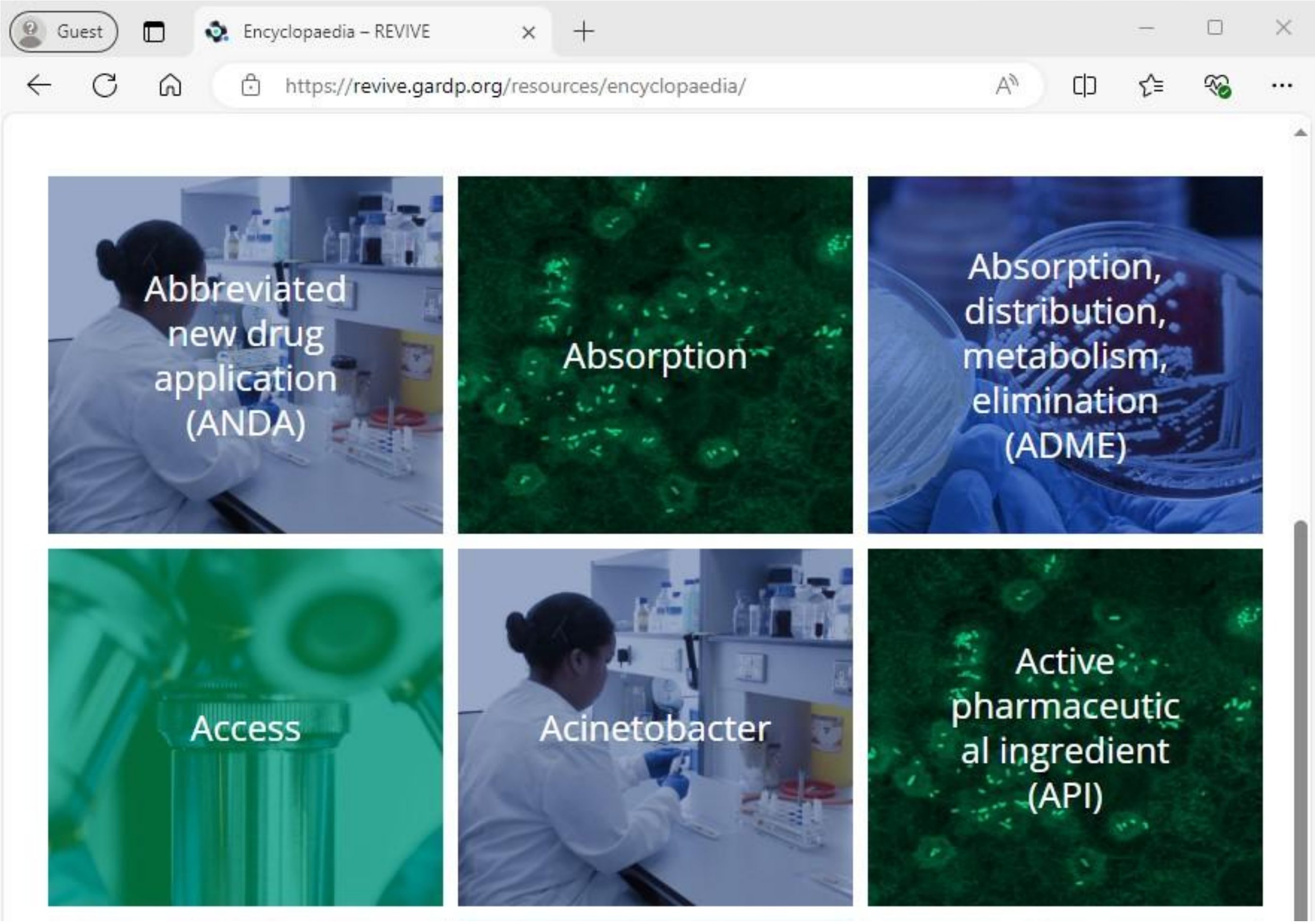

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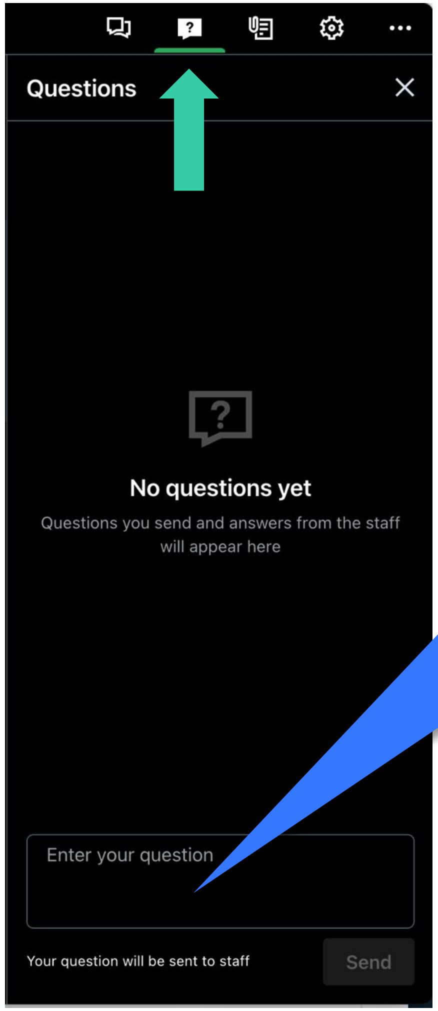


Please submit your questions through the box provided after clicking the ‘questions’ button. We will review all questions and respond to as many as possible after the presentation.

Today's speakers

Using artificial intelligence to analyse and predict susceptibility to antimicrobials

Moderator:
Margo Diricks
Postdoctoral researcher, Research Center Borstel – Leibniz Lung Center (Germany)

Adrian Egli
Director, Institute of Medical Microbiology, University of Zürich (Switzerland)

Javier Fernández Domínguez
Co-founder and co-CEO, Pragmatech AI Solutions (Spain)

Adrian Egli

Adrian Egli is Director of the Institute of Medical Microbiology, University of Zürich. His research aims include developing new diagnostics for rapid detection of multidrug-resistant and virulent pathogens, exploring novel typing technologies such as whole genome sequencing (including long reads, e.g. Pacbio, Minion) and MALDI-TOF mass spectrometry for clinical applications and to understand evolution of pathogens within the host (e.g. during antibiotic treatment).

Between 2015 and 2022, Adrian was the Head of Clinical Microbiology at the University Hospital of Basel, Switzerland where he was also a fellow in Clinical Microbiology. He is also a Research Group Leader in Applied Microbiology Research in the Department of Biomedicine of the University of Basel. Adrian studied medicine at the University of Basel and also received his PhD from the same university in 2008.

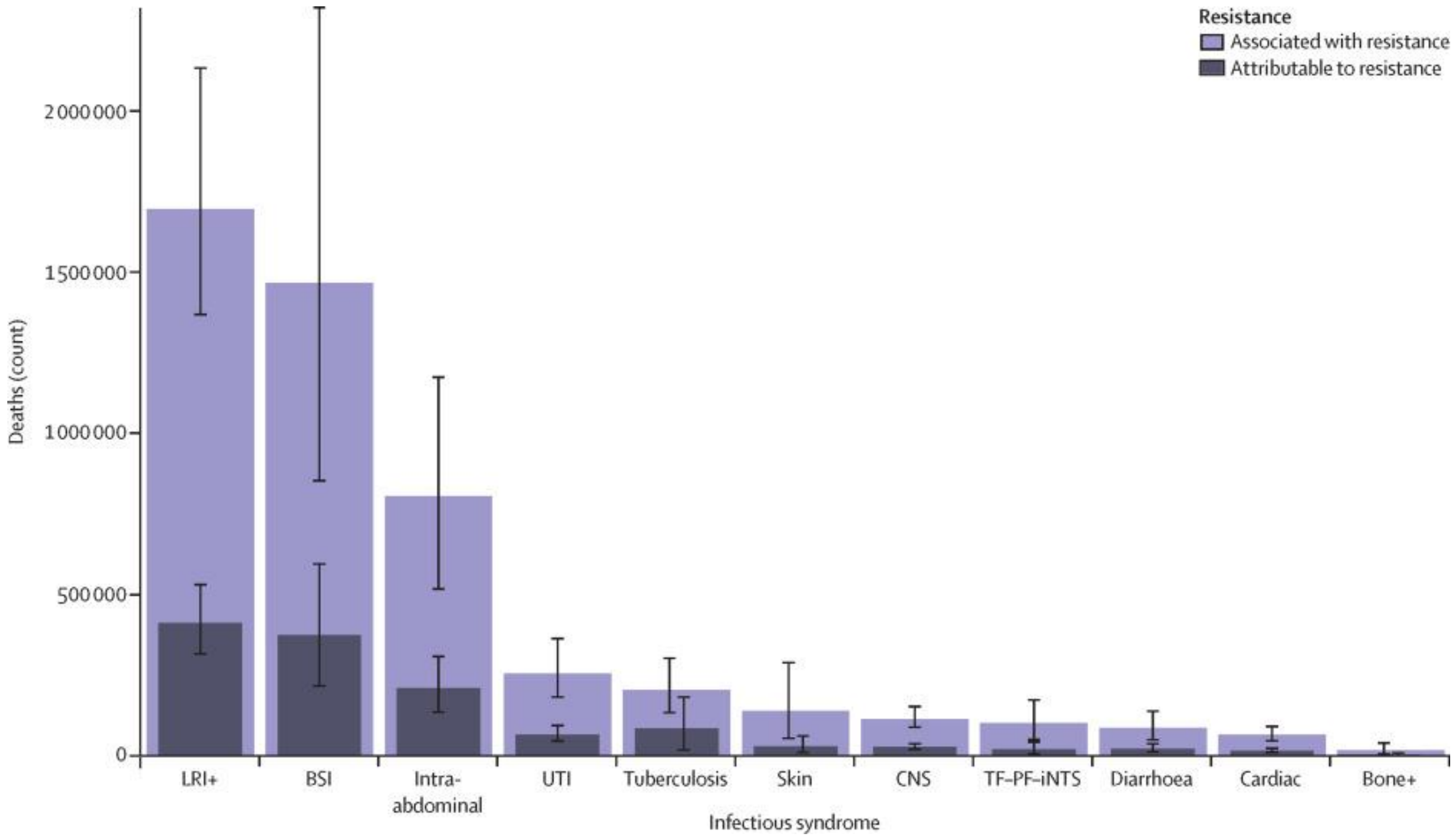
linkedin.com/in/adrian-egli-90b970b9

Using artificial intelligence to analyse susceptibility to antimicrobials

Prof. Adrian Egli; MD PhD, FAMH, ESCMID fellow

29 October 2025

Problem for diagnostics: different pathogens

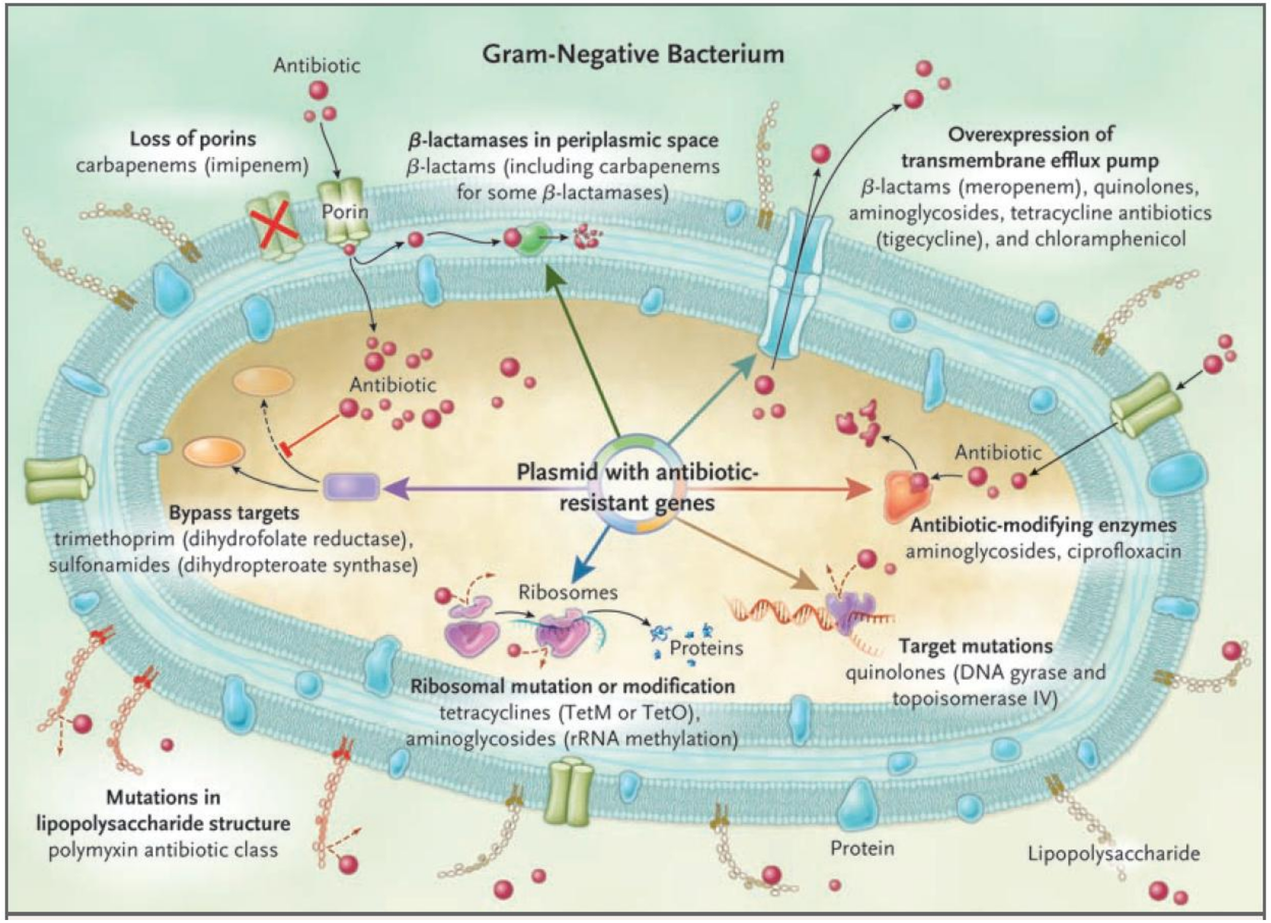


➔ Different lead pathogens.
➔ Different sample types.

Antimicrobial resistance collaborators, Lancet 2022

In 2019: Estimated 4,95 million people (95% CI 3,62–6,57) died with AMR, incl. 1,27 million people (95% CI 0,91–1,71) died due to AMR

Problem for diagnostics: different molecular mechanisms for resistance



Peleg AY and Hooper DC, NEJM 2010

- Porin loss
- Efflux pump
- Target modification
- Cleaving enzymes

→ Diverse resistance mechanisms, not all are simply based on a single gene.

→ Heterogenity

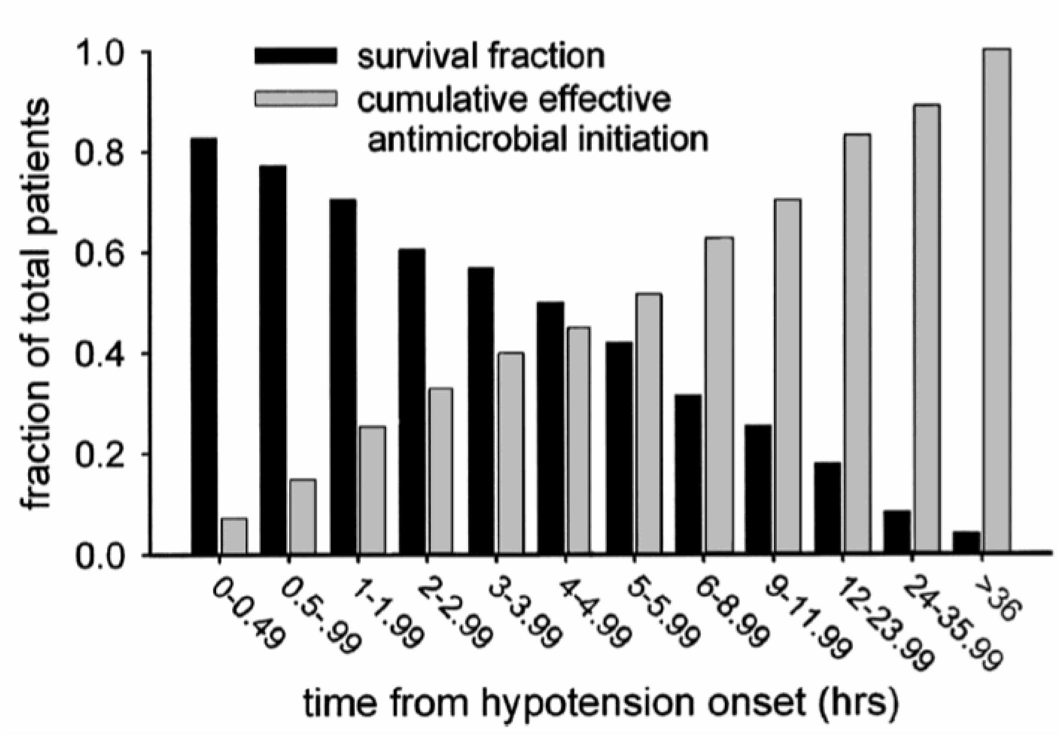
Delay in antibiotic susceptibility testing

Time to efficient treatment is associated with survival [1].

