Artificial Intelligence in Pediatric Medicine:
Prediction, Prevention, Personalization

Shelby Kutty, MD, PhD, MHCM, FRCP
The Helen B. Taussig Professor
Chair, Cardiovascular Analytic Intelligence (CVAi^2)

DISCLOSURES

Grants: National Institutes of Health NIH

Research Support: Microsoft

Consultant: GE Lantheus

I will be discussing off-label uses of medical devices

Artificial Intelligence in Pediatric Medicine: Outline

Rationale for AI	Definitions	Medically Useful ML Algorithms	Examples	Personalizing Pediatrics	Implementational Challenges
• *Pursuit of Clinical Excellence*	• *AI* • *Machine Learning* • *Deep Learning* • *Algorithms*		• *Pediatric Imaging* • *Prediction and Clinical Decision Support* • *Big Data - Complex or Continuous Input*	• *Generative AI* • *Predictive Treatment Allocation*	• *Practical* • *Ethical* • *Legal*

Support Vector Machine: Outcome Prediction

OBJECTIVE

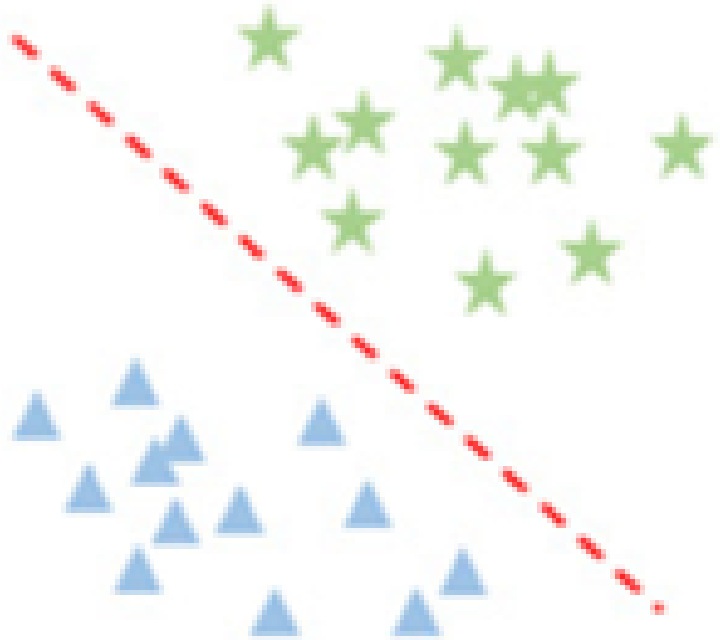
Find a classifier that distinguishes blue triangles from green stars using features x1 and x2

