

Integrating Electronic Health Records, Artificial Intelligence and 'Omics Technologies

The Future of Infection Prevention Surveillance?

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Alfred Hospital / Monash University

ACIPC 2024



Data as the new oil...



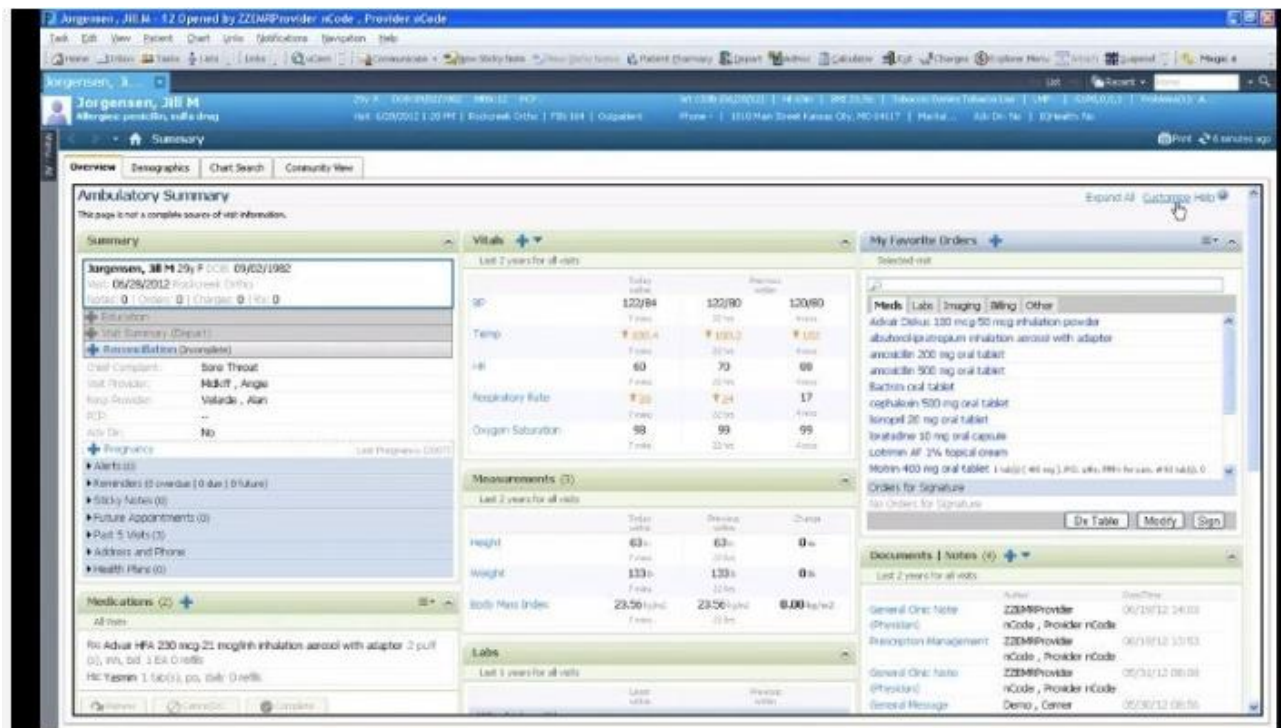
The Economist

Theresa May v Brussels
Ten years on: banking after the crisis
South Korea's unfinished revolution
Biology, but without the cells

MAY 6TH-12TH 2017

The world's most valuable resource

Data and the new rules of competition



Summary

Jorgensen, Jil M
DOB: 09/02/1982
Males

Vital	Value	Normal Range
SP	122/84	120/80
Temp	37.5	36.1 - 37.8
HR	60	50 - 90
Respiratory Rate	17	12 - 20
Oxygen Saturation	99	95 - 100

Measurement	Value	Change
Height	63 in	0 in
Weight	133 lb	0 lb
Body Mass Index	23.56	0.00

Medications (2)

- Ri-Advair HFA 250/500 21 mg/10 mg inhalation aerosol with adapter 2 puff QD, Inh, Inh 1 EA Q15D
- H2-Tagam 1.5000, po, bid, Q15D

Documents | Notes

Document Name	Author	Date/Time
General Clinic Note (Physician)	ZZEMProvider iCode , Provider iCode	06/15/12 14:00
Prescription Management	ZZEMProvider iCode , Provider iCode	06/15/12 13:13
General Clinic Note (Physician)	ZZEMProvider iCode , Provider iCode	05/23/12 08:08
General Message	Demo , Corner	05/03/12 08:56

Real-world data



Clinical

Demographics, EHR Data, Lab Test Results, Diagnoses, Procedures, Pathology/Histology Data, Radiology Images, Microbiology Data, Provider Notes, Admission/Discharge and Progress Reports, Performance Status



Medication

Medication Orders, Administration (Dose, Route, NDC/RxNorm codes), Concomitant Therapies, Point of Sale Data, (Prescription & OTC) Prescription Refill, Allergies



Claims

Medical Claims, Prescription Drug Claims, Other Drug and Treatment Use Data



Molecular Profiling

Genomic and Genetic Testing Data (SNPs/Panels), Multi-Omics Data (Proteomics, Transcriptomics, Metabonomics, Lipidomics), Other Biomarker Status



Family History

Historical Data on Health Conditions and Allergies Relating to Patient and Extended Family, Smoking Status, Alcohol Use



Mobile Health

Fitness Trackers, Wearable Devices, Other Health Apps Measuring Activity and Body Function



Environmental

Climate Factors, Pollutants, Infections, Lifestyle Factors (diets, stress), Other Environmental and Occupational Sources



Patient Reported

Patient Reported Outcomes, Surveys, Diaries (diets, habits), Personal Health Records, Adverse Event Reporting, Quality of Life Measures



Social Media

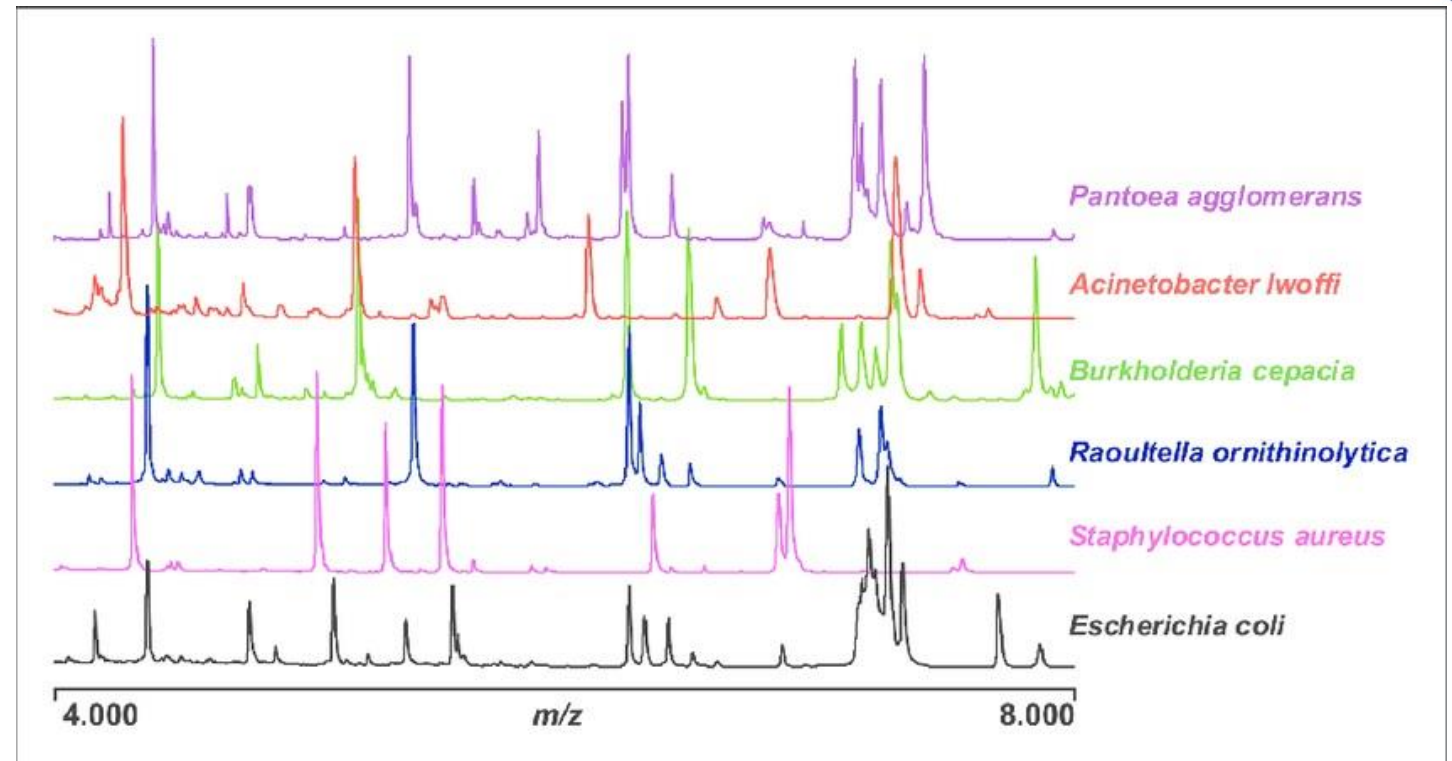
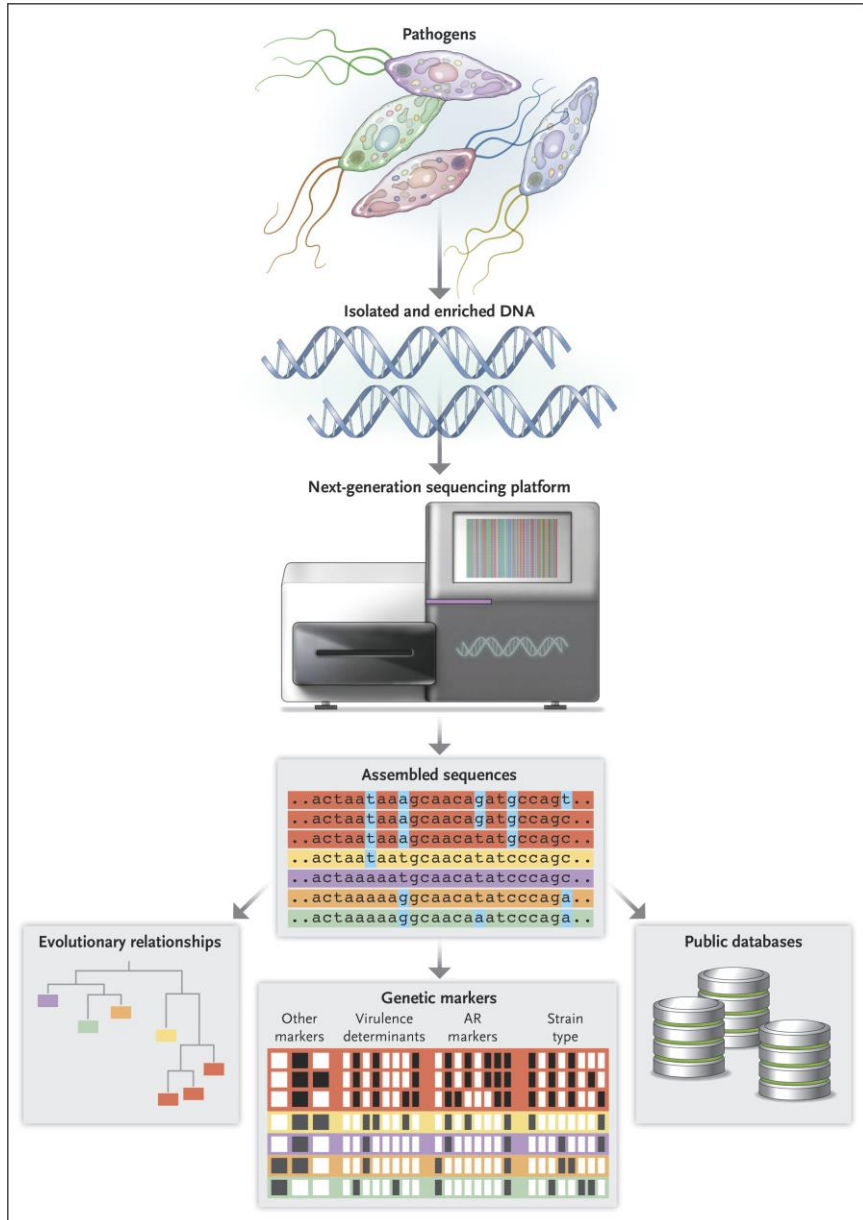
Patient Communities, Twitter, Facebook, Blogs