Problem: Antibiotic susceptibility testing takes time.
→ As consequence, broad-spectrum empiric treatment is given. Not everything can be covered.

Reason for need: Antimicrobial resistance is rapidly expanding. Diagnostic information helps to treat adequatly.

One question we asked outselves: Can we use artificial intelligence for rapid assessment?

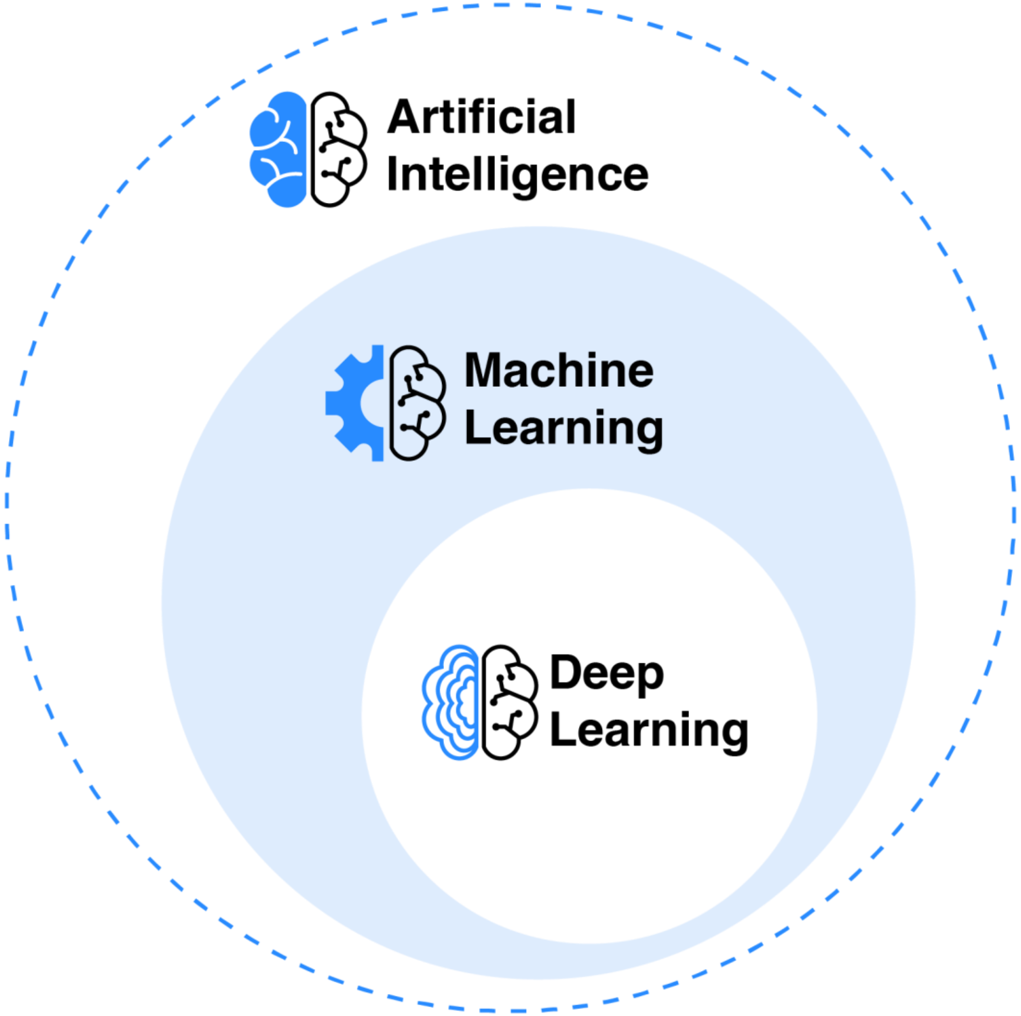


1 Kumar A et al., Crit Care Med 2006

What is artificial intelligence?

Artificial intelligence (AI) is the field of computer science focused on creating machines that can perform tasks requiring human-like intelligence, such as reasoning, learning, problem-solving, and decision-making. AI systems achieve this by learning from vast amounts of data to identify patterns, make predictions, and adapt their behavior, enabling them to automate complex tasks and improve performance over time.

Google: “What is artificial intelligence?” (26.09.2025, AE)



What can we do with AI?

1. Categorisation!

Input

Black box (a.k.a. AI)

Trend towards explainable AI

Output

What can we do with AI?

Accessing information! (≠ knowledge).

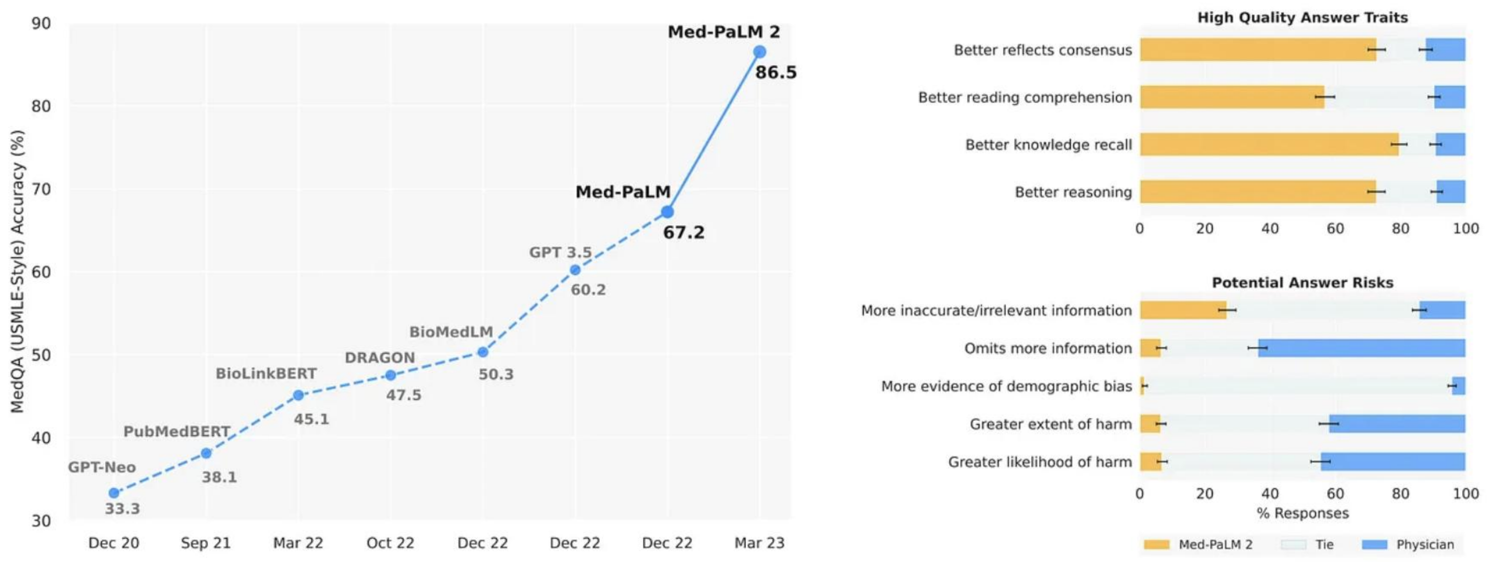


Figure 1 | Med-PaLM 2 performance on MultiMedQA Left: Med-PaLM 2 achieved an accuracy of 86.5% on USMLE-style questions in the MedQA dataset. Right: In a pairwise ranking study on 1066 consumer medical questions, Med-PaLM 2 answers were preferred over physician answers by a panel of physicians across eight of nine axes in our evaluation framework.

- Newst models with deep research capacity reach >98% in MedQA.
- **Domain level expertise** e.g. in public health and epidemiology is likely much lower.
- **Challenges:** Data scarcity. Medicine is per se a very heterogenous topic, little data interoperability.

Singhal K, Azizi S, Tu T et al. Nature 2023

Where can AI be implemented? [1]

aka "the brain-to-brain cycles"

① **Pre-analytics**

e.g., **diagnostic stewardship, quality assessment**

Clinic

Patient
Physician
Nurse

Intervention

Laboratory

Microbiologist
Technician
Bioinformatician

1011100
0010111

② **Analytics**

e.g. **microscopy image analysis, agar plate image analysis, Interpretation of results, MALDI-TOF MS spectral analysis, genome sequencing**

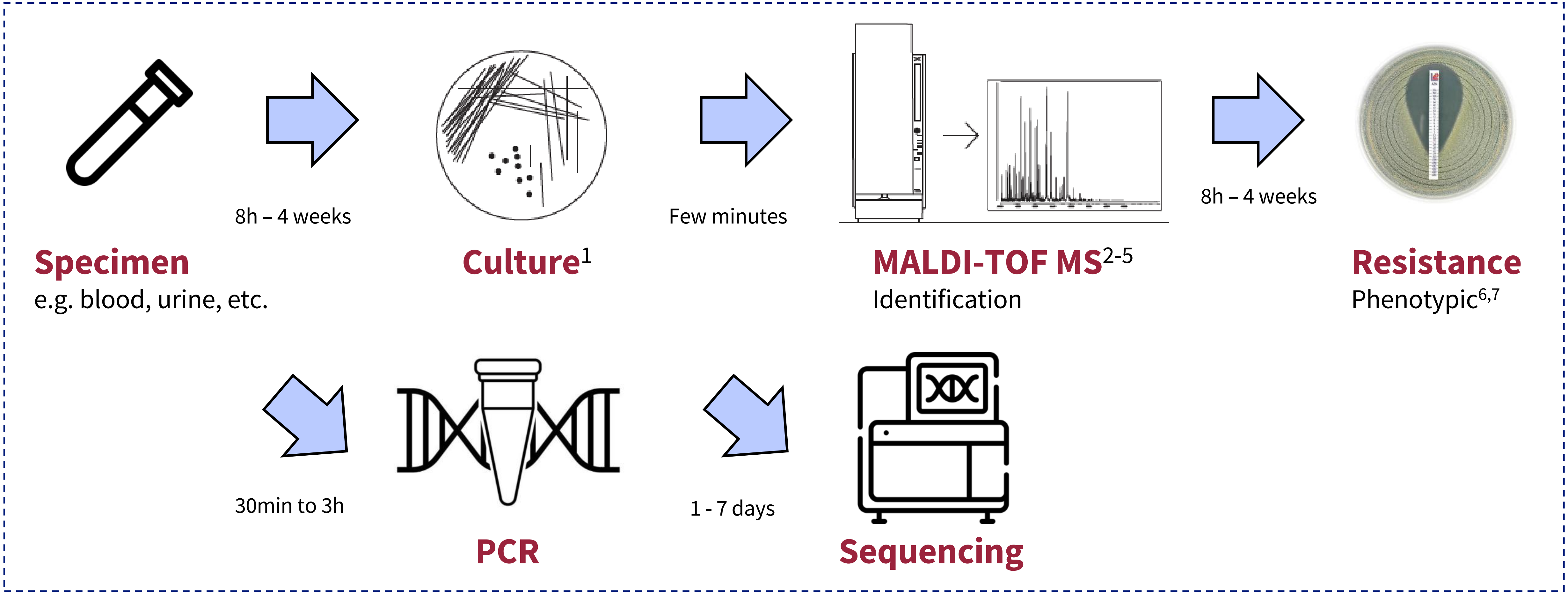
→ **Attention:** IVDR/FDA approval

③ **Post-analytics**

e.g., **communication, summary**

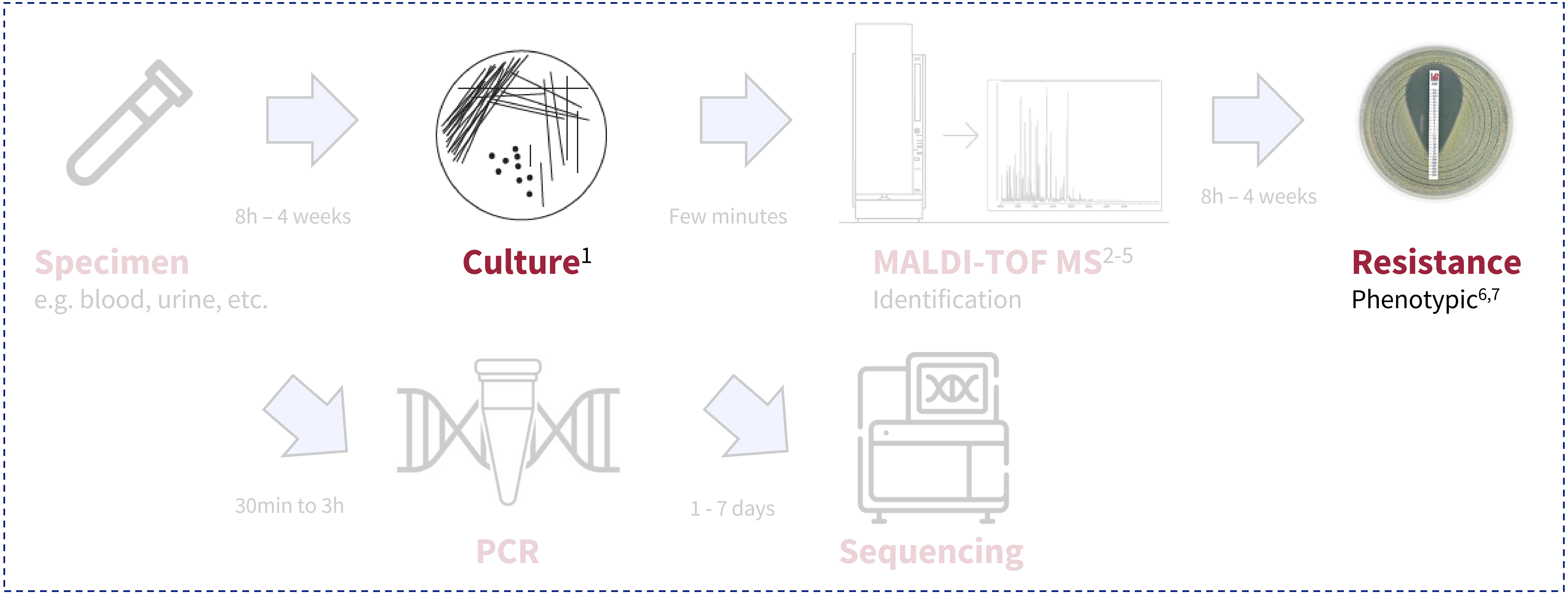
[1] Egli A, Schrenzel J, Greub G, Clin Micro Infect 2020; [2] Egli A, Clin Infect Disease 2023

Analytics in routine labs



[1] Hinic V, Amrein I, … et Egli A J Micro Met 2017; [2] Dierig A, Frei R, Egli A, Ped Infect Dis J 2015 [3] Egli A et al. Transpl Infect Dis 2015; [4] Osthoff M, … et Egli, A. Clin Microbiol Infect 2017; [5] Weis C, … Egli A, Borgwardt K, Bioinformatics 2020; [6] Egli A, Schmid H, et al. Clin Microbiol Infect 2017; [7] Hinic V, Reist J, Egli A J Microbiol Met 2018

Analytics in routine labs



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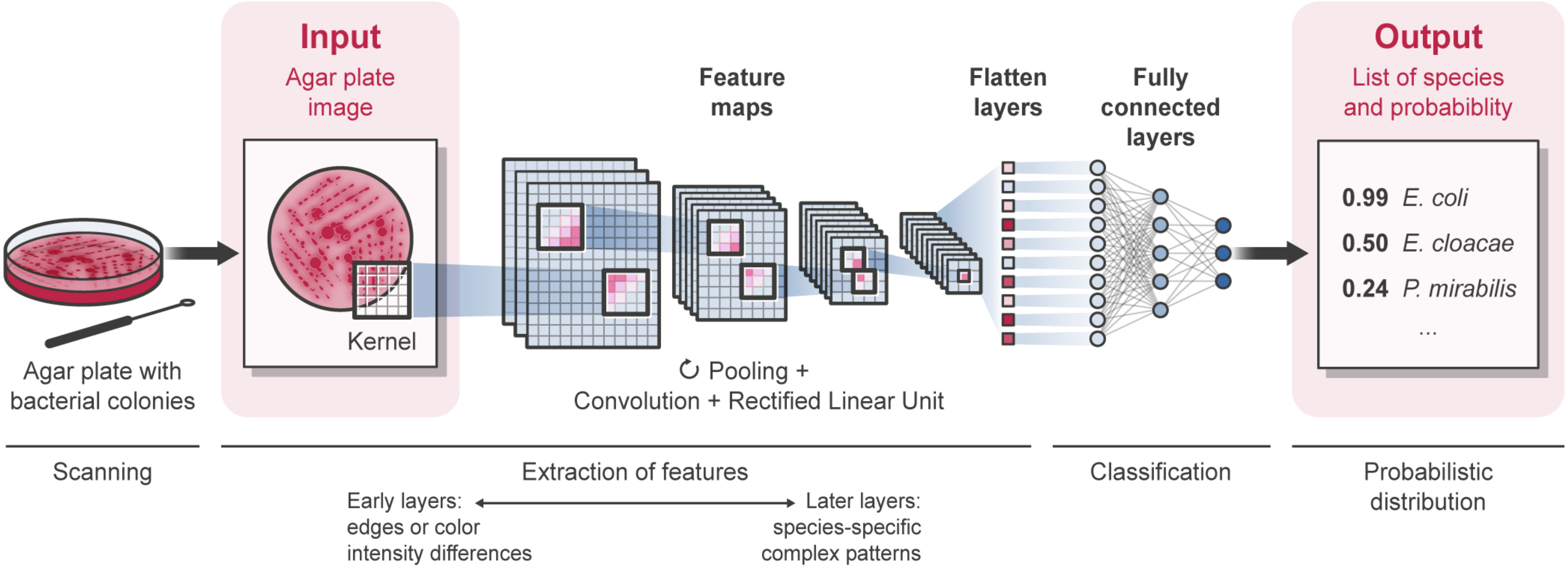
What is a convolutional neural network?