UNDERSTAND

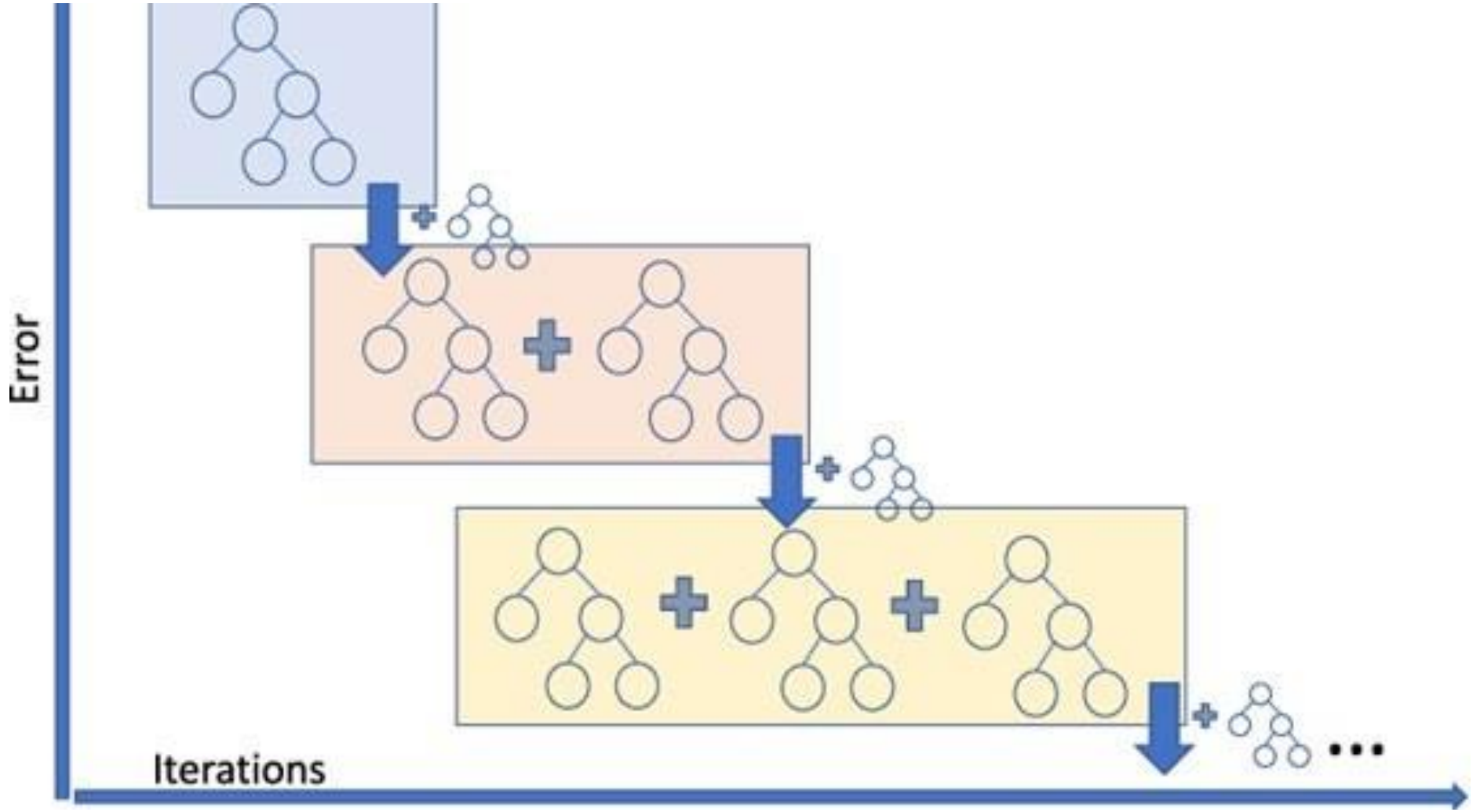
The solution is a line (2D), plane (3D), or hyperplane (nD)