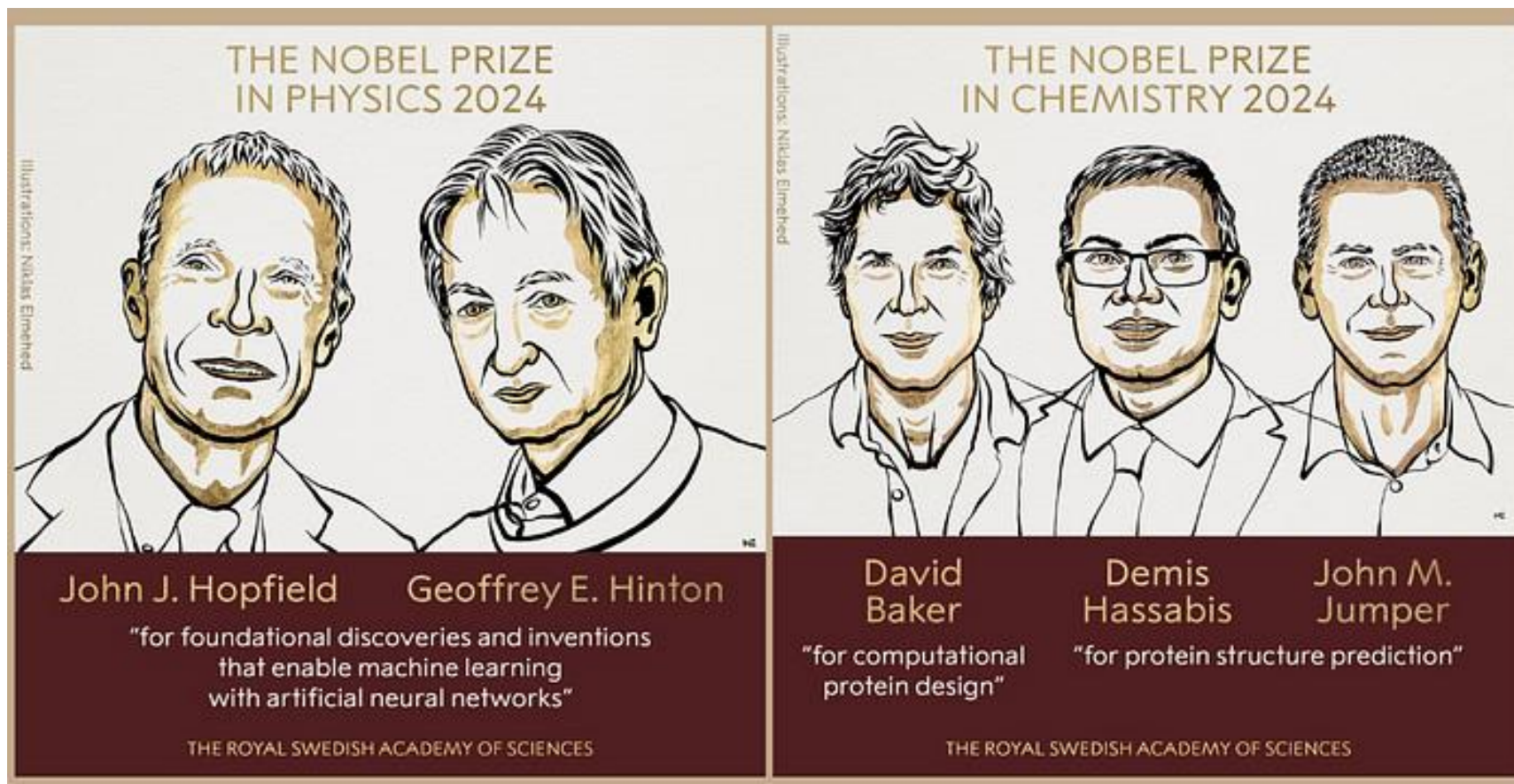
Literature

Disease Burden, Clinical Characteristics, Prevalence/Incidence, Rates of Treatment, Resource Use and Costs, Disease Control, Quality of Life Measures

The arrival of new technologies...

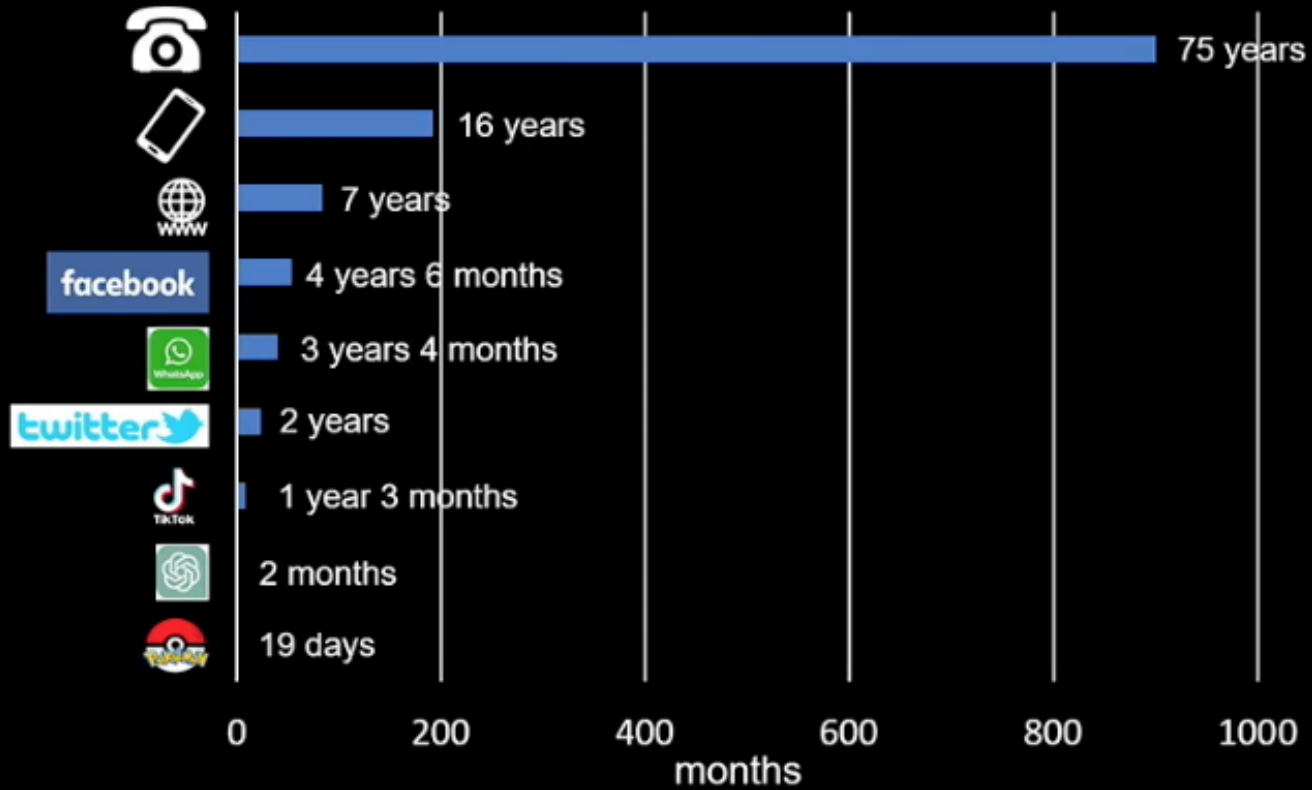


AI reaching prime time?