Weber L, … et Egli A, in prepare

Culture plates on total lab automation

Detection of colonies

— positive vs. negative plates; Sensitivity 97-99%; specificity 94-99%. [1-2]

Identification of bacterial species

— *Staphylococcus aureus, E. coli*, etc. with specificity of 94%-99%. [1-4]

Special thanks to
Dr. Oliver Nolte
for providing the images

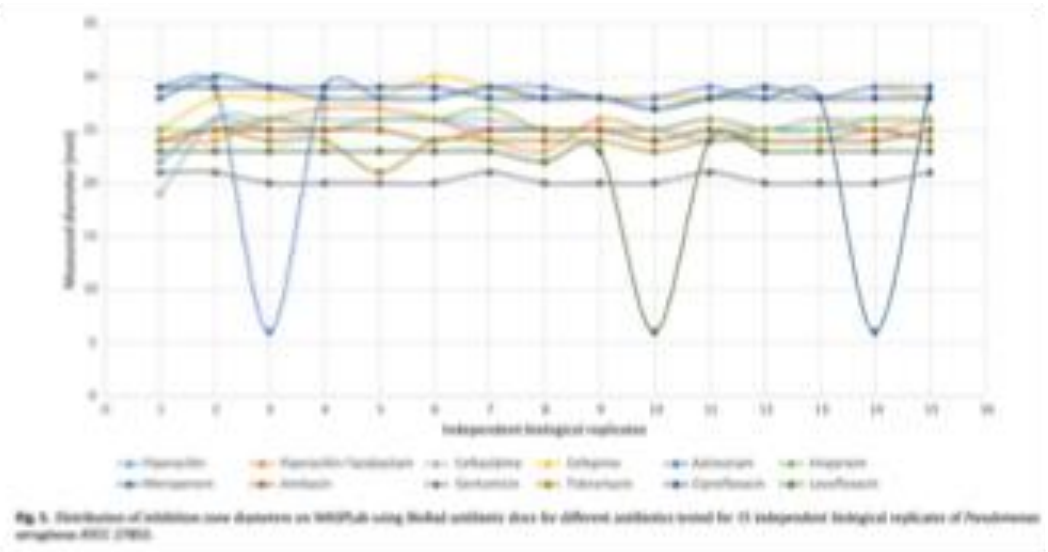
[1] Croxatto A et al. Biomedical J 2017; [2] Glasson J et al JCM 2016; [3] Cherkaoui A, Renzi G et al. Front Cell Infect Microbiol 2019
[4] Signoroni A et al. Nat Commun 2023

Automated reading of resistance

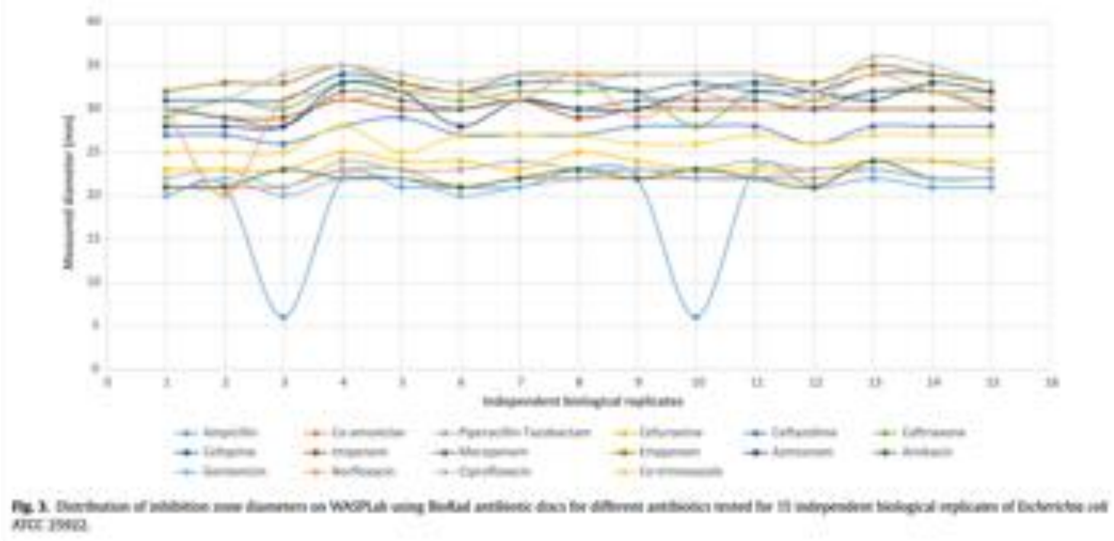
Automated measurement of inhibition zones: principles. [1-2]

“Currently all results are approved by clinical microbiologists, but in the near future these instruments would automatically deliver S/I/R categories without requiring a human check.“[3]

Pseudomonas aeruginosa



E. coli

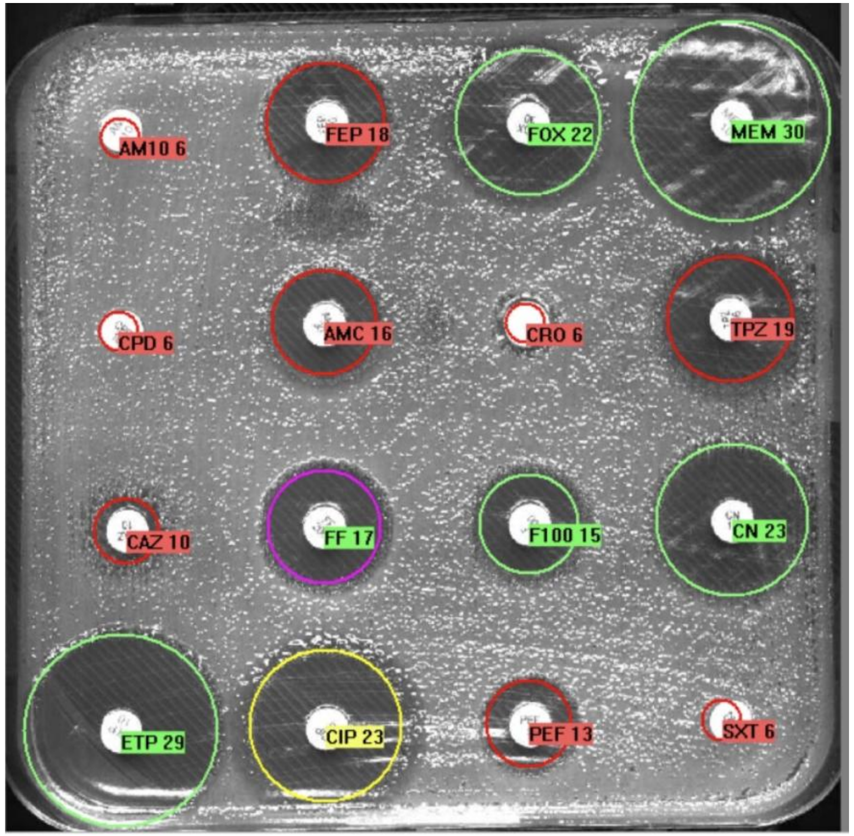


[1] Cherkaoui A, Renzi G, et al. CMI 2019; [2] Hombach M et al. JAC 2017; [3] Dauwalder O et Vandenesch F, CMI 2020

Customized GPT as an expert

Prof. Ch. Giske Dr. M. Bressan

Leading question: Can we use a multi-modal LLM to predict the underlaying molecular resistance mechanism?



OpenAI

Step 1: Generation of a GPT powered generative AI agent.

EUCAST GPT Expert

Expert on EUCAST standards and general antimicrobial susceptibility

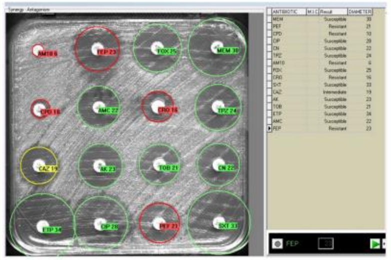
Step 2: Acquisition of knowledge.

Using document from EUCAST.org
- EUCAST breakpoint table v13.1
- Expert rules

Step 3: Within model testing.

Checked with few examples. Improving rules for obvious mistakes e.g. list of species with chromosomal AmpC.

Step 4: Input for prompt.



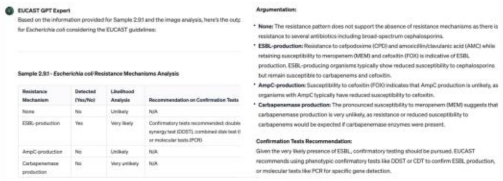
+ same image without measurement circles.

+ Table with measured inhibition zones

Step 5: Standardized prompting.

Ask for:
(i) Interpretation of image and table;
(ii) Provide output table with 4 categories: “None”, “ESBL”, “AmpC”, and “Carbapenemase”;
(iii) recommended confirmation;
(iv) and short argumentation text.

Step 5: Output analysis



Output table Argumentation

Step 6: Calculation of output performance e.g., sensitivity and specificity.

Giske Ch, Bressan M, … Egli A, JCM 2024

Human expert vs. custom GPT

		Human experts[a]	EUCAST-GPT-expert[b]
ESBL	Sensitivity	98.0% (91.8 – 100)	95.4% (94.5 – 96.3)
	Specificity	99.1% (97.1 – 100)	69.2% (63.8 – 85.7)
AmpC	Sensitivity	96.8% (93.3 – 100)	96.9% (87.5 – 96.9)
	Specificity	97.1% (95.9 – 97.7)	86.3% (84.1 – 91.8)
Carbapenemases	Sensitivity	95.5% (90.9 – 100)	100% (90.9 – 100)
	Specificity	98.5% (98.5 – 98.5)	98.8% (98.8 – 98.8)

Giske Ch, Bressan M, … Egli A, JCM 2024

Human expert vs. custom GPT

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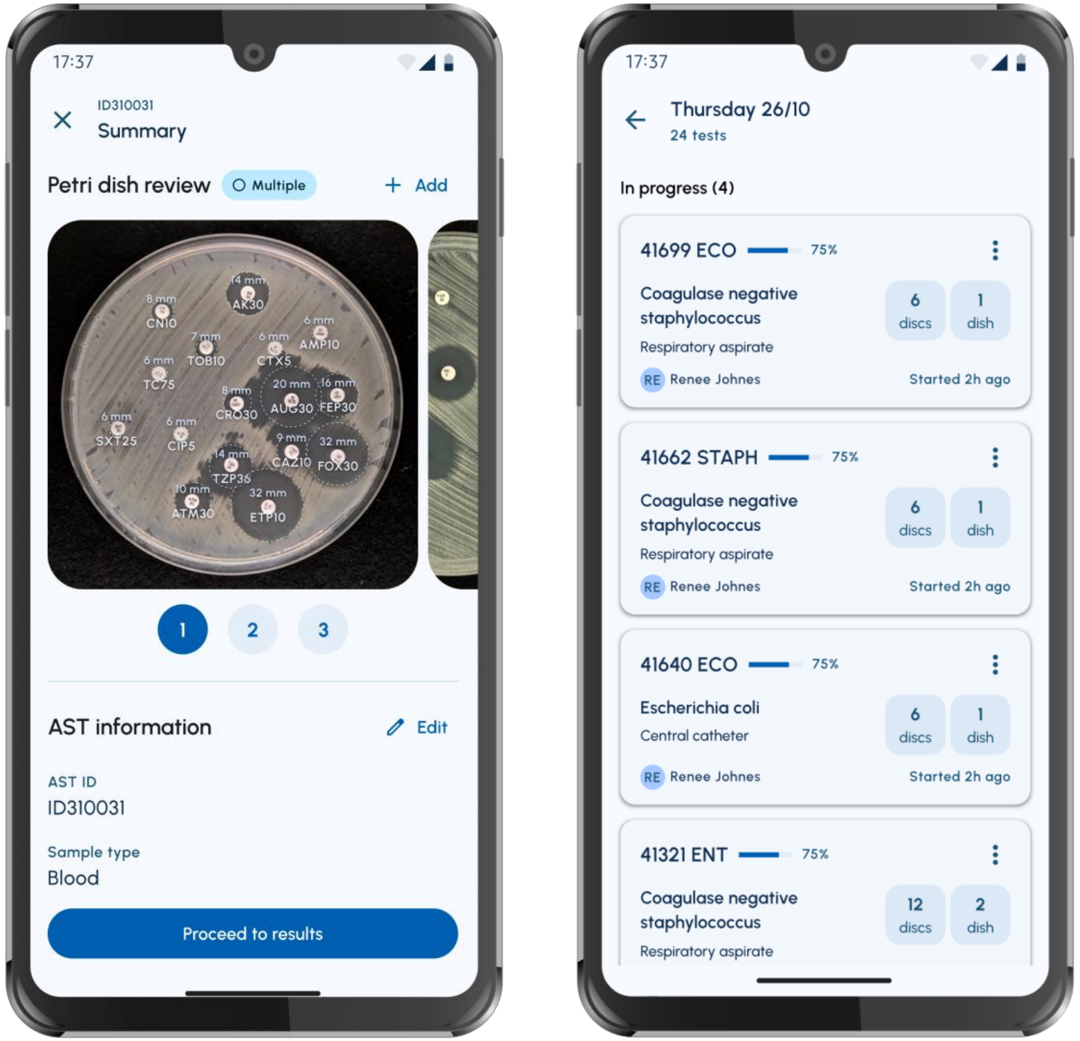
	Specificity	98.5% (98.5 – 98.5)	98.8% (98.8 – 98.8)

- Customized GPT is necessary (domain level expertise), as GPT-4 cannot provide a useful output.
- **Specificity of human experts much better** than the AI.
- Prospective validation is necessary.