LEARNING ALGORITHM

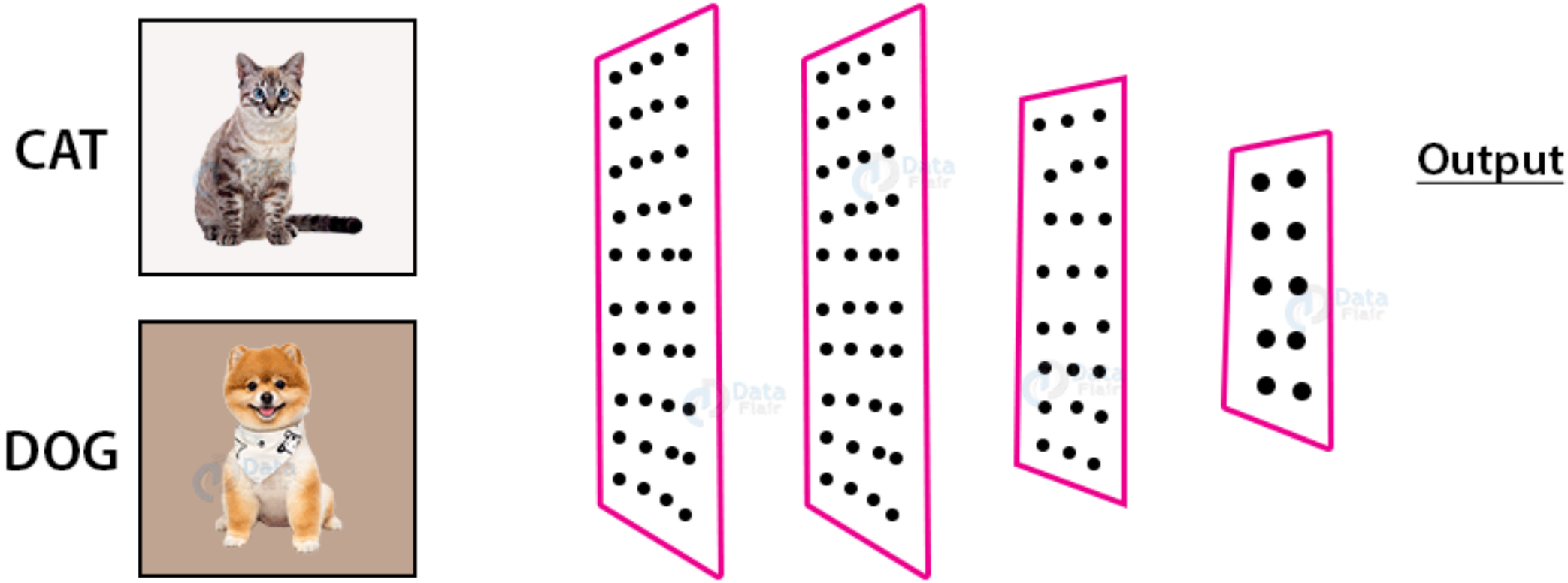
Initialization → Loss (Cost)
Minimization and Marginalization