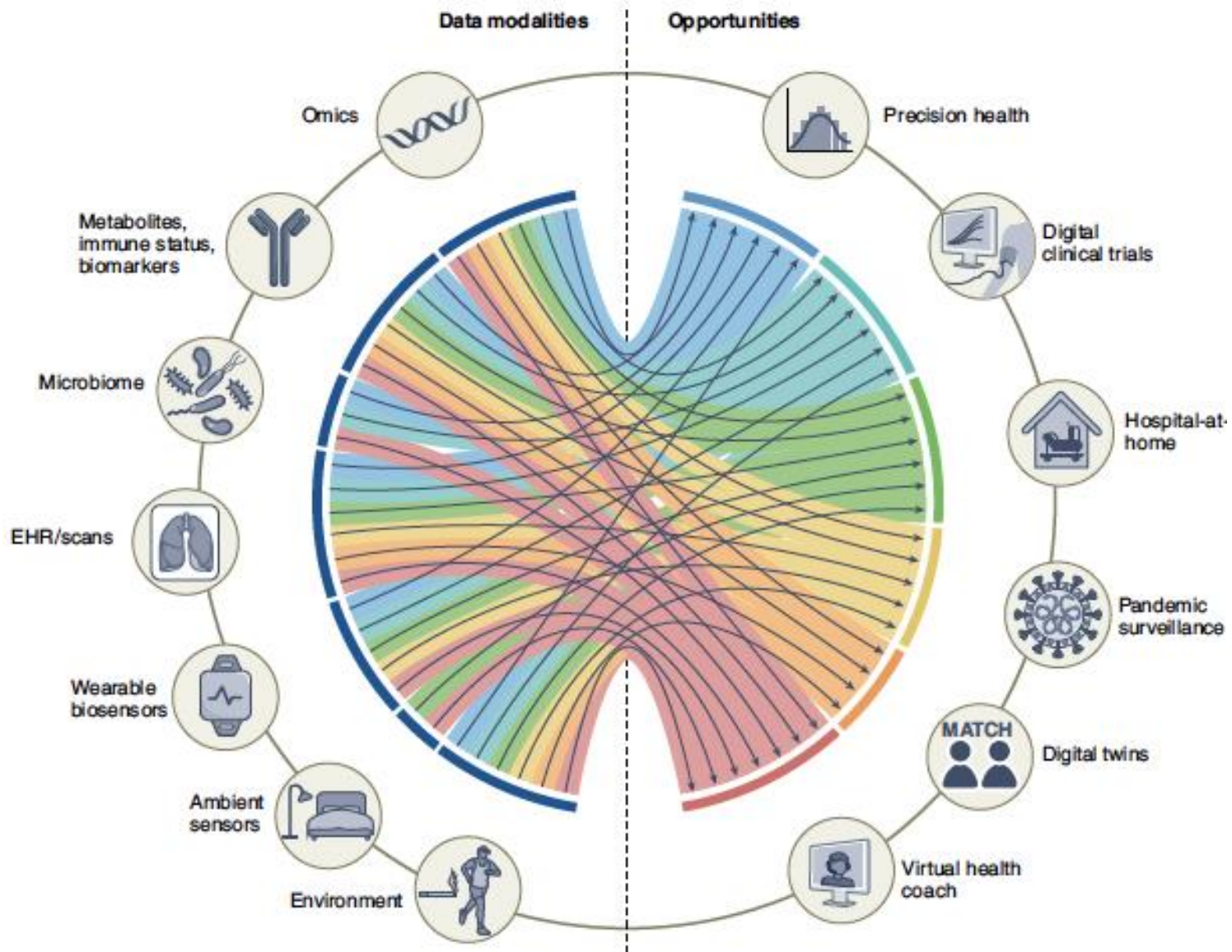


The arrival of AI

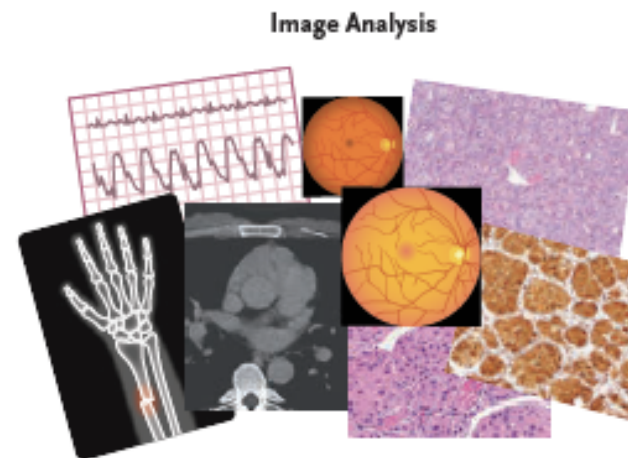
Time to reach 100 million users



Multi-modal AI



Potential applications in healthcare



Clinical-Trial Performance

- Decision support in trial design
- Patient identification, recruitment, and retainment
- Outcome and side-effect monitoring



Retrieval of Medical Information

- Use of multiple information sources about a patient to make a diagnosis
- Internet search engines
- EMR decision support



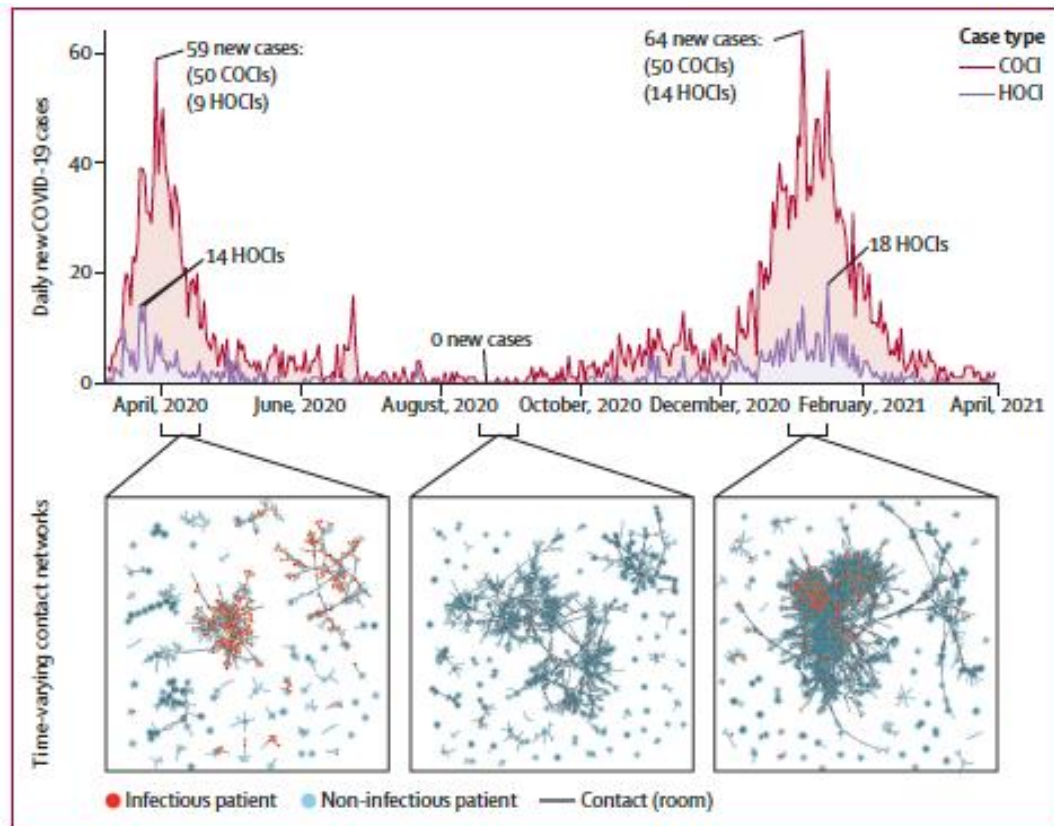
Operational Organization

- Operating-room scheduling
- Billing and collections
- Patient follow-up



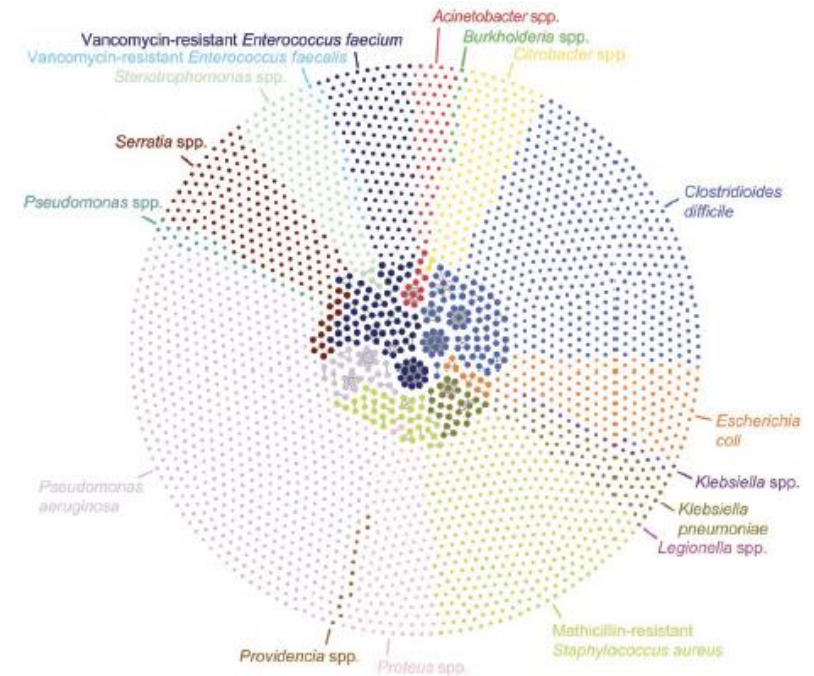
Prediction of hospital-onset COVID-19 infections using dynamic networks of patient contact: an international retrospective cohort study