Giske Ch, Bressan M, … Egli A, JCM 2024

Antibiogo – a tool by Medecins sans frontieres

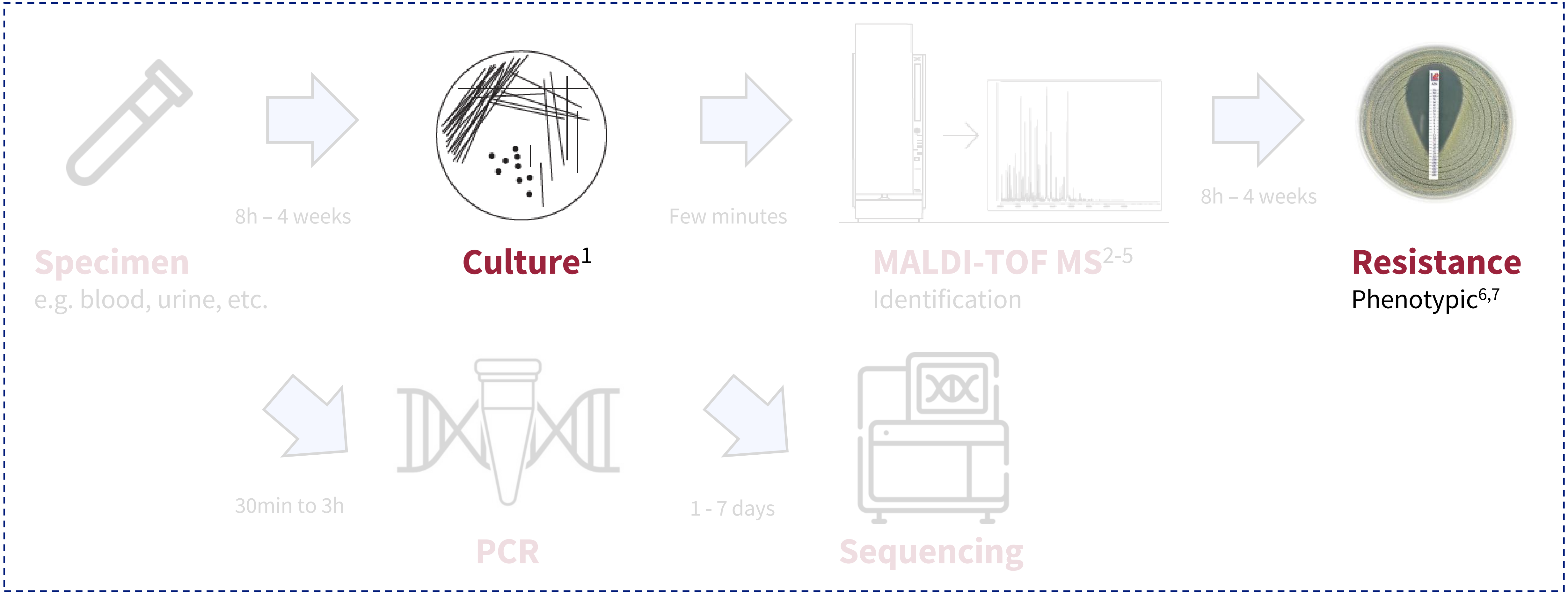


ASTapp is a **free, offline** application to help the non-expert staff in low resources setting laboratories with the **interpretation of antibiograms**.[1]

Portable AI via smart phone-based applications or cloud. Example: Smart phone on microscope

1 Malou N, Al Asmar M, et al. MSF Science Portal 2021

Analytics in routine labs



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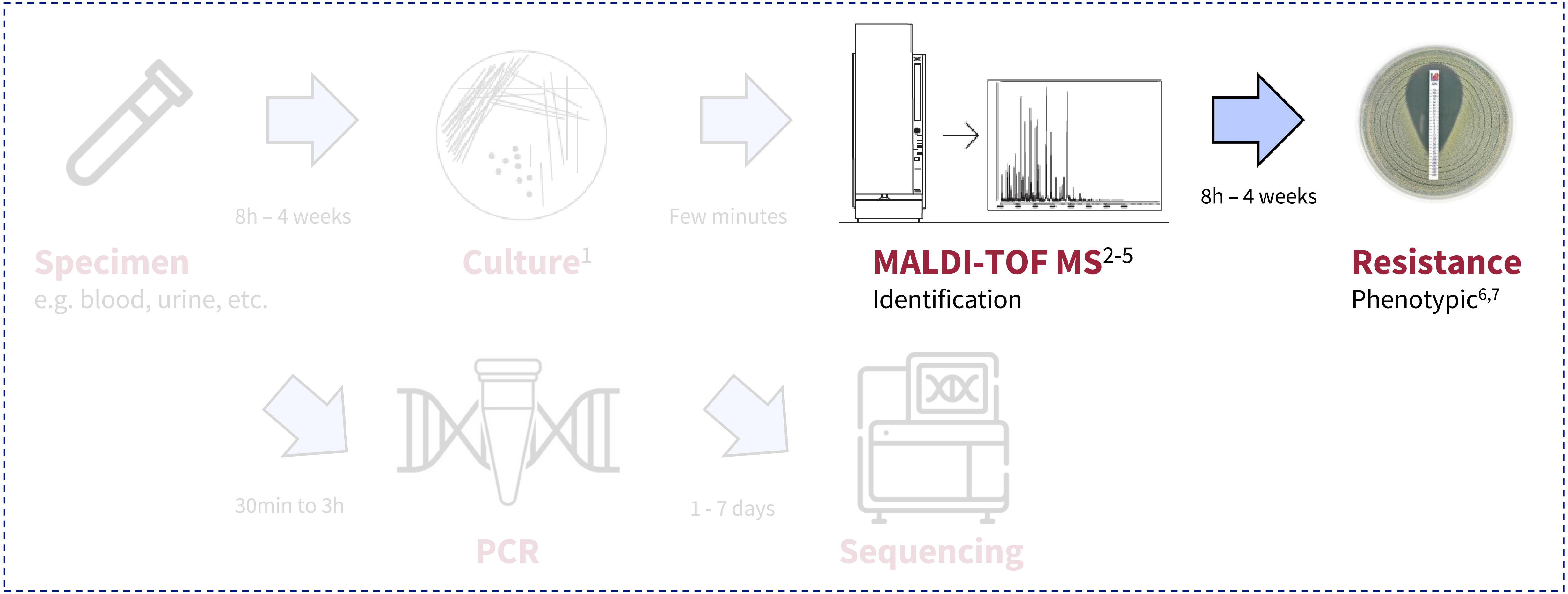
Analytics in routine labs



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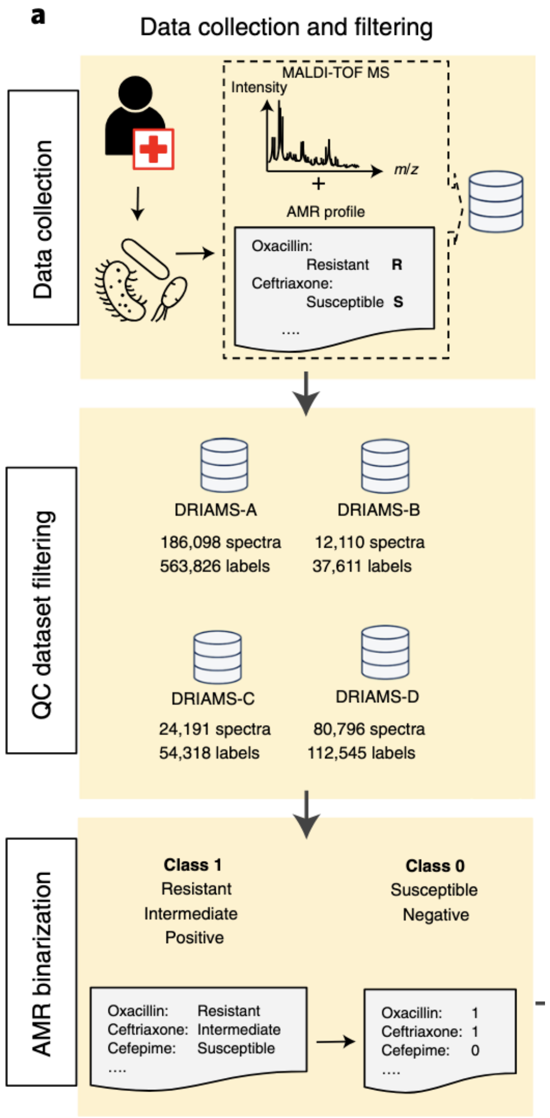


Can we predict AMR profiles directly from MALDI-TOF?

Dr. C. Weis

Dr. A. Cuénod

Universitätsspital Basel

Aline Cuénod, Michael Osthoff
Kirstine K. Soegaard, Adrian Egli

ETH zürich

Caroline Weis, Bastian, Rieck,
Karsten Borgwardt

VIOLLIER

Claudia Lang, Olivier Dubuis

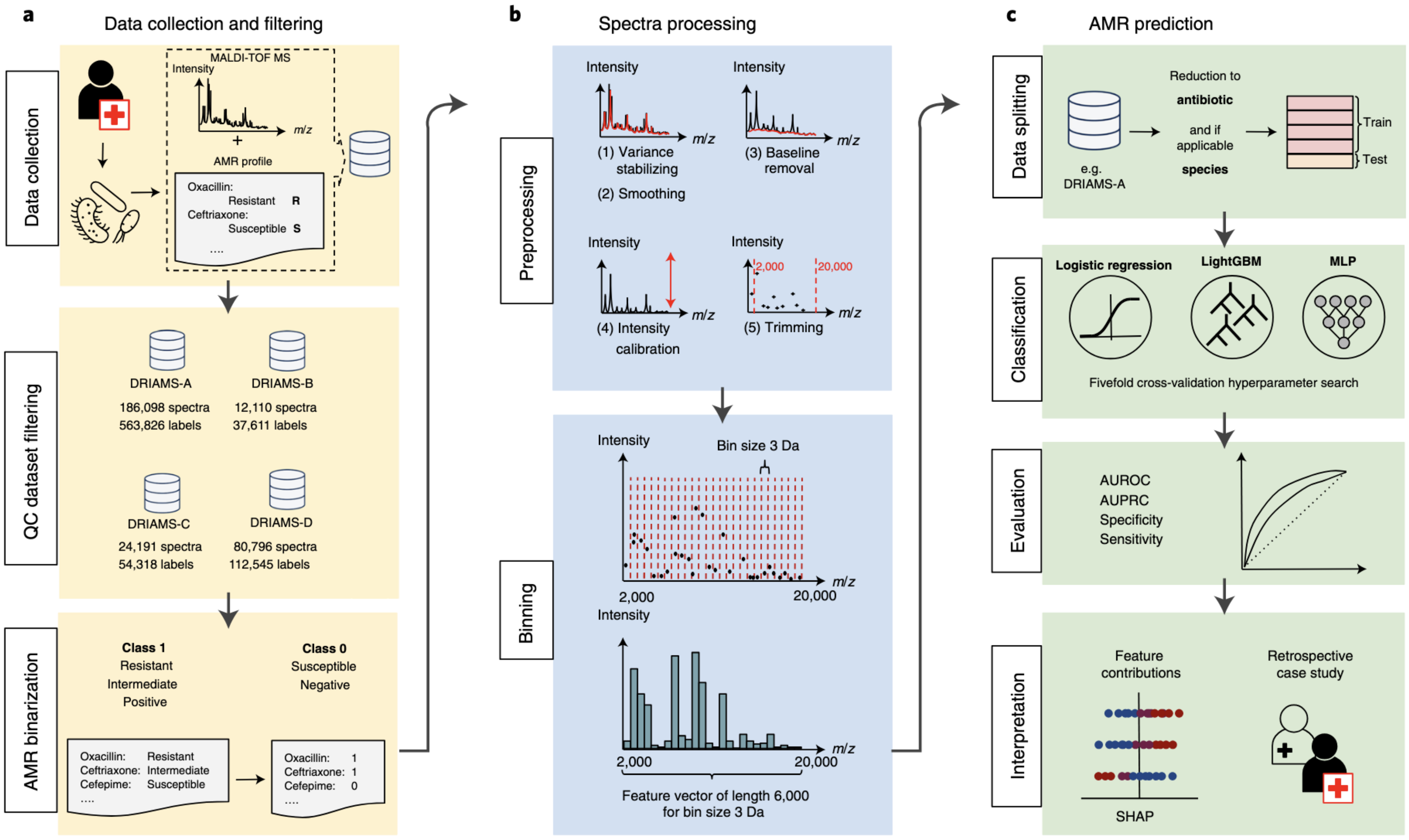
KSA Kantonsspital Aarau

Michael Oberle

Kantonsspital Baselland

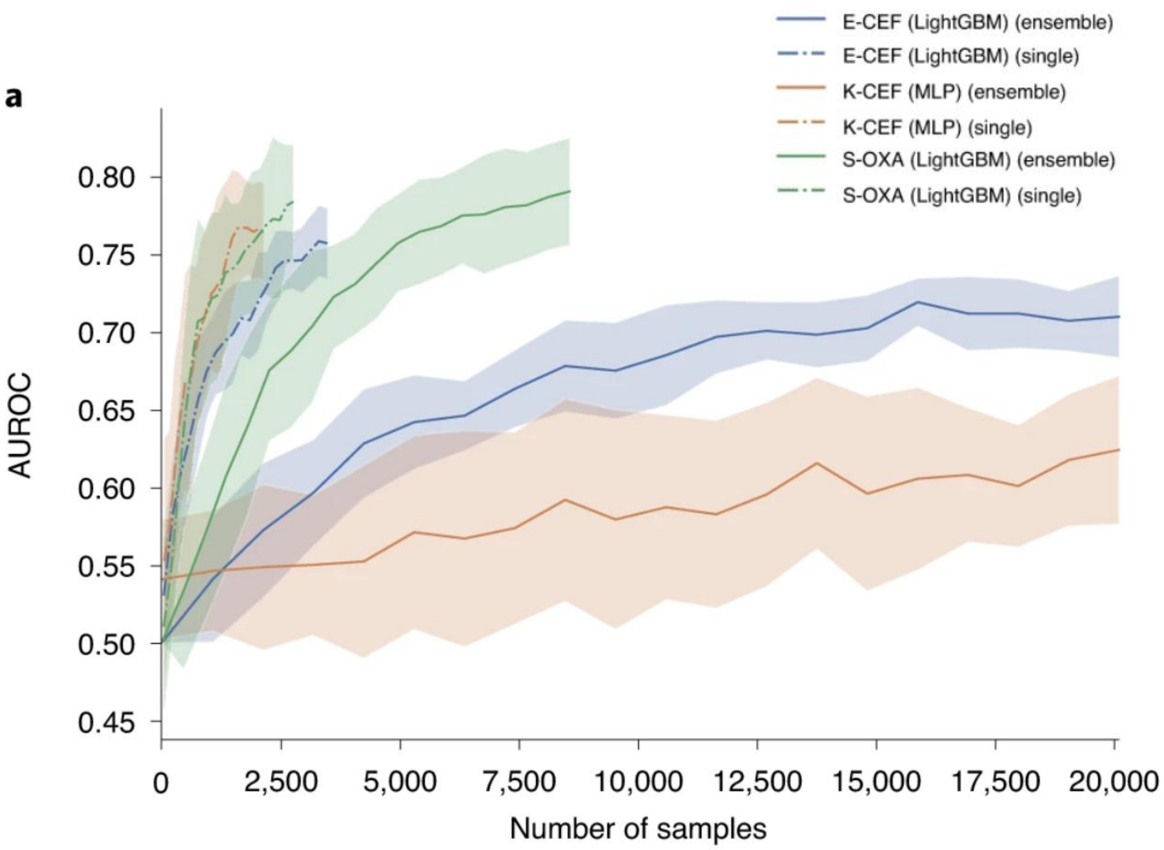
Susanne Graf

[1] Weis C, Cuénod A, … et Egli A, Nature Med 2021; [2] Weis C, et al. Bioinformatics 2020



[1] Weis C, Cuénod A, … et Egli A, Nature Med 2021; [2] Weis C, et al. Bioinformatics 2020

Prediction of AMR phenotypes directly from MALDI-TOF MS



Prediction of susceptibility

		AUROC
S. aureus	Oxacillin	0.8
E. coli	Ceftriaxon	0.74
K. pneumoniae	Ceftriaxon	0.74

→ Not perfect, but promising

DRIAMS data set is public available.

Multiple studies confirmed findings [1-8]

[1] Weis C, Cuénod A, … et Egli A. Nature Med 2021; [2] Ren M, Chen Q, et al. Scientific Reports, 2024; [3] Astudillo CA, Lopez-Cortes XA et al. Scientific Reports 2024; [4] Nguyen HA, Peleg AY, et al. mSystems 2024; [5] Lopez-Cortes XA, Mariquez-Trocoso JM et al. Int J Mol Sci 2025; [6] De Waele G, Menschaert G, et al. Elife 2024; [7] Wang WY, Chui CF, et al. Int J Antimicrob Agents 2024; [8] Yu J, Lin HH et al. Int J Antimicrob Agents 2023

Conclusion.

Time is critical for adequat and efficient antibiotic treatments.
- Traditional culture-based diagnostics takes time.
- Resistance mechanisms are diverse and require a high degree of knowledge.
- Value-based diagnostics = (high) impact for the patient.

→ **AI has a huge potential**
- LLMs can be used for a broad range of applications.
- Smart phone based apps can support AST interpretation.
- More sophisticated use is possible but requires large datasets for training.

… but again we **need careful evaluation** (step-by-step) – allowing ethical, legal and regulatory sound usage.

→ **Stay critical** regarding the usage of AI. Do not believe everything the AI tells you.

What comes next…?

Past

- Cognitive knowledge
- Manuel skills
- Good observation
- Patience & carefulness
- Routine based work

Present and future

- Digital research & critical thinking
- Data interpretation & bioinformatics
- Flexibility & interdisciplinary working
- Communication skills
- Quality management and regulatory knowledge
- Adaptability and resilience

→ Regular and continuous education is critical.

→ Adaptation of curricula for lab technicians and microbiologists

→ It is very likely that **in 10 years, we cannot define ourselves via knowledge**.

Egli Andrea & Egli Adrian, LabMag 2025, in press

Regulatory space…

Most diagnostics labs are nowadays ISO 15189 accredited

In Europe, AI in healthcare is a **tightly regulated space**.
- IVDR
- AI act

All shown tools cannot be used for routine applications.
IVDR is a huge problem for academic labs and start ups.

There is innovation, but there is a **valley of death for application.**

Only large companies can handle the burden – we will run into a company dependency with AI tools.

→ How can we generate an environment in Europe, where diagnostic is value-based (for the patient) but the regulatory burden does not kill the innovation?