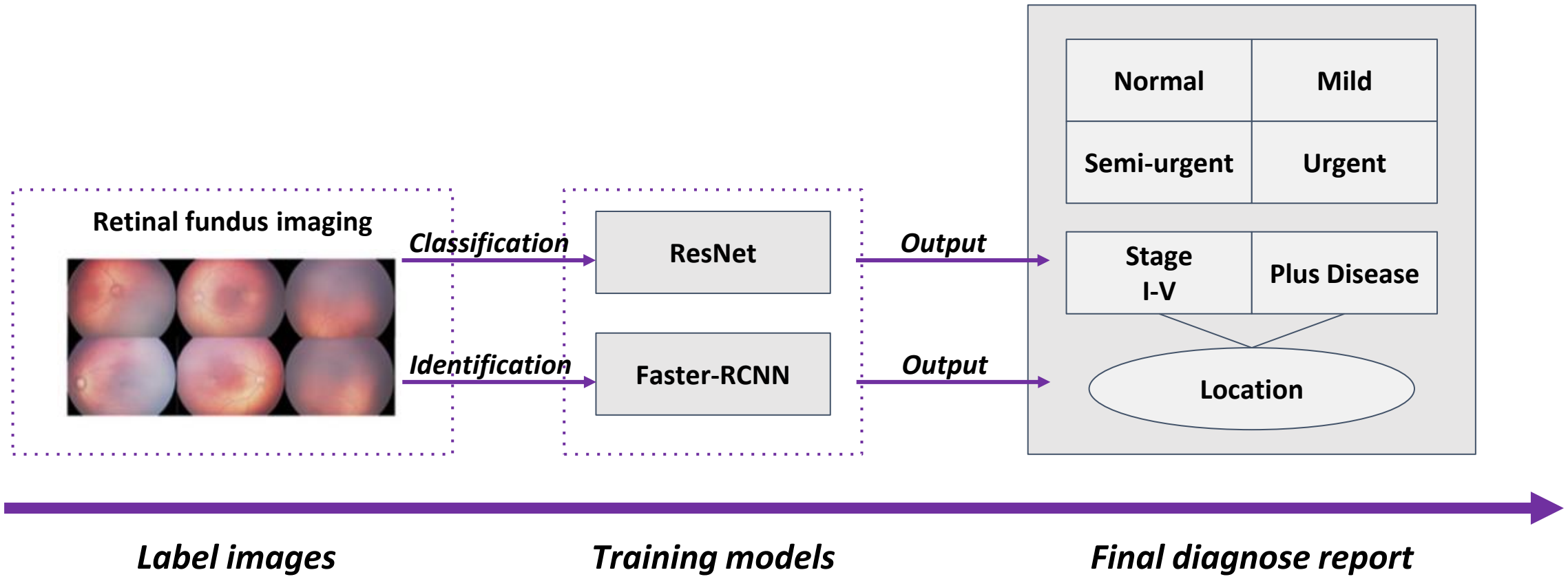
Gradient Boosting and Random Forest



Dealing with Images Using AI: Components of Neural Networks

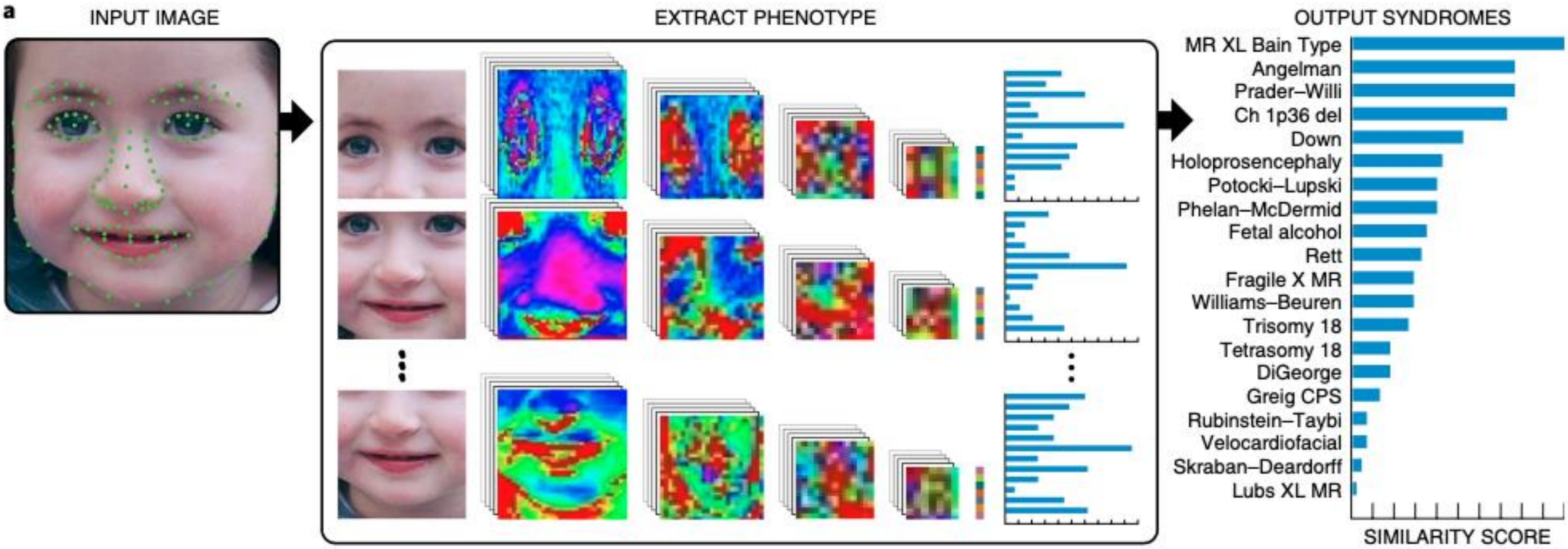


AI in Image Interpretation Retinopathy of Prematurity



Tong Y, et al. Eye Vis (Lond). 2020 Aug 1;7:40.

AI in Image Interpretation Dysmorphology



Gurovich Y, et al: Nat Med. 2019 Jan;25(1):60-64.

Classic Clinical Decision Support

Intended to promote

- Quality care, safety, efficiency, cost-effectiveness, better outcomes

Identifies best practice

- Clinical trials
- Systematic reviews
- Expert consensus

System to encourage implementation