Ashleigh Myall, James R Price, Robert L Peach, Mohamed Abbas, Sid Mookerjee, Nina Zhu, Isa Ahmad, Damien Ming, Farzan Ramzan, Daniel Teixeira, Christophe Graf, Andrea Y Weifse, Stephan Harbarth, Alison Holmes, Mauricio Barahona



Whole-Genome Sequencing Surveillance and Machine Learning of the Electronic Health Record for Enhanced Healthcare Outbreak Detection

Alexander J. Sundermann,^{1,2,3} Jieshi Chen,⁴ Praveen Kumar,⁵ Ashley M. Ayres,⁶ Shu-Ting Cho,² Chinelo Ezeonwuka,^{1,2} Marissa P. Griffith,^{1,2} James K. Miller,⁴ Mustapha M. Mustapha,^{1,2} A. William Pasculle,⁷ Melissa I. Saul,⁸ Kathleen A. Shutt,^{1,2} Vatsala Srinivasa,^{1,2} Kady Waggle,^{1,2} Daniel J. Snyder,⁹ Vaughn S. Cooper,⁹ Daria Van Tyne,² Graham M. Snyder,^{2,6} Jane W. Marsh,^{1,2} Artur Dubrawski,⁴ Mark S. Roberts,^{5,8} and Lee H. Harrison,^{1,2,3}



Myall et al. Lancet Digit Health. 2022 Aug;4(8):e573-e583. doi: 10.1016/S2589-7500(22)00093-0.

Sundermann et al. Clin Infect Dis. 2022 Aug 31;75(3):476-482. doi: 10.1093/cid/ciab946.

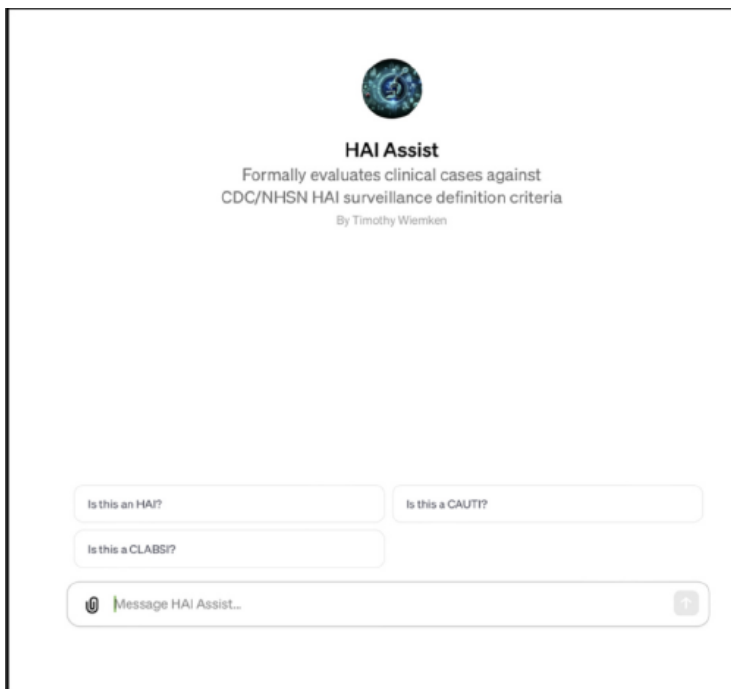
Major Article


Assisting the infection preventionist: Use of artificial intelligence for health care–associated infection surveillance

Timothy L. Wiemken PhD, MPH^{a,*}, Ruth M. Carrico PhD DNP^b

^a Saint Louis University School of Medicine, Department of Medicine, Division of Infectious Diseases Allergy & Immunology, Saint Louis, MO

^b Department of Medicine, Division of Infectious Diseases, University of Louisville School of Medicine, Louisville, KY



 **You**
Is this a CLABSI?

On March 2, 2023 Mrs. Dis N. Fect is admitted to the medical unit with severe abdominal pain and fever. On March 4, 2023 white blood count (WBC) increased and chills were documented. On March 4, 2023 patient had central line placed and blood specimens were collected, Staphylococcus aureus x1 identified. No other source of infection is identified.

 **HAI Assist**

To determine if Mrs. Dis N. Fect's case is a Central Line-Associated Bloodstream Infection (CLABSI), we must consider the CDC's NHSN surveillance definitions and criteria as detailed in my knowledge source. Here's the analysis:

1. Timeline of Events:

- **March 2, 2023:** Admission with severe abdominal pain and fever.
- **March 4, 2023:** WBC increased, chills documented, central line placed, and blood specimens collected revealing Staphylococcus aureus.

2. CLABSI Criteria Assessment:

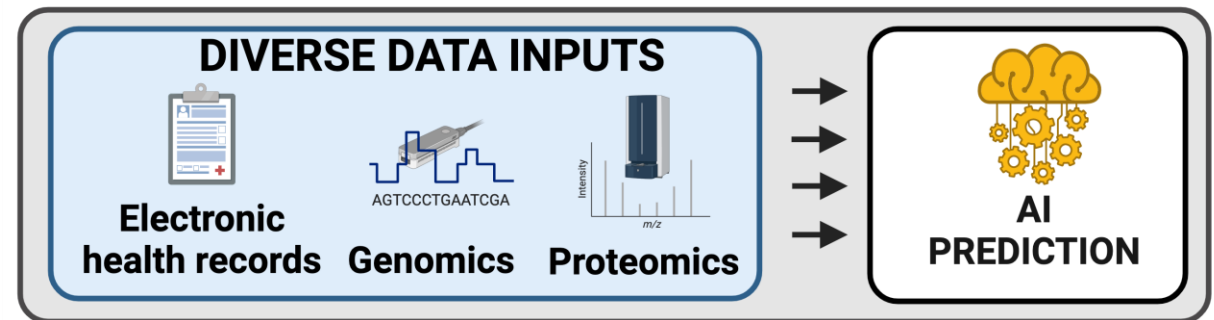
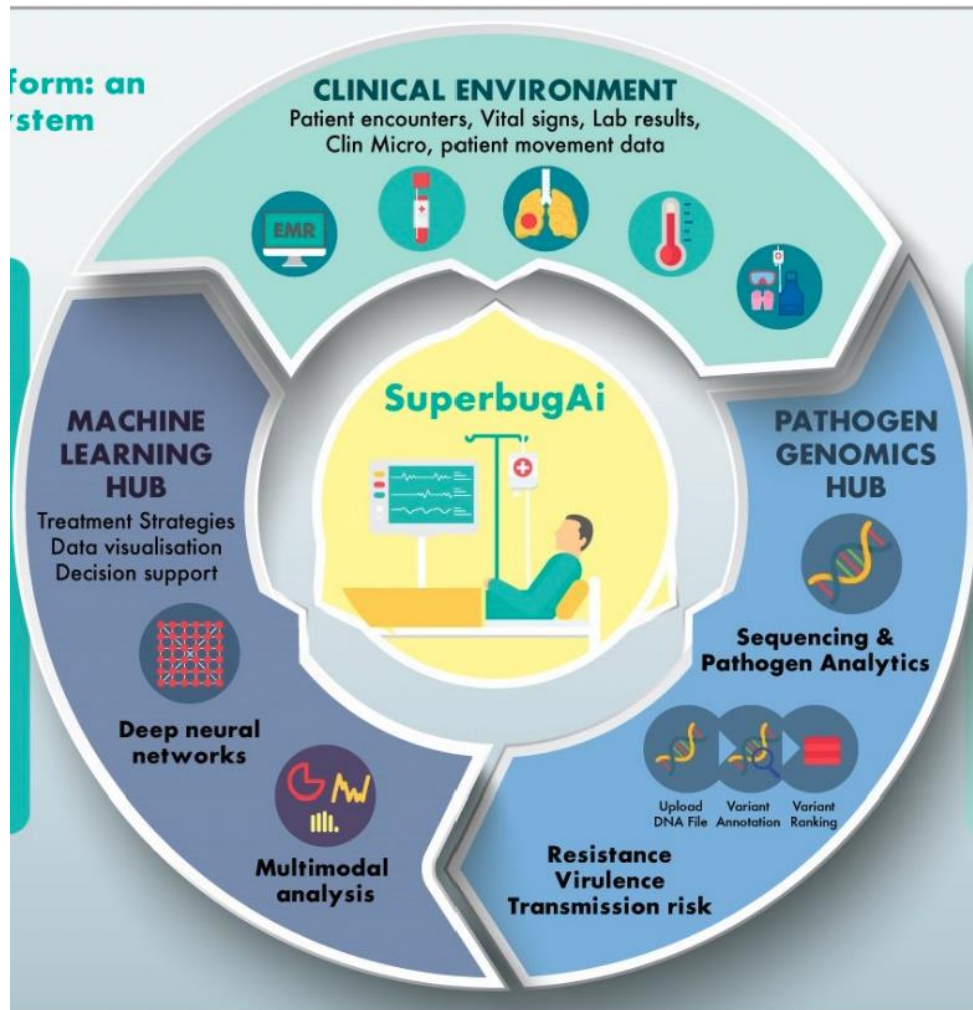
- **Presence of a Central Line:** A central line was placed on March 4, 2023.
- **Laboratory Confirmed Bloodstream Infection (LCBI):** The identification of Staphylococcus aureus from blood specimens meets the criteria for LCBI.
- **Timing of Central Line Placement:** For a CLABSI, the central line must be in place for at least 2 calendar days on the date of the event (date of first positive blood specimen for LCBI). In this case, the central line was placed on the same day as the blood specimen collection, which does not meet the 2-day requirement.