Key messages

① **The key challenges in AMR are:** Knowledge and speed.

② **Image analysis is a low hanging fruit.**

③ **MALDI-TOF MS with AI makes huge progress,** but will not replace standard testing – it will provide early info.

④ **Everything outside of the lab**, including patient data, **is currently a tightly regulated space.**

⑤ **Usage of AI** has to be critically evaluated, but currently it is over regulated.

“The age of AI has started” Bill Gates 2022

Acknowledgment

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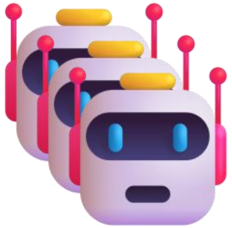


Contact me if you want to collaborate!

Routine Diagnostics: Franca Baggi, Michelle Bressan, Pauline Göller, Vladimira Hinic, Frank Imkamp, Hendrik Kolliwer Stefano Mancini, Oliver Nolte, Bettina Schulthess, Helena Seth-Smith, Tim Roloff
My research group: Diana Albertos Torres, Ana Andrade Barrios, Mehmet Bilgin, Lars Binder, Vera Bregy, Anna Diversi, Ashim Kumar Dubey, Zoey Germuskova, Mariella Greutmann, Alejandro Guerrero Lopez, Yukino Gütlin, Klara Haldimann, Sina Leutenegger, Claudia Li, Eline Meijer, Ana Gabriela Monsalve, Eleonora Pronzini, Srinithi Purushotaman, Janis Rogenmoser, Ashley Rooney, Joy Scherrer, Elisa Sosa, Kittipit Srisanoi, Araney Thrairatnam, Fanny Wegner

University Hospital Zurich: Annelies Zinkernagel and Team
ETH Zurich: Catherine Jutzerler, Emma Slack, Andreas Güntner, Wolf Dietrich Hardt
Max Planck Institute Munich: Karsten Borgwardt

Funding

Swiss National Science Foundation

SPHN

Fondazione Helmut Horten
Helmut Horten Stiftung

Universität Zürich[UZH]

Javier Fernández Domínguez

Javier Fernández Domínguez is co-founder and co-CEO at Pragmatech AI Solutions. A start up whose main product is iAST, an AI-based software platform for antibiotic prescribing support that has obtained the CE certification, becoming the first software of its kind to achieve this milestone.

Javier is a specialist in clinical microbiology with extensive experience in antibiotic resistance and applying innovation in artificial intelligence to infectious diseases. Between 2016 and 2025, he led the antibiotic susceptibility testing section at the Central University Hospital of Asturias (HUCA), was a founding member of the hospital's antimicrobial stewardship team, and served as principal investigator in antimicrobial resistance research within the Translational Microbiology Group at ISPA (Health Research Institute of the Principality of Asturias). He was also previously an adjunct professor at the University of Oviedo in Spain between 2022–2025.

Javier holds a degree in Pharmacy from the Complutense University of Madrid. He specialized in Clinical Microbiology at HUCA and earned his PhD from the University of Oviedo, He has sat on the editorial boards of national and international journals, published over 80 scientific articles and has received several research awards, including two PRAN awards granted by the Spanish Agency of Medicines and the Ministry of Health.

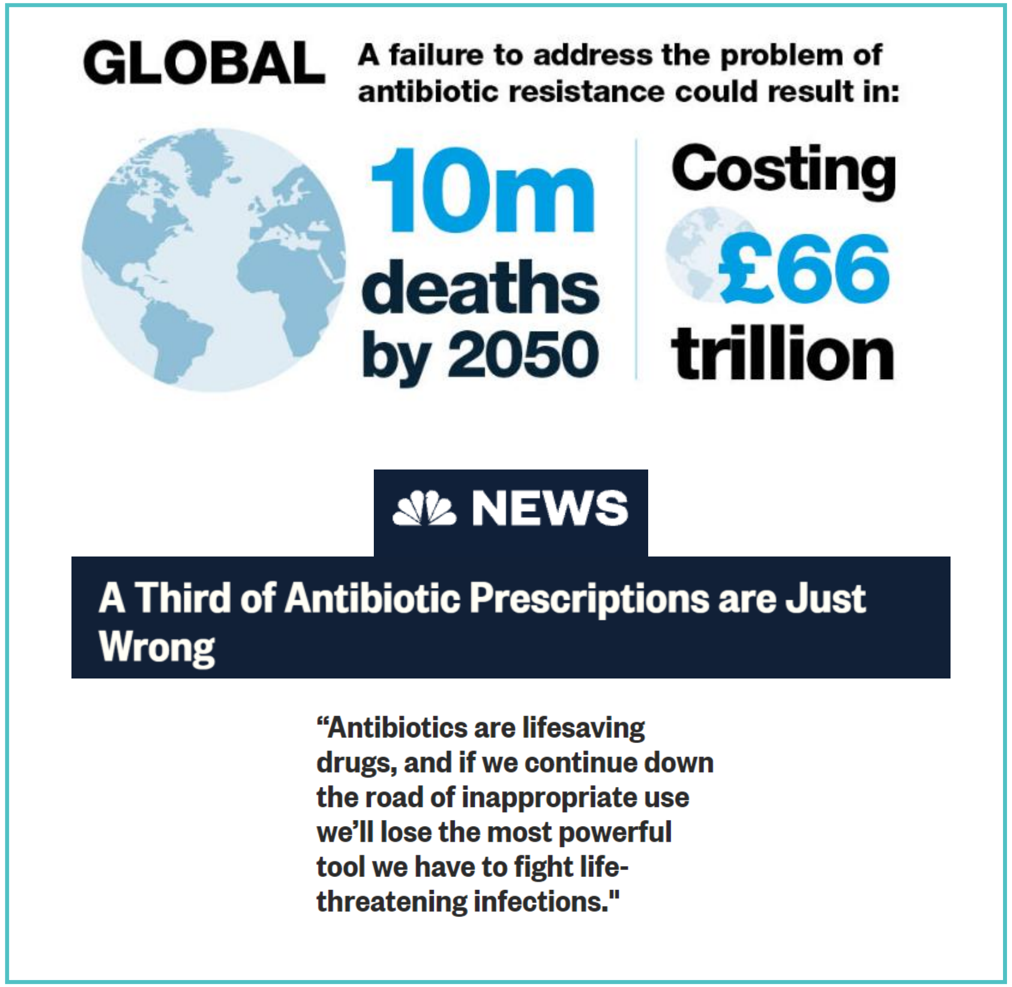
linkedin.com/company/pragmatech-ai

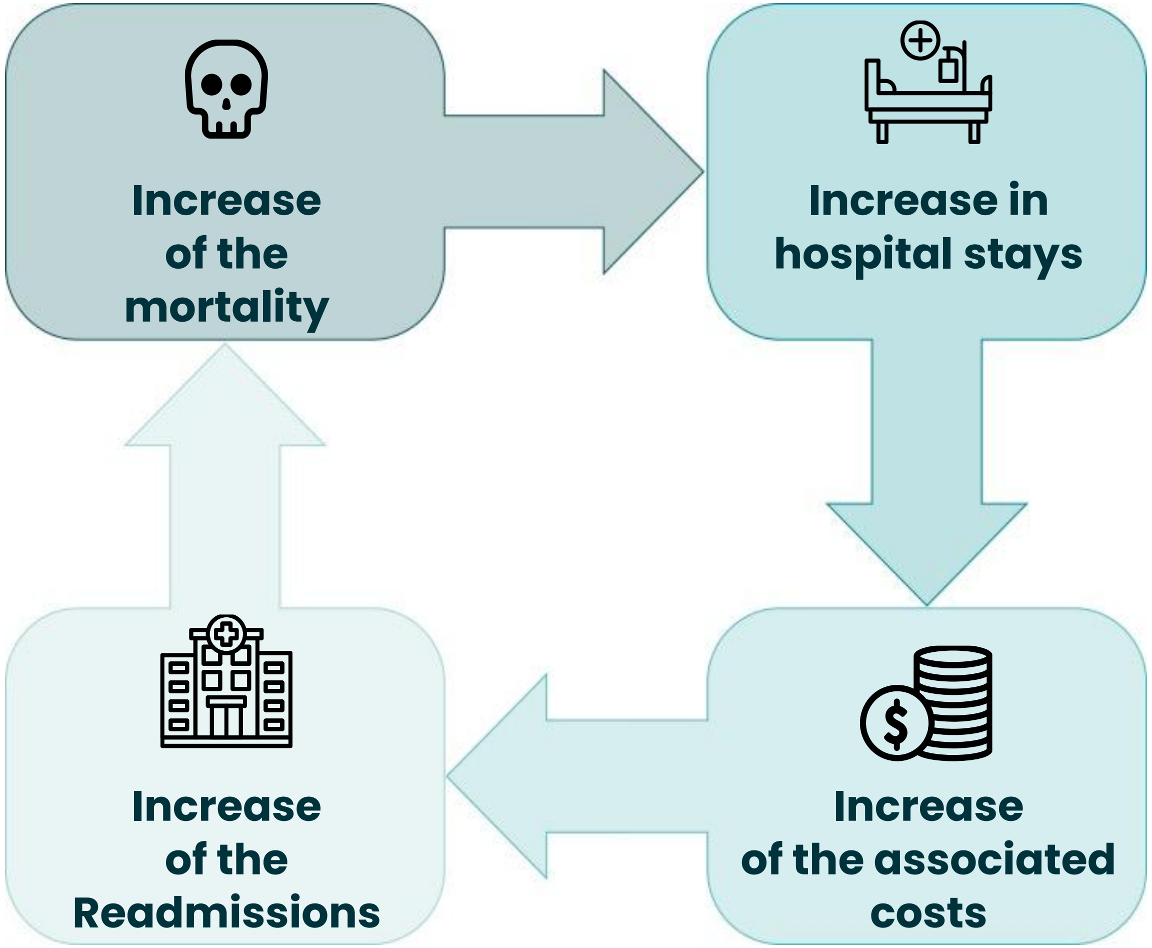
Using artificial intelligence to analyse and predict susceptibility to antimicrobials

28 October 2025, 17:00-18.30 CET
(12:00 pm – 13:30 pm EDT)

Javier Fernández Domínguez, PharmD, PhD
Founder and coCEO, Pragmatech AI Solutions

The challenge of antibiotic resistance





The challenge of errors in antibiotic therapy

Original Investigation

May 3, 2016

Prevalence of Inappropriate Antibiotic Prescriptions Among US Ambulatory Care Visits, 2010-2011

Katherine E. Fleming-Dutra, MD[1]; Adam L. Hersh, MD, PhD[2]; Daniel J. Shapiro[3]; et al

» Author Affiliations | Article Information

JAMA. 2016;315(17):1864-1873. doi:10.1001/jama.2016.4151

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Inappropriate empirical antibiotic therapy for bloodstream infections based on discordant in-vitro susceptibilities: a retrospective cohort analysis of prevalence, predictors, and mortality risk in US hospitals

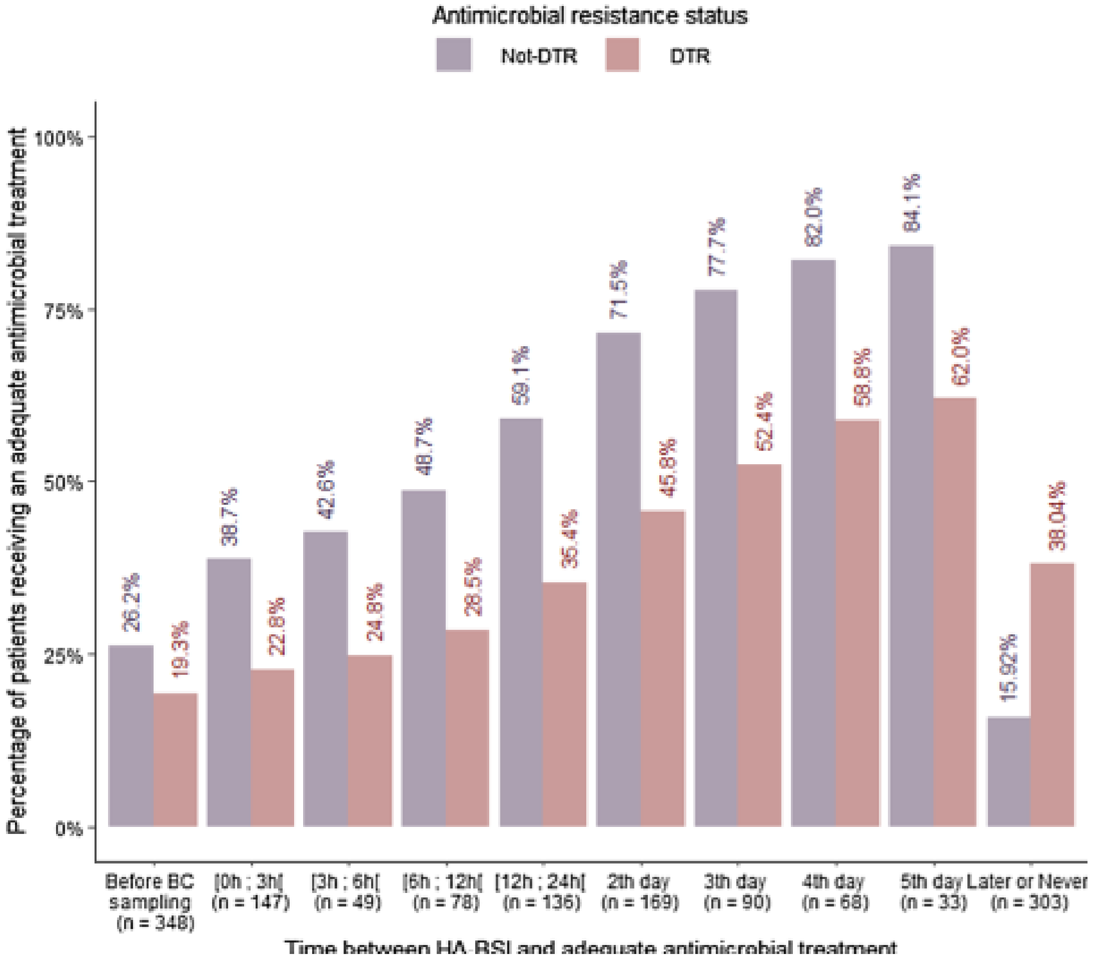
Home › Intensive Care Medicine › Article

Epidemiology and outcomes of hospital-acquired bloodstream infections in intensive care unit patients: the EUROBACT-2 international cohort study

Original | Published: 10 February 2023

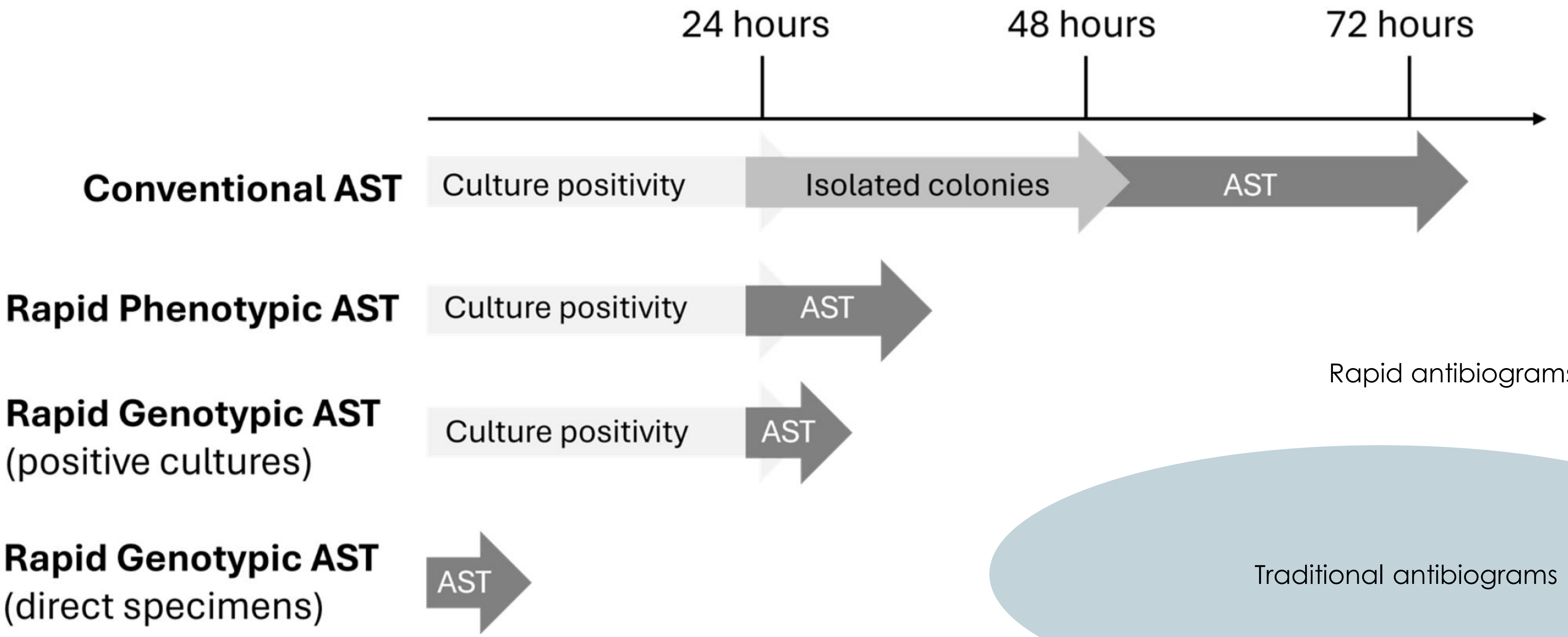
Volume 49, pages 178–190, (2023) Cite this article

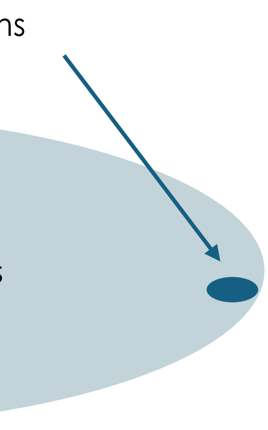
Enterobacterales, *Pseudomonas sp.* and *Acinetobacter sp.*, n=1421 patients



Tabah A, et al. Intensive Care Med. 2023 Feb;49(2):178-190.

Causes of errors in antibiotic therapy: 1. Delayed microbiological results





Causes of errors in antibiotic therapy: 2. Variety in local ecology

	n	AMP	AMC	CRM	CTX	CIP	SXT	GM	TOB	FOS	NTF
Escherichia coli	3044	51,3	90,0	87,1	88,5	72,1	71,9	90,0	86,6	95,8	94,3
Escherichia coli BLEE	335	0,0	74,0	0,0	0,0	14,0	33,1	69,9	48,4	82,7	99,4
Klebsiella pneumoniae	578	R	85,1	83,1	86,2	79,9	85,6	94,6	91,4	NT	87,5
Klebsiella pneumoniae BLEE	75	R	42,7	0,0	0,0	12,0	21,3	62,7	41,3	NT	62,7
Proteus mirabilis	342	61,4	89,8	94,1	97,4	64,3	64,0	74,6	67,0	NT	R
Pseudomonas aeruginosa	161	R	R	R	R	87,6	R	NT	92,6	NT	R
Morganella morganii	94	R	R	R	76,2	62,8	64,9	78,7	85,1	NT	R
Enterobacter cloacae complex	77	R	R	R	71,1	85,7	75,3	93,5	93,5	NT	69,8
Klebsiella oxytoca	68	R	89,7	92,2	97,1	92,6	89,7	97,1	97,1	NT	100,0
Citrobacter freundii complex	53	R	R	R	75,5	79,3	79,3	90,6	90,6	NT	100,0
Citrobacter koseri	68	R	97,1	88,0	100,0	100,0	100,0	100,0	100,0	NT	98,5
Klebsiella variicola	50	R	94,0	98,0	100,0	92,0	98,0	100,0	100,0	NT	98,0
Klebsiella aerogenes	45	R	R	R	88,9	93,3	100,0	97,8	95,6	NT	84,4
Providencia stuartii	35	R	R	R	77,1	8,6	80,0	R	R	NT	R

	n	AMP	AMC	CRM	CTX	CIP	SXT	GM	TOB	FOS	NTF
Escherichia coli	598	41,0	82,1	78,4	81,3	60,2	66,1	88,8	86,0	95,0	98,8
Escherichia coli BLEE	103	0,0	70,9	0,0	0,0	16,5	32,0	65,1	50,49	83,5	97,1
Klebsiella pneumoniae	143	R	79,7	76,6	86,7	68,5	82,5	95,1	88,8	NT	83,9
Klebsiella pneumoniae BLEE	18	R	55,6	0,0	0,0	16,8	16,7	72,2	44,4	NT	66,7
Proteus mirabilis	136	57,4	81,6	91,9	93,3	58,8	66,9	72,1	66,2	NT	R
Pseudomonas aeruginosa	155	R	R	R	R	78,7	R	87,2	89,7	NT	R
Enterobacter cloacae complex	47	R	R	R	68,1	78,7	80,9	91,5	91,5	NT	59,3
Klebsiella oxytoca	48	R	89,6	80,4	95,8	93,8	93,8	97,9	93,8	NT	91,7
Morganella morganii	56	R	R	R	75,0	57,1	64,3	83,9	82,1	NT	R
Serratia marcescens	39	R	R	R	70,3	84,6	89,7	100,0	66,7	NT	R

- Limited information
- Not well known among prescribers

Volume 69, Issue 6
15 September 2019

JOURNAL ARTICLE

The Importance of Cumulative Antibiograms in Diagnostic Stewardship FREE

Javier Fernández, Fernando Vazquez

Clinical Infectious Diseases, Volume 69, Issue 6, 15 September 2019, Pages 1086–1087, https://doi.org/10.1093/cid/ciz082

Published: 30 January 2019

Causes of errors in antibiotic therapy: 3. Limitations of evidence-based medicine in ID

- Inclusion and exclusion criteria leave out a certain population
- Results applicable to populations not individuals
- Thousands of uncontrolled variables: the microorganism, its virulence, its resistance…

Viewpoint | ONLINE FIRST

June 26, 2013

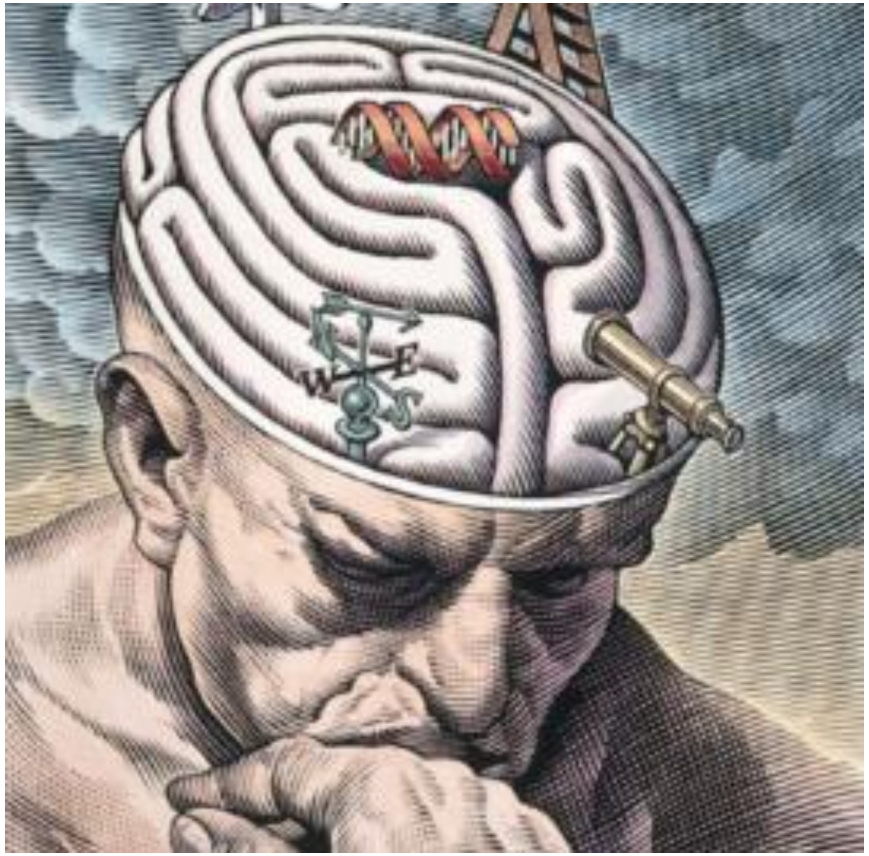
Personalized Medicine vs Guideline-Based Medicine

Jeffrey J. Goldberger, MD, MBA; Alfred E. Buxton, MD

Goldberger, J. J., & Buxton, A. E. (2013). Personalized medicine vs guideline-based medicine. *JAMA*, *309*(24), 2559–2560.

Causes of errors in antibiotic therapy: 4. Errors in medical judgments

MEDICINE: SCIENCE/ART

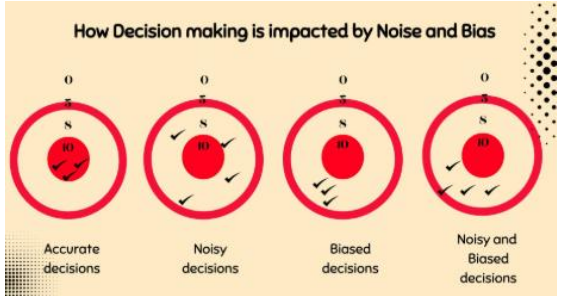


KNOWLEDGE INSPIRATION

PROBABILITY

EMPIRICISM

NOISE



BIAS

Using artificial intelligence to analyse and predict susceptibility to antimicrobials

JAMA Network

JAMA Internal Medicine

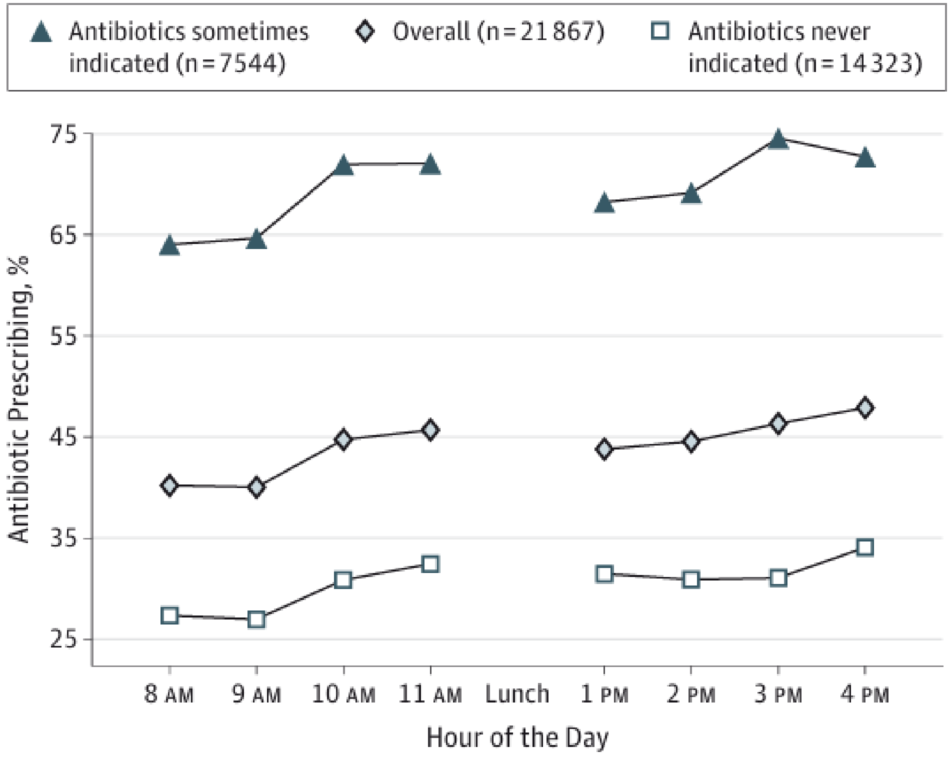
RESEARCH LETTER

Time of Day and the Decision to Prescribe Antibiotics

Jeffrey A. Linder, MD, MPH
Jason N. Doctor, PhD
Mark W. Friedberg, MD, MPP
Harry Reyes Nieva, BA
Caroline Birks, MD
Daniella Meeker, PhD
Craig R. Fox, PhD

Author Affiliations: Division of General Medicine and Primary Care, Brigham and Women's Hospital, Boston, Massachusetts (Linder, Friedberg, Reyes Nieva); Harvard Medical School, Boston, Massachusetts (Linder, Friedberg, Reyes Nieva, Birks); Schaeffer Center for Health Policy and Economics, University of Southern California, Los Angeles (Doctor); RAND, Boston, Massachusetts (Friedberg); Division of General Medicine, Massachusetts General Hospital, Boston (Birks); RAND, Santa Monica, California (Meeker); Anderson School of Management, University of California, Los Angeles (Fox).

Figure. Antibiotic Prescribing by Hour of the Day



Diagnoses for which antibiotics are sometimes indicated were otitis media, sinusitis, pneumonia, and streptococcal pharyngitis. Diagnoses for which antibiotics are never indicated were acute bronchitis, nonspecific upper respiratory infection, influenza, and nonstreptococcal pharyngitis. Linear trend

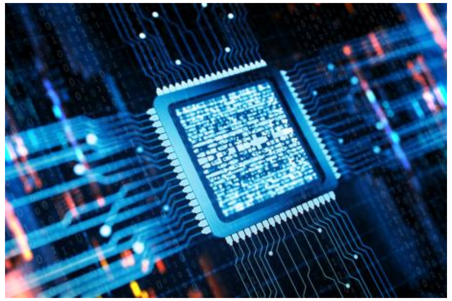
REVIVE by GARDP

Using artificial intelligence to analyse and predict susceptibility to antimicrobials

AI to predict antibiotic susceptibility and help antibiotic prescription

1. Allows microbiological results (including AST) to be anticipated and predicted

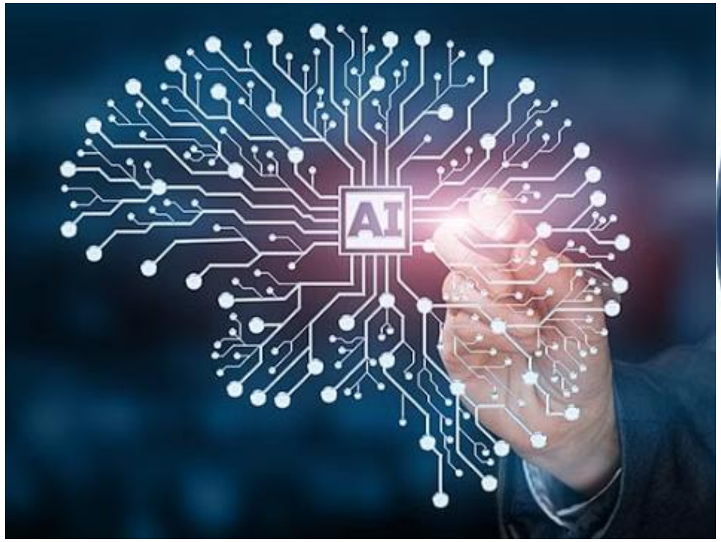
2. Allows recommendations to be adapted to local ecology data

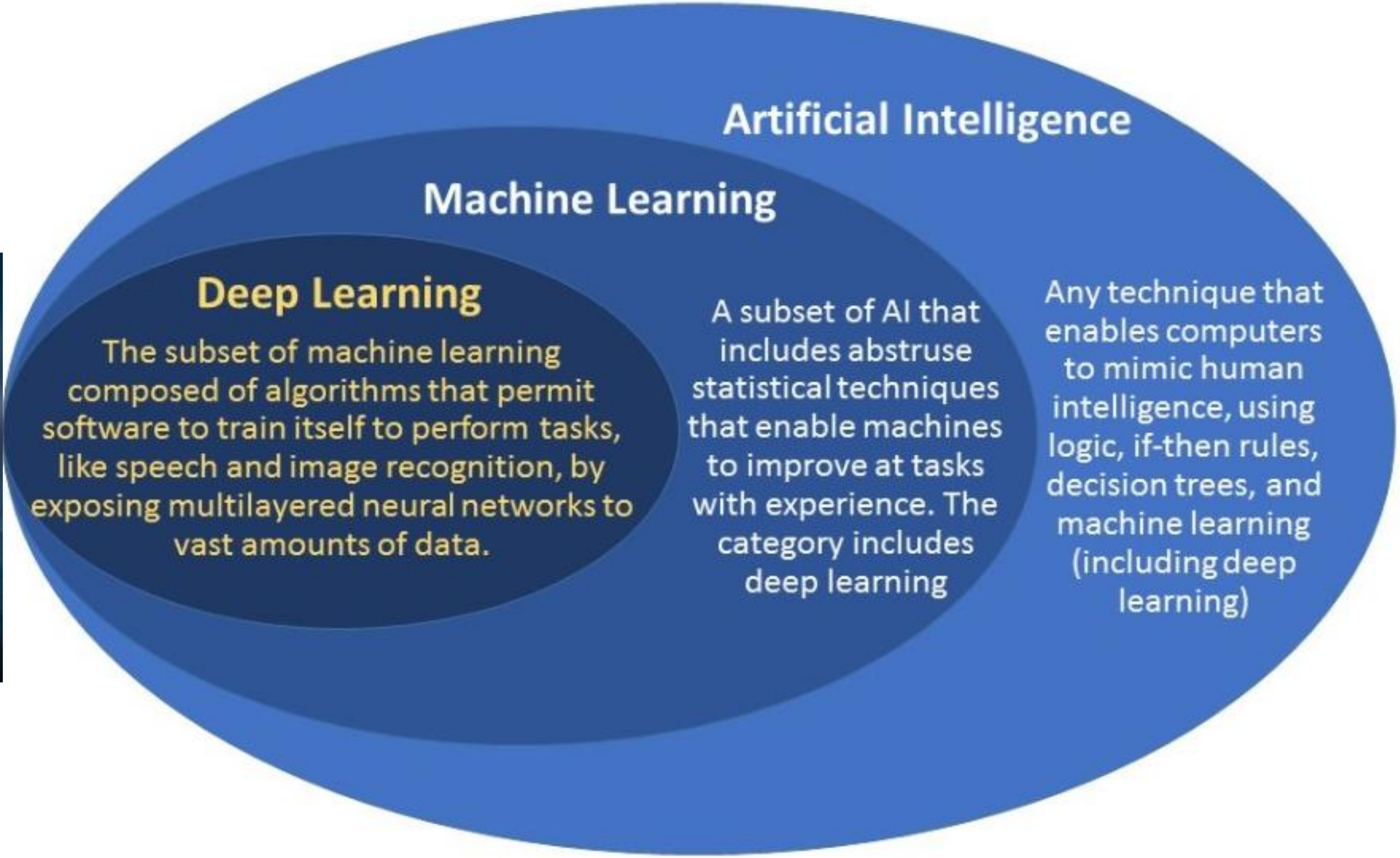


3. Allows combine evidence-based medicine with a personalized approach

4. Allows reduce bias and noise

Using artificial intelligence to analyse and predict susceptibility to antimicrobials





The Future Computed: Artificial by Microsoft Corporation
https://www.devacademy.es/

AI algorithms to predict antibiotic resistance

Table 1. Performance of machine learning across different studies in predicting antibiotic susceptibility patterns.