3. Conclusion:

- Based on the provided information, Mrs. Dis N. Fect's case does not meet the definition of a CLABSI as per CDC's NHSN surveillance criteria. The central line was not in place for at least 2 calendar days before the collection of the blood specimen that identified Staphylococcus aureus.

Therefore, this case cannot be classified as a CLABSI.

The SuperbugAI project overview



Theme 1:
AMR Diagnosis and Treatment



Theme 2:
Infection Prevention



Grappling with EHR data

Challenges



Data Volume and Variety



Data Quality



Privacy and Security



Interoperability

Opportunities

Population Health Management



Predictive Analytics



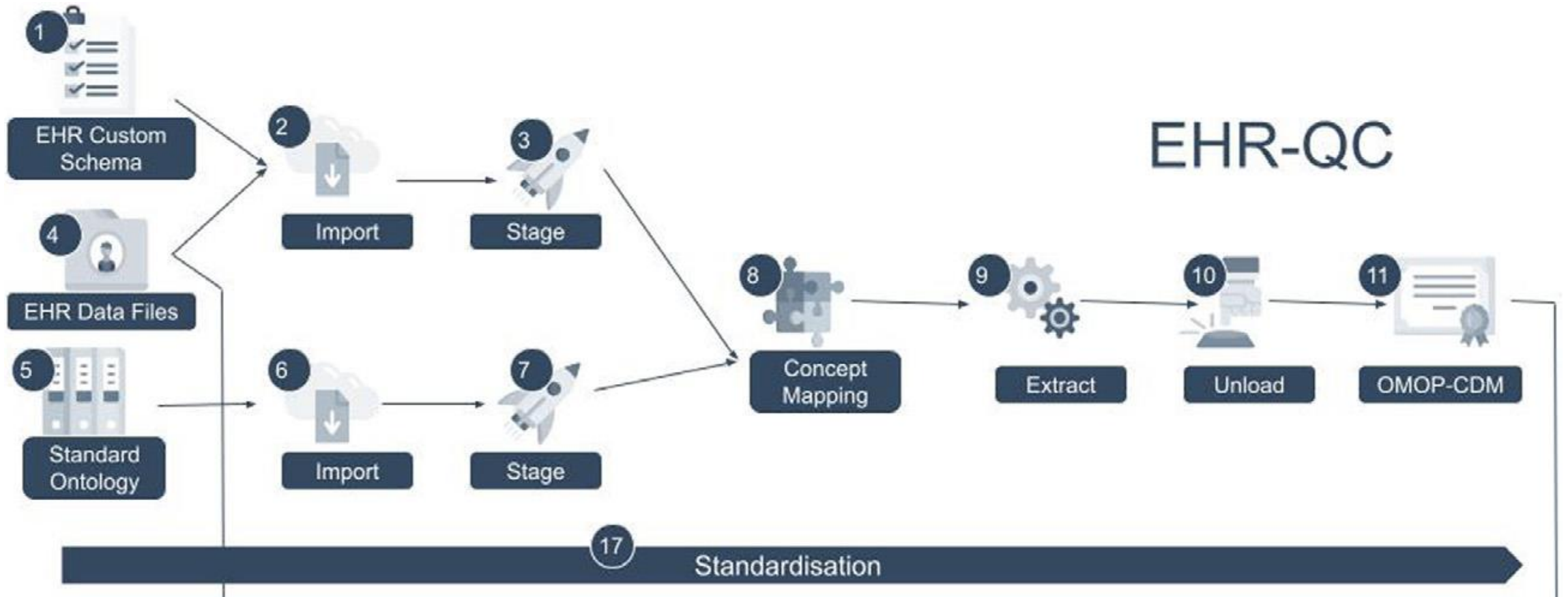
Personalized Medicine



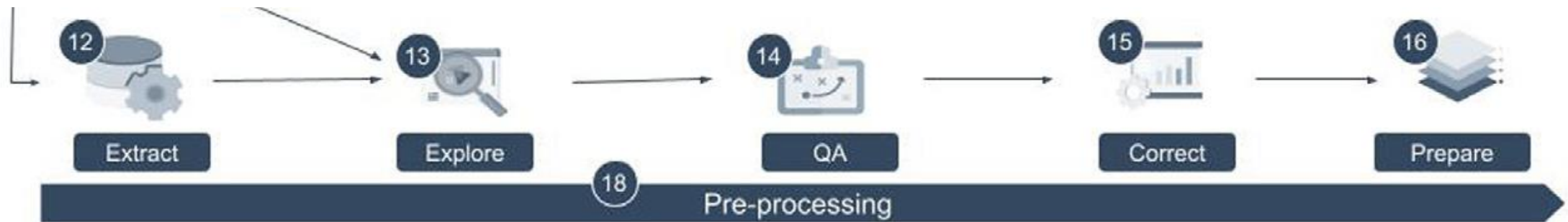
Drug Discovery



AI Digital Health Toolbox - Data processing



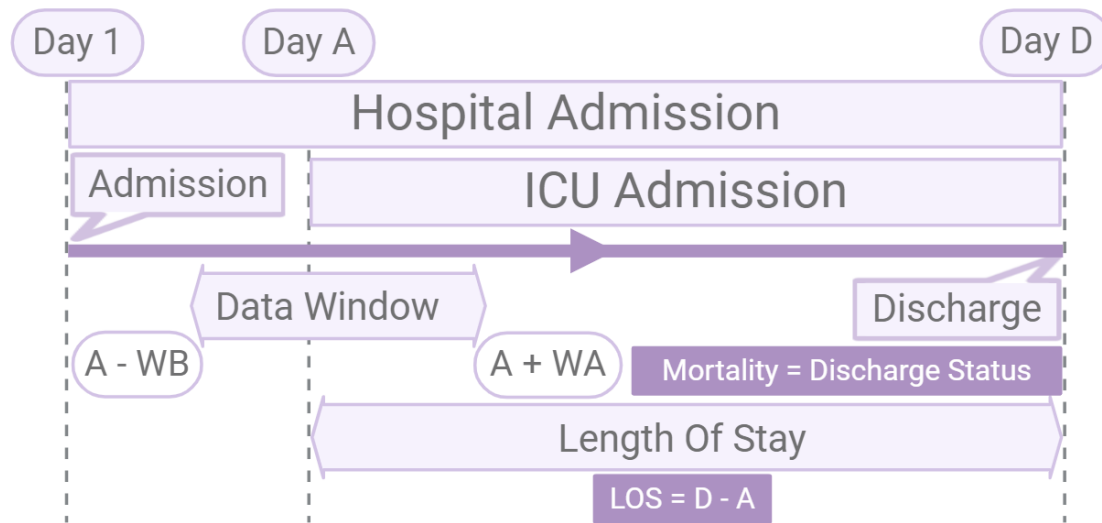
AI Digital Health Toolbox - Data processing