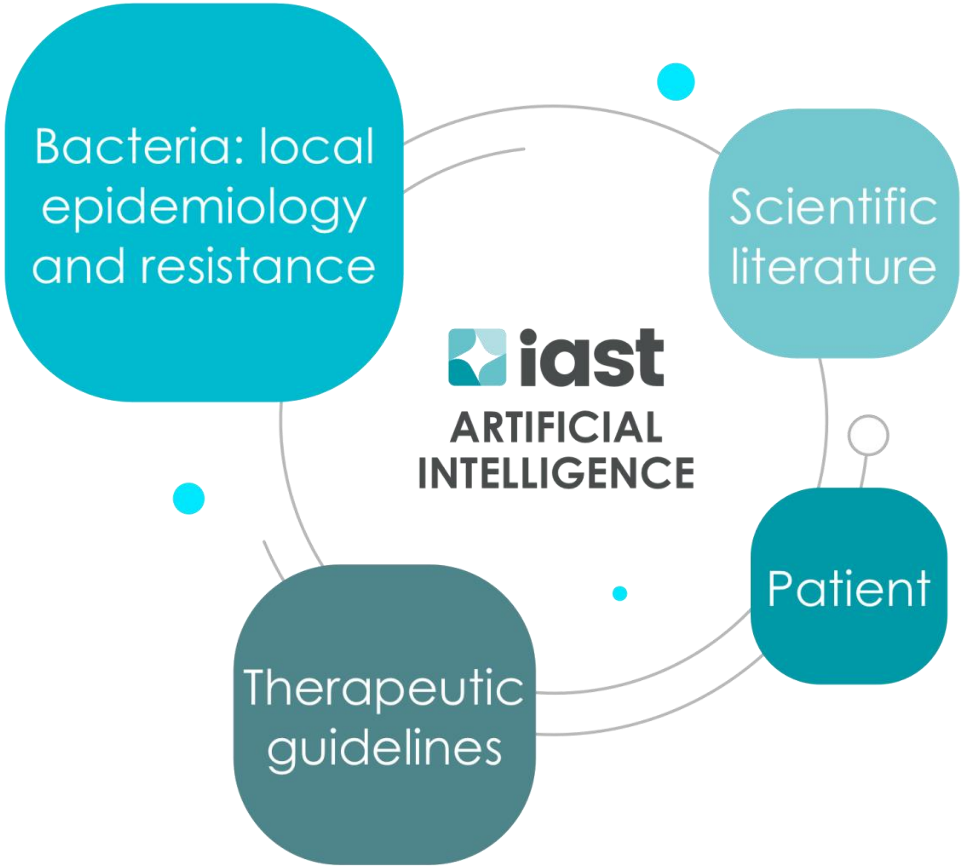
Authors	Year of Publication	Medical Setting	Geographical Setting	Input Data	ML Algorithms	Performance Evaluation	Bacterial Species
Goodman et al. [27]	2016	Hospital admissions	USA	Blood cultures/AST	Recursive partitioning, DT	PPV 0.908-NPV 0.919	*Escherichia coli, Klebsiella pneumoniae, Klebsiella oxytoca*
Vazquez-Guillamet et al. [29]	2017	Hospital admissions	USA	EHR data/Blood cultures/AST	Recursive partitioning, DT	AUC 0.61–0.80	GNB
Sousa et al. [28]	2019	Hospital admissions	Spain	Clinical/demographic data/Blood cultures/AST	DT	AUC 0.76	BL-GNB
Moran et al. [20]	2020	Hospital admissions and primary care	UK	Blood/urine cultures	XGBoost	AUC 0.70	*Escherichia coli, Klebsiella pneumoniae* and *Pseudomonas aeruginosa*
Feretzakis et al. [33]	2020	Medical wards	Greece	Demographics/Cultures/AST/Bacterial Gram stain/Type of sample	MLR	AUC 0.758	All isolated bacterial species
Feretzakis et al. [34]	2020	Intensive Care Unit	Greece	Demographics/Cultures/AST/Bacterial Gram stain/Type of sample	LR, RF, k-NN, J48, MLP	AUC 0.726	All isolated bacterial species
Feretzakis et al. [35]	2021	Intensive Care Unit	Greece	Demographics/Cultures/AST/Bacterial Gram stain/Type of sample	JRip, RF, MLP, Class. Regr, REPTree	F-measure 0.884, AUC 0.933	*Pseudomonas aeruginosa, Acinetobacter baumannii, Klebsiella pneumoniae*
Martínez-Agüero et al. [36]	2019	Intensive Care Unit	Spain	Demographics/Clinical data/Type of sample/Cultures/AST	LR, k-NN, DT, RF, MLP	Accuracy for quinolone resistance 88.1 ± 1.6	*Pseudomonas, Strenotrophomonas, Enterococcus*
McGuire et al. [5]	2021	Hospital admissions	USA	Demographic, medication, vital sign, laboratory, billing code, procedure, culture, and sensitivity data (67 features)	XGBoost	AUC 0.846	Bacterial isolates with CR
Pascual-Sánchez et al. [32]	2021	Intensive Care Unit	Spain	EHR data	LR, DT, RF, XGBoost, MLP	AUC 0.76	MDR bacteria
Garcia-Vidal et al. [31]	2021	FN Hematological Patients	Spain	EHR data	RF, GBM, XGBoost, GLM	AUC 0.79	MDR-*Pseudomonas aeruginosa*/ESBL-E
Henderson et al. [30]	2022	HIV patients	USA	EHR data	PLR, naïve Bayes, gradient boosting, SVM, RF	AUC 0.70	MDR-E

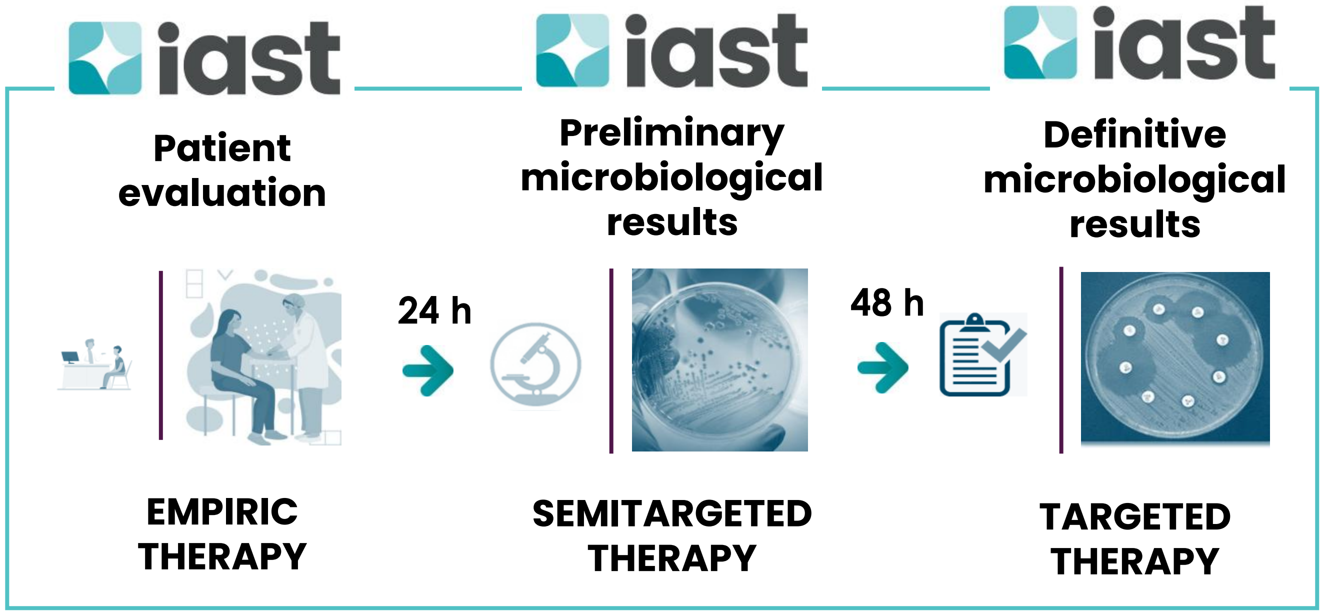
Sakagianni A, et al. Using Machine Learning to Predict Antimicrobial Resistance-A Literature Review. Antibiotics (Basel). 2023 Feb 24;12(3):452. doi: 10.3390/antibiotics12030452.

REVIVE by GARDP

Using artificial intelligence to analyse and predict susceptibility to antimicrobials

AI algorithms to predict antibiotic resistance: iAST® (Pragmatech AI Solutions)





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CE

iAST® is a class IIa medical device and is in the marketing approval phase by the AEMPS after a successful clinical trial

iAST® clinical evaluation

AMERICAN SOCIETY FOR MICROBIOLOGY | Antimicrobial Agents and Chemotherapy

ANTIMICROBIAL STEWARDSHIP
October 2024 Volume 68 Issue 10 e00777-24
https://doi.org/10.1128/aac.00777-24

Retrospective validation study of a machine learning-based software for empirical and organism-targeted antibiotic therapy selection

Maria Isabel Tejeda[1], **Javier Fernández**[2,3,4,5], **Pablo Valledor**[2], **Cristina Almirall**[6], **José Barberán**[1,7], **Santiago Romero-Brufau**[2,8,9]

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[6]Department of Laboratory Medicine, HM Hospitales, Madrid, Spain
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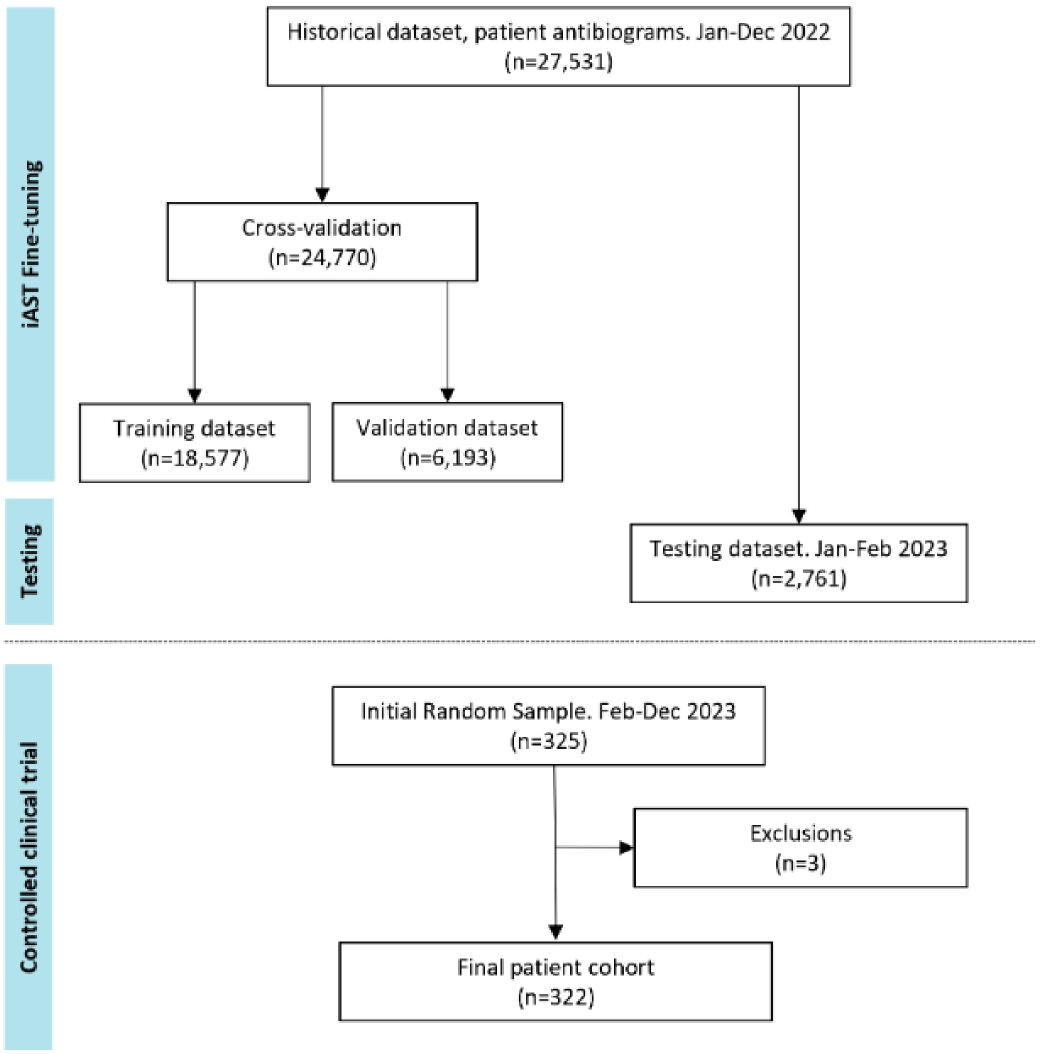
[8]Department of Otorhinolaryngology–Head & Neck Surgery, Mayo Clinic, Rochester, Minnesota, USA
[9]Department of Biostatistics, Harvard T.H. Chan School of Public Health, Harvard University, Boston, Massachusetts, USA

La AEMPS anuncia los ganadores de la IV edición de los premios del Plan Nacional frente a la Resistencia a los Antibióticos

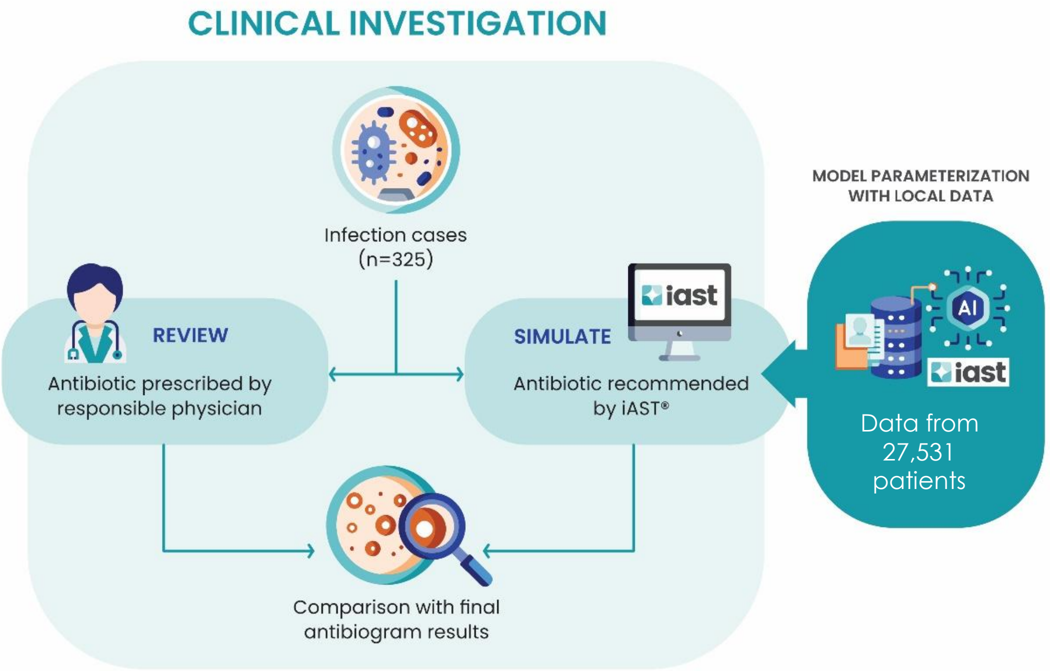
EVIAST Project: Clinical evaluation of iAST®, presented by Pragmatech AI Soluctions S.L., in the category of "Best initiative in surveillance and control of antibiotic consumption and resistance in the field of human health".

Tejeda MI, Fernández J, Valledor P, Almirall C, Barberán J, Romero-Brufau S. 0. Retrospective validation study of a machine learning-based software for empirical and organism-targeted antibiotic therapy selection. Antimicrob Agents Chemother 0:e00777-24. https://doi.org/10.1128/aac.00777-24

Using artificial intelligence to analyse and predict susceptibility to antimicrobials



iAST® clinical evaluation



Tejeda MI, Fernández J, Valledor P, Almirall C, Barberán J, Romero-Brufau S. 0. Retrospective validation study of a machine learning-based software for empirical and organism-targeted antibiotic therapy selection. Antimicrob Agents Chemother 0:e00777-24. https://doi.org/10.1128/aac.00777-24

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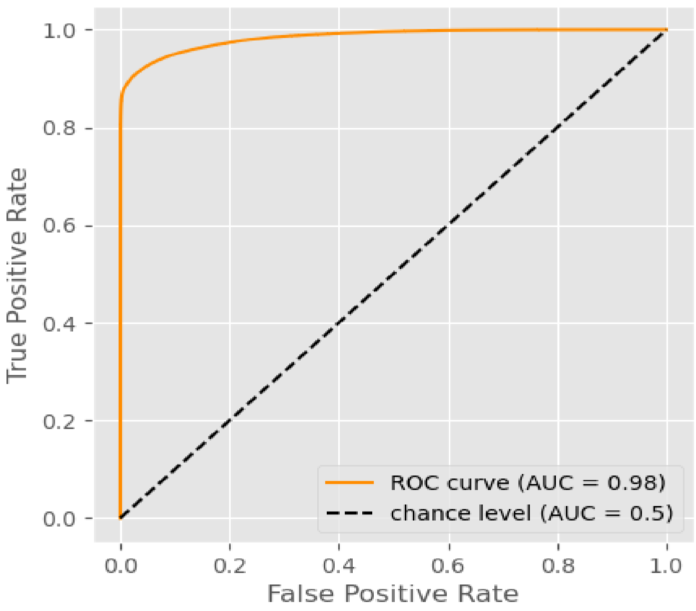
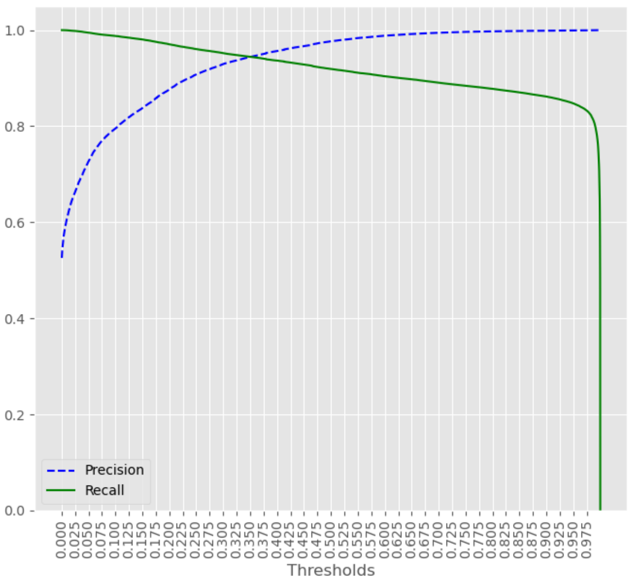
Using artificial intelligence to analyse and predict susceptibility to antimicrobials

iAST® model performance metrics





Validation dataset

- Precision: 97%
- Recall (sensitivity): 97%
- Log loss: 0.143

Testing dataset

- Precision: 97%
- Recall (sensitivity): 97%
- Log loss: 0.148

TABLE 1 Main features of patients and infections included in the study

Characteristic	Value
Age (mean)	68.87
Gender	
Female	136 (42.24)
Male	186 (57.76)
Hospital attention	
Emergency department (outpatients)	120 (37.27)
Hospitalization	202 (62.73)
Hospitalization ward	
Anesthesia/postoperative intensive care unit	1 (0.49)
Gastroenterology/general surgery	1 (0.49)
General intensive care unit	65 (32.18)
Hematology	1 (0.49)
Internal medicine/infectious diseases	129 (63.86)
Neurology/neurosurgery	2 (0.99)
Oncology	2 (0.99)
Orthopedics/traumatology	1 (0.49)
Type of infection	
Bacteremia/sepsis	93 (28.88)
Urinary tract infection	73 (22.67)
Complicated[a]	57 (78.08)
Uncomplicated[a]	16 (21.91)
Nosocomial lower respiratory infection	69 (21.43)
Pneumonia	52 (75.36)
Ventilator-associated pneumonia	38 (73.07)
No ventilator-associated pneumonia	14 (26.92)
Tracheobronchitis	17 (24.64)
Others[b]	87 (27.02)
Bone and joint infection	6 (6.89)
Gastrointestinal infection	7 (8.05)
Lower respiratory system infection[c]	2 (2.29)
Reproductive tract infection	2 (2.29)
Skin and soft tissue infection	42 (48.28)
Surgical site infection	28 (32.18)

Tejeda MI, Fernández J, Valledor P, Almirall C, Barberán J, Romero-Brufau S. 0. Retrospective validation study of a machine learning-based software for empirical and organism-targeted antibiotic therapy selection. Antimicrob Agents Chemother 0:e00777-24. https://doi.org/10.1128/aac.00777-24

Using artificial intelligence to analyse and predict susceptibility to antimicrobials

iAST® was shown to reduce overall medical errors in empirical treatment from 31.1% to 8.9%

Patients included
n=325

3 Screen failures[1]

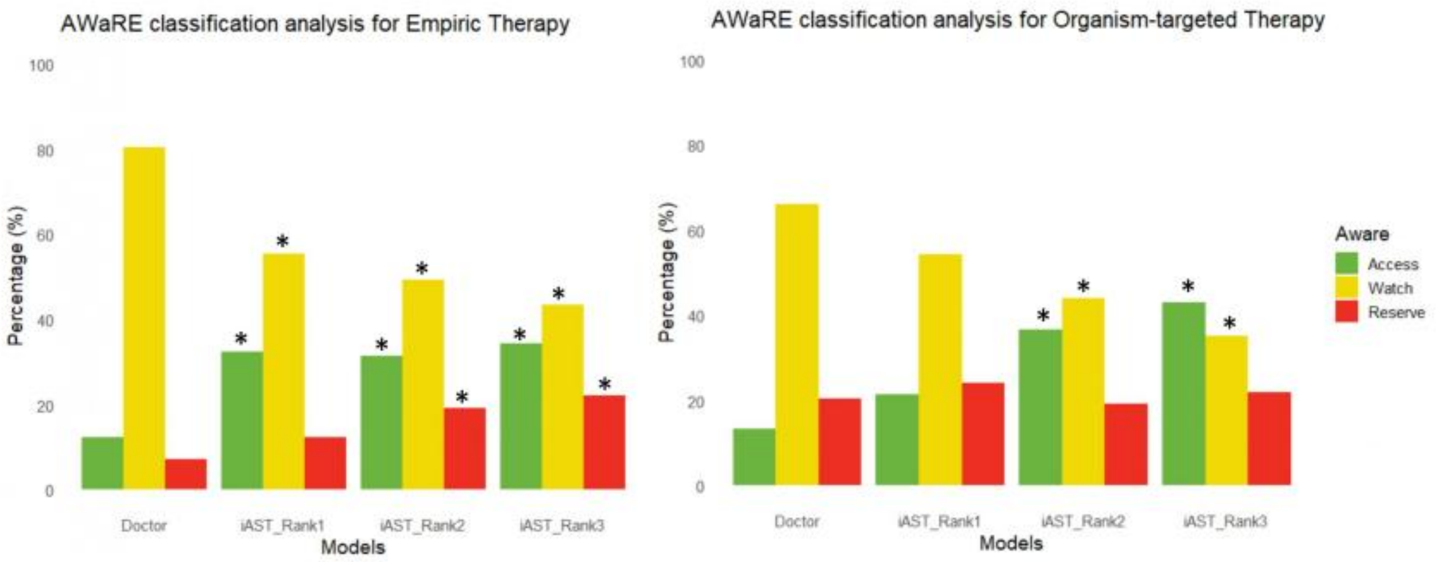
Site of infection	Bacteremia / Sepsis n = 93	Urinary tract infection n = 73	Pneumonia / VAT n = 69	Other infections[2] n = 87
Empiric therapy[3] achievement rate				
Doctor prescription	65 (69.9%)	56 (76.7%)	41 (59.4%)	--
1st iAST® choice	87 (93.5%) (p<0.001)	66 (90.4%) (p=0.044)	61 (88.4%) (p<0.001)	--
2nd iAST® choice	88 (94.6%) (p<0.001)	67 (91.8%) (p=0.023)	58 (84.1%) (p=0.002)	--
3rd iAST® choice	84 (90.3%) (p<0.001)	70 (95.9%) (p=0.002)	60 (87.0%) (p<0.001)	--
Semi-targeted therapy[4] achievement rate				
Doctor prescription	78 (83.9%)	65 (89.0%)	51 (73.9%)	77 (88.5%)
1st iAST® choice	90 (96.8%) (p=0.006)	71 (97.3%) (p=0.101)	68 (98.6%) (p<0.001)	87 (98.9%) (p=0.013)
2nd iAST® choice	88 (94.6%) (p=0.033)	68 (93.2%) (p=0.561)	63 (91.3%) (p=0.013)	84 (96.6%) (p=0.084)
3rd iAST® choice	82 (88.2%) (p=0.526)	67 (91.8%) (p=0.779)	62 (89.9%) (p=0.027)	82 (95.4%) (p=0.163)

The figure shows the percentages of success of the physicians and of iAST® (first three recommendations of the ranking) for each type of infection in empirical and semi-targeted treatment, with the difference being statistically significant (p<0.001) in most cases.

Tejeda MI, Fernández J, Valledor P, Almirall C, Barberán J, Romero-Brufau S. 0. Retrospective validation study of a machine learning-based software for empirical and organism-targeted antibiotic therapy selection. Antimicrob Agents Chemother 0:e00777-24. https://doi.org/10.1128/aac.00777-24

Using artificial intelligence to analyse and predict susceptibility to antimicrobials

THE 1ST OPTION OF IAST® **REDUCES THE WATCH FROM 80% TO 55% AND INCREASES ACCESS FROM 12% TO 32%**



Empirical Therapy (n=235[1])							
AWaRE	**Doctor**	**$iAST_1$**	**p-value**	**$iAST_2$**	**p-value**	**$iAST_3$**	**p-value**
Access	29 (12.3%)	76 (32.3%)	< 0.001	74 (31.5%)	< 0.001	81 (34.5%)	< 0.001
Watch	189 (80.4%)	130 (55.3%)	< 0.001	116 (49.4%)	< 0.001	102 (43.4%)	< 0.001
Reserve	17 (7.23%)	29 (12.3%)	0.077	45 (19.1%)	< 0.001	52 (22.1%)	< 0.001
Organism-targeted Therapy (n=322[1])							
AWaRE	**Doctor**	**$iAST_1$**	**p-value**	**$iAST_2$**	**p-value**	**$iAST_3$**	**p-value**
Access	43 (13.4%)	69 (21.4%)	0.014	118 (36.6%)	< 0.001	138 (43.0%)	< 0.001
Watch	213 (66.1%)	175 (54.3%)	0.054	142 (44.1%)	< 0.001	113 (35.2%)	< 0.001
Reserve	66 (20.5%)	78 (24.2%)	0.317	62 (19.3%)	0.724	70 (21.8%)	0.732

Tejeda MI, Fernández J, Valledor P, Almirall C, Barberán J, Romero-Brufau S. 0. Retrospective validation study of a machine learning-based software for empirical and organism-targeted antibiotic therapy selection. Antimicrob Agents Chemother 0:e00777-24. https://doi.org/10.1128/aac.00777-24

iAST® features

1. EMPIRIC ANTIBIOTIC THERAPY

2. SEMI-TARGETED ANTIBIOTIC THERAPY

3. PRESCRIPTION ALERTS

4. CUMULATIVE AST REPORTS

5. INCIDENCE DENSITY MDR BACTERIA

6. CONSUMPTION MONITORING (DDD)

7. CONSUMPTION MONITORING (DOT)

Conclusions

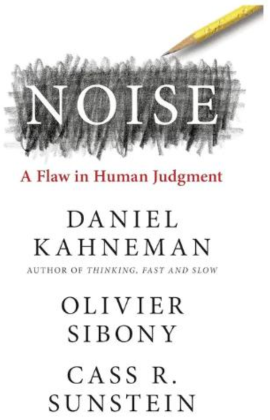
- The mathematical performance metrics of the iAST® model have exhibited robust values, surpassing those of any other published algorithm to date.
- Clinical research conducted has demonstrated that iAST ® can significantly mitigate physician errors in empirical and semi-targeted antibiotic therapy, while concurrently fostering antimicrobial stewardship.
- Reducing errors in early antibiotic therapy holds the potential for enhanced infection outcomes, cost savings within healthcare systems, and combating antibiotic resistance.
- Further prospective studies are warranted to corroborate iAST® performance across diverse epidemiological settings and to quantitatively assess its benefits.

Using artificial intelligence to analyse and predict susceptibility to antimicrobials

THANKS

Javier Fernández Domínguez, PharmD, PhD
Founder and coCEO, Pragmatech AI Solutions

pragmatech AI SOLUTIONS

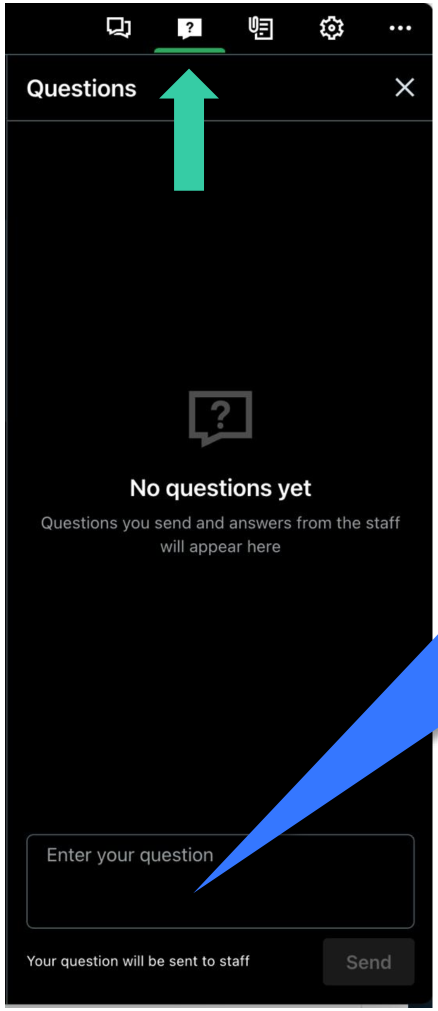


"Most people are surprised to learn that the accuracy of their predictive judgments is not only low, but also inferior to that of formulas. Even simple models built from limited data, or simple rules that can be written on a napkin, consistently outperform human judges. The fundamental advantage of rules and models is that they are noise-free. [...] It is difficult for us to imagine that simple rules applied in an almost automatic way are often more exact than we are."

Daniel Kahneman

How to submit your questions

If your question is addressed to a specific speaker, please include their name when submitting the question.



Please submit your questions through the box provided after clicking the 'questions' button. We will review all questions and respond to as many as possible after the presentation.

Today's speakers

Using artificial intelligence to analyse and predict susceptibility to antimicrobials

<u>Moderator:</u>
Margo Diricks
Postdoctoral researcher,
Research Center Borstel –
Leibniz Lung Center (Germany)

Adrian Egli
Director, Institute of
Medical Microbiology,
University of Zürich
(Switzerland)

Javier Fernández Domínguez
Co-founder and co-CEO,
Pragmatech AI Solutions
(Spain)

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2025 Antibacterial Therapeutics Funding Round

PACE | Pathways to Antimicrobial Clinical Efficacy

Up to £6m initially available to support up to eight projects

focused on developing new antibacterial treatments for the most threatening microbes and resistance mechanisms

Up to £1M per project & 2 years in length

Innovative, higher risk projects of smaller scales are highly encouraged to apply

Deadline for EoI submission: 23:59 (GMT) on 5 November

Aim to provide participants with funding and support that secures delivery of key data for onward development and investment

The portfolio will be actively managed. Projects will receive support and advice from the PACE team

Visit paceamr.org.uk/funding for full details of scope and to apply.

Thank you for joining us