AI Digital Health Toolbox – Applying AI

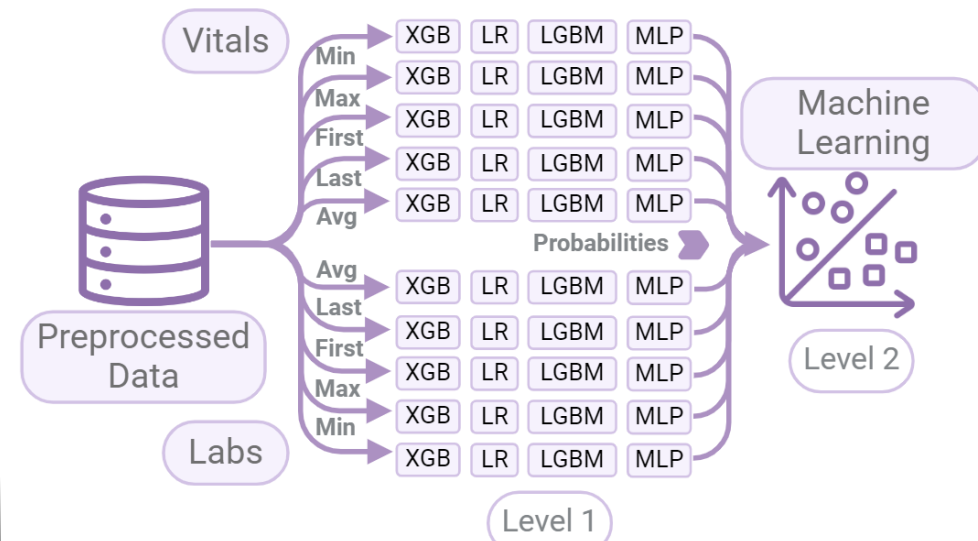
EHR-ML

Design Parameters



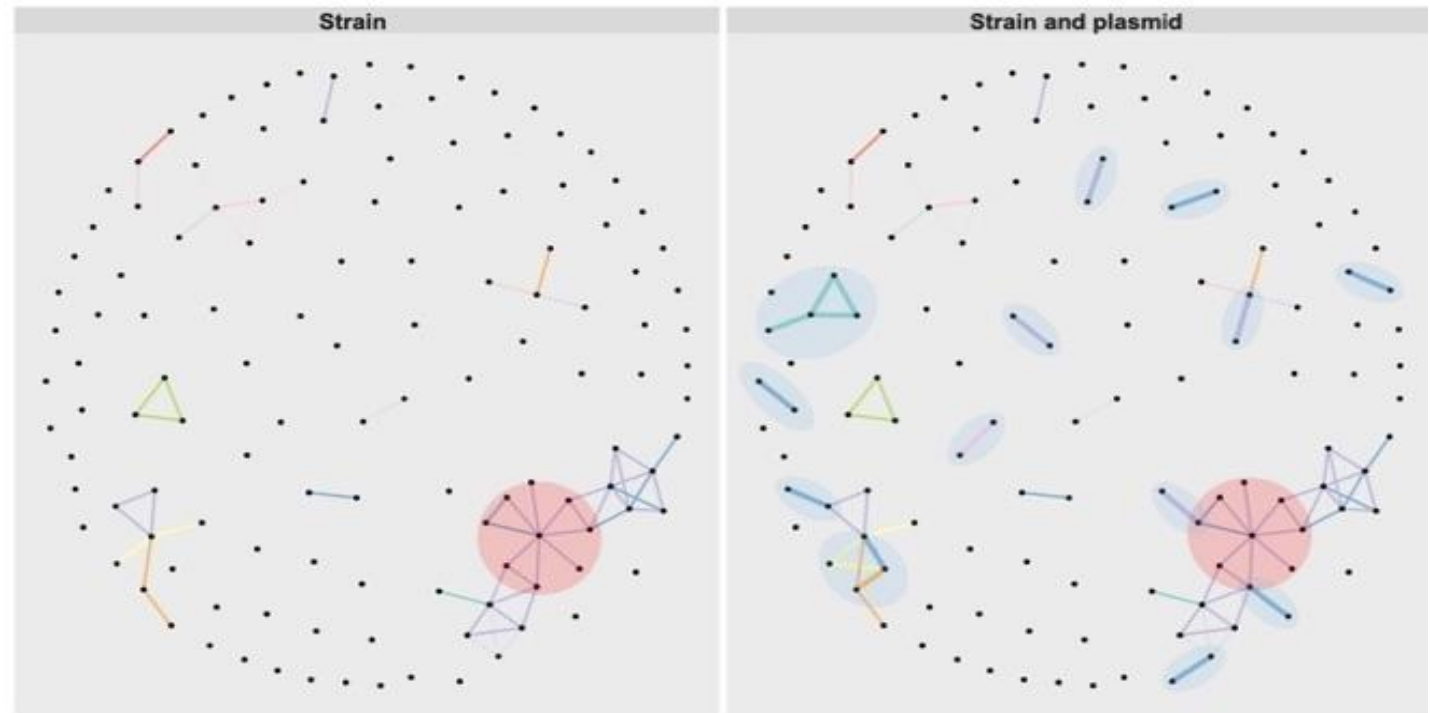
A) Patient timeline

Machine Learning

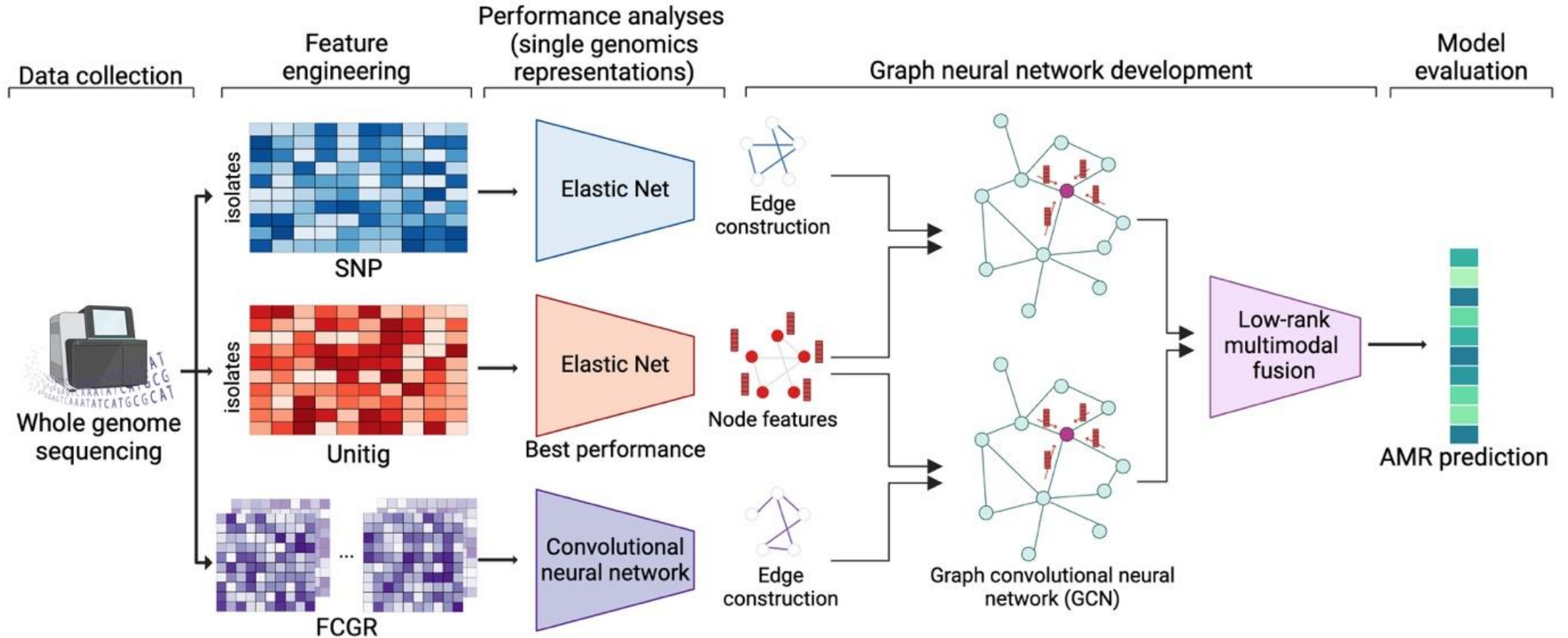


B) Ensemble Architecture

Genomics for hospital outbreak detection

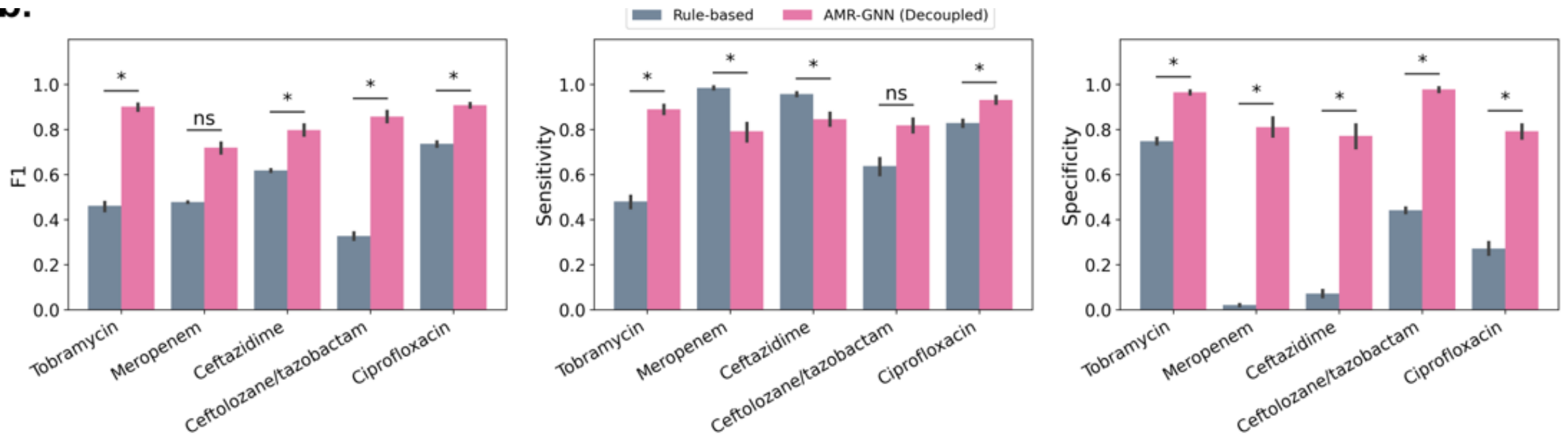


Working with genomic data

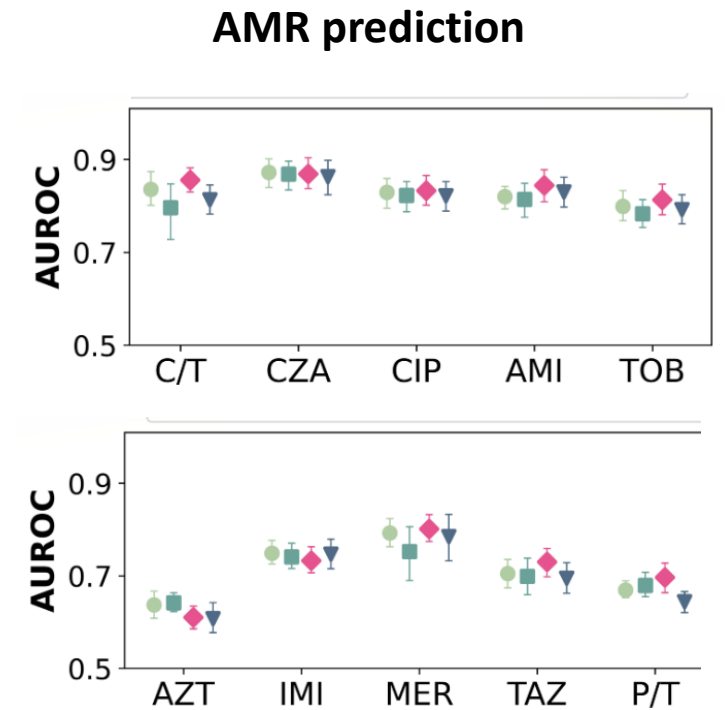
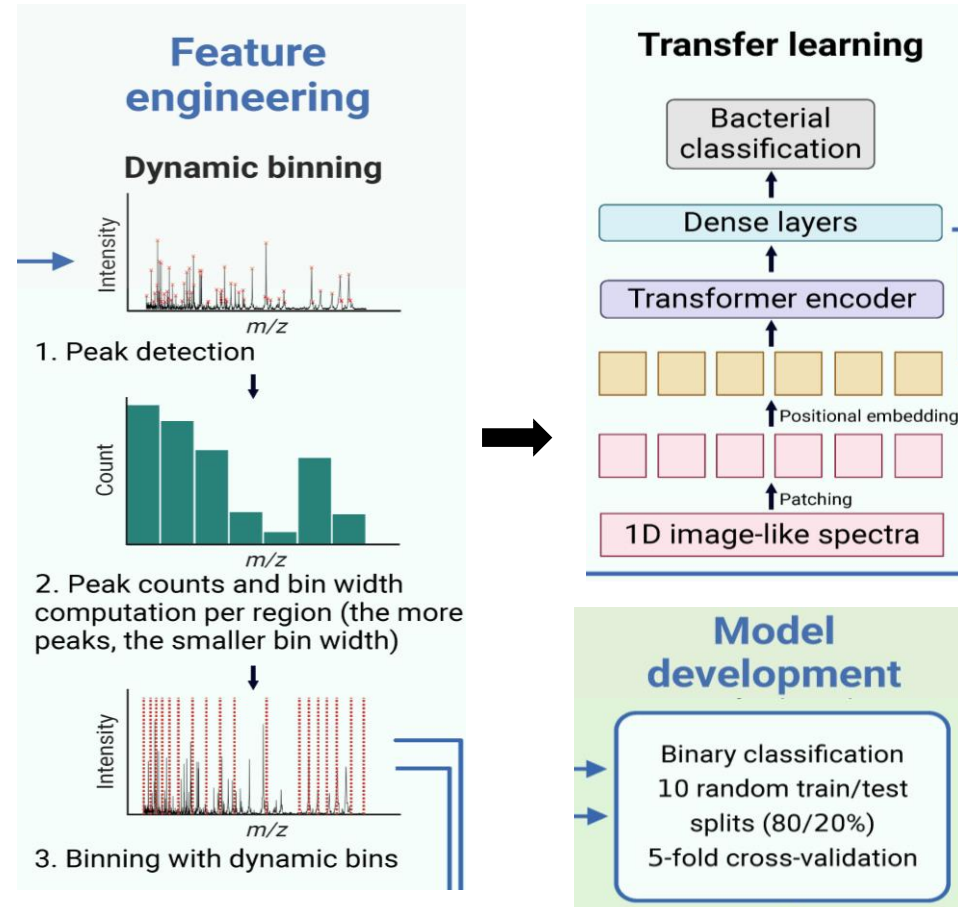
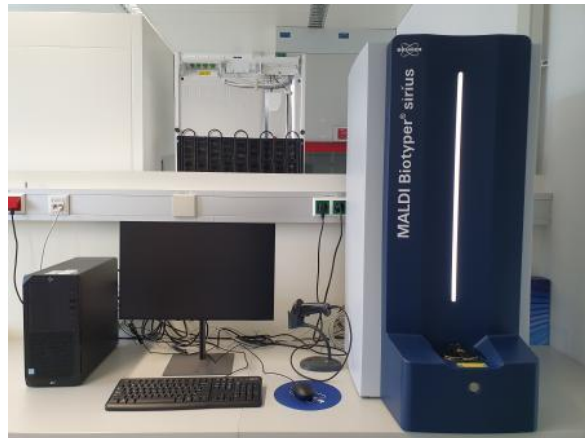


Genomic data for AI AMR prediction

2.

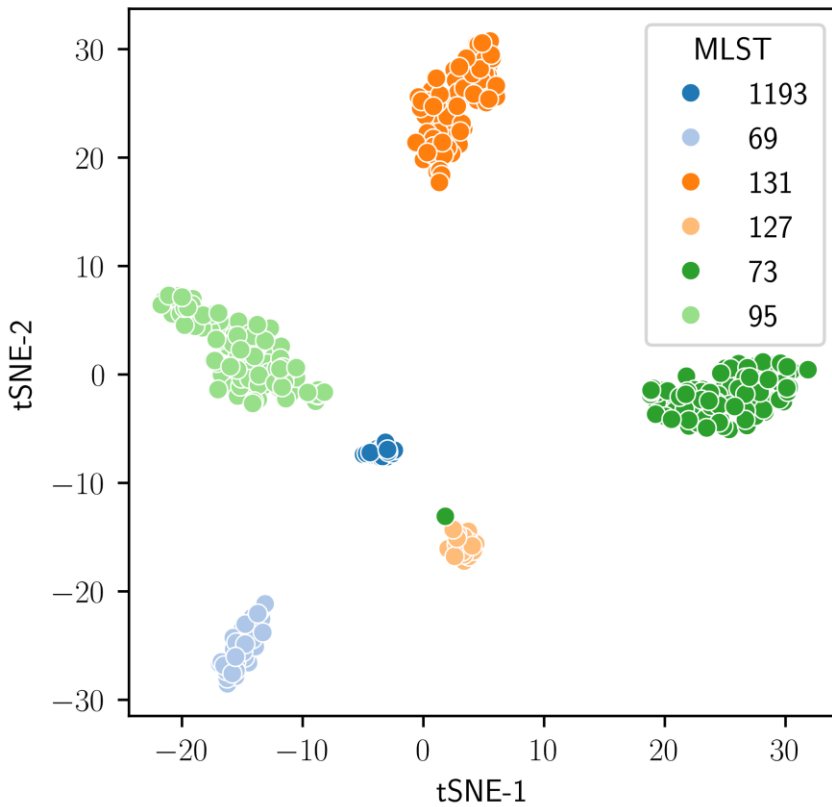


AI and MALDI-TOF for AMR prediction

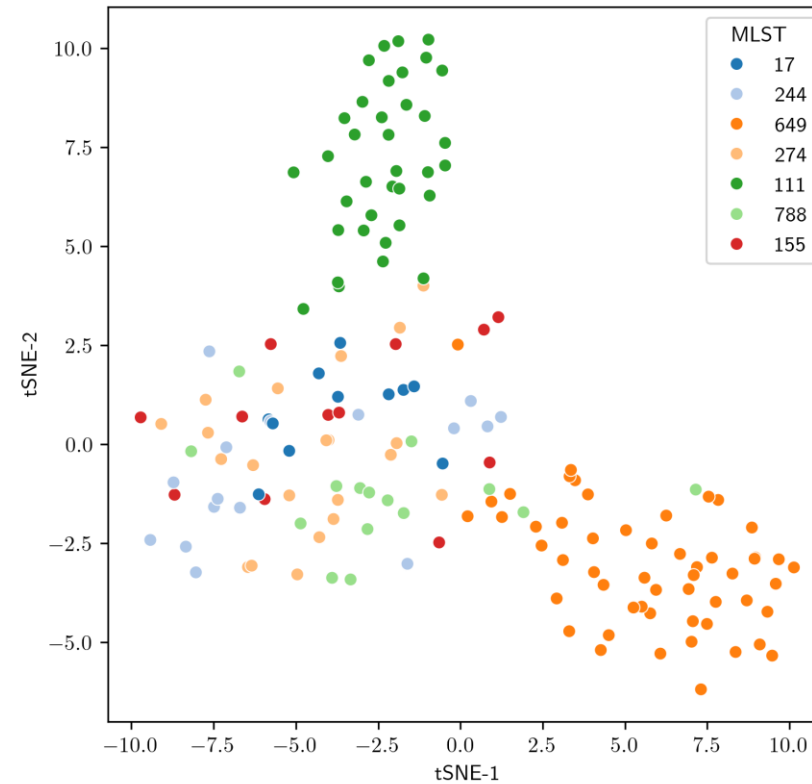


AI and MALDI-TOF for strain typing

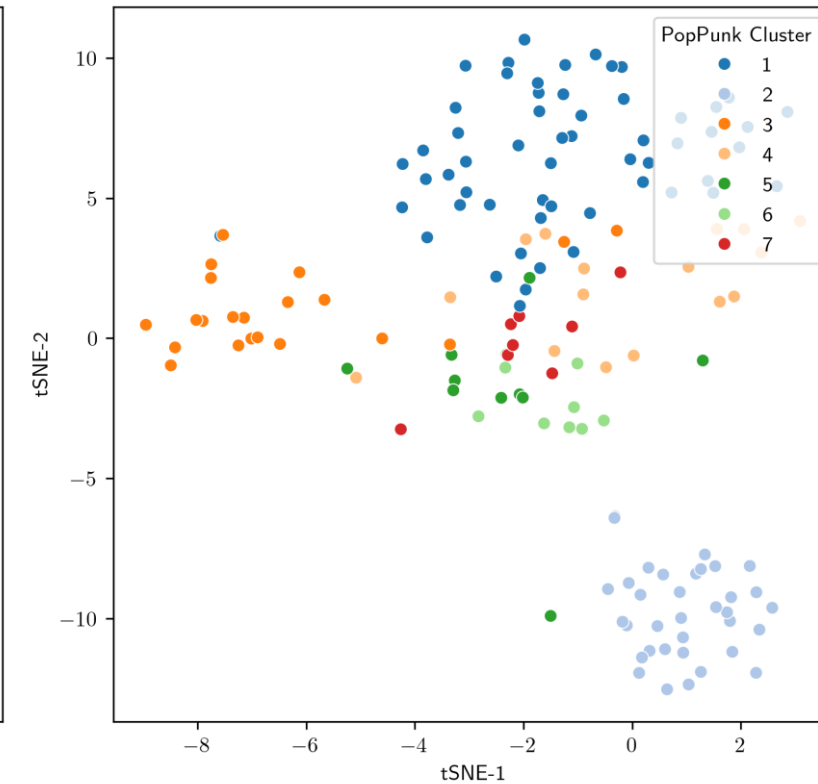
E. coli and MLST



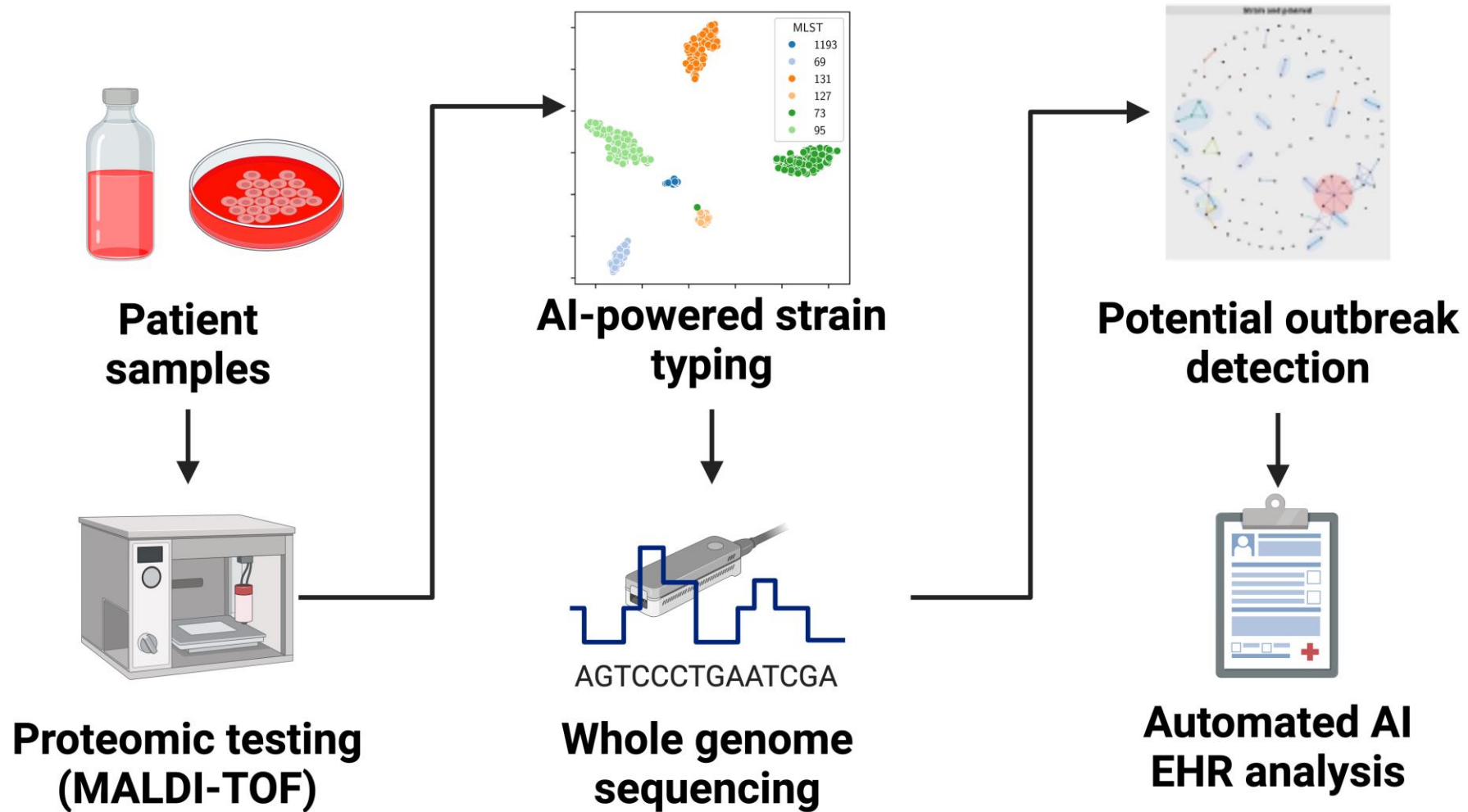
P. aeruginosa and MLST



P. aeruginosa and high-resolution genomic strain typing



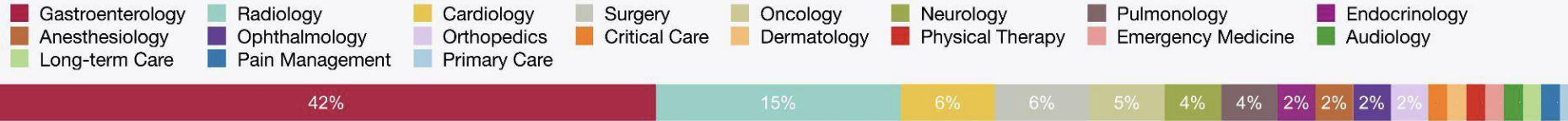
Automated AI surveillance platform



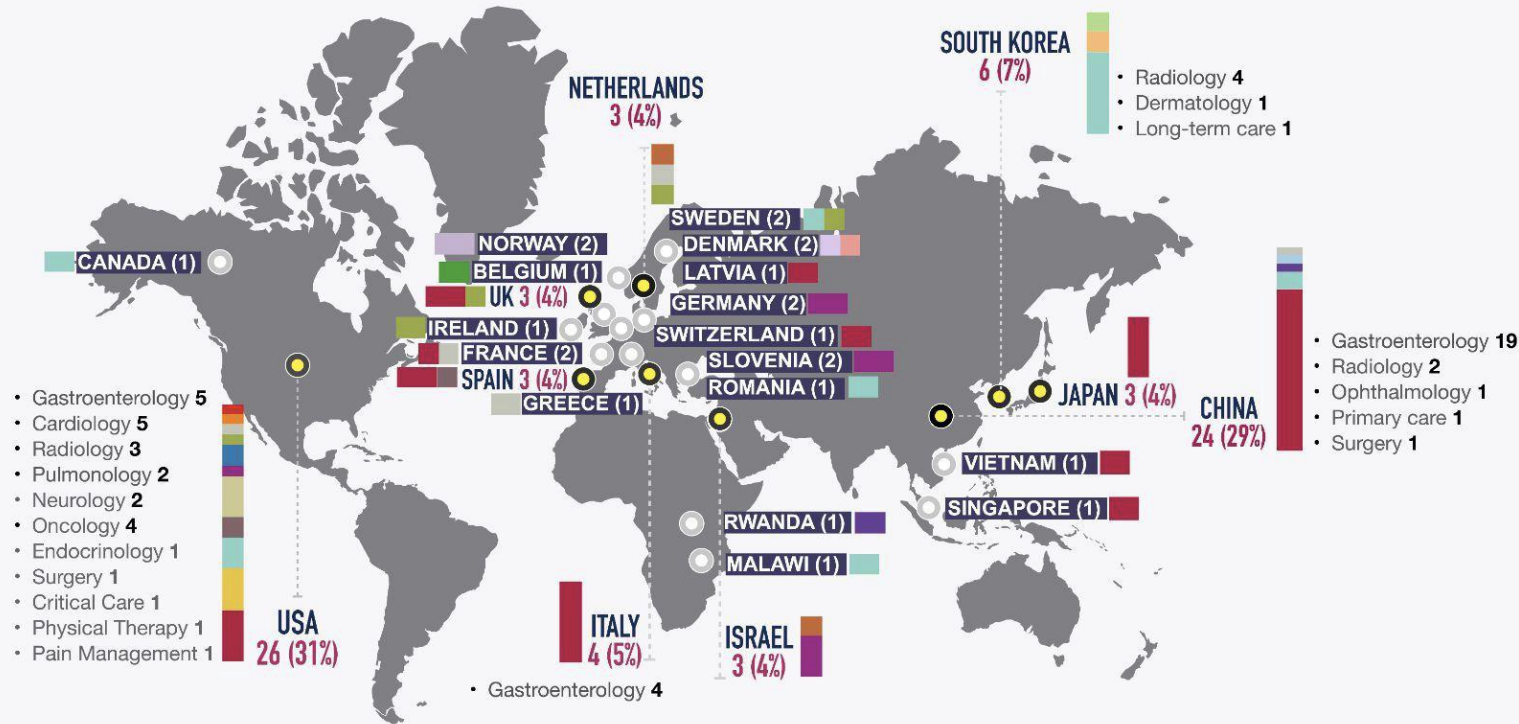
The AI evidence gap



Overall Distribution



Country-level Distribution



Challenges in AI implementation



Myth	Reality
More data means better AI models	Although adequate data volume is important for developing an accurate AI model, data and label quality matters more ³ , especially as the quantity becomes less critical as AI advances ^{12,18} .
Only AI experts are needed	Although AI experts are core contributors in developing medical AI models, building a complete, well-functioning AI system takes a village of multidisciplinary team members.
AI performance leads to clinical confidence	Building users' confidence in using medical AI takes time and careful validations.
Integrating AI into routine workflows is straightforward	AI should be designed around humans, not the other way around.
Launch means success	Ensure AI's high-quality performance through continuous monitoring and iterations.

Acknowledgments



SuperbugAI team

- Dr. Andy Nguyen
- Yashpal Ramakrishnaiah
- A/Prof. Sonika Tyagi
- Dr. Jess Wisniewski
- Dr. Jane Hawkey

- Prof. Anton Peleg



Funders

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- NHMRC Emerging Leader 1 Fellowship APP1176324 to N.M.
- NHMRC Practitioner Fellowship APP1117940 to A.Y.P.

Questions?



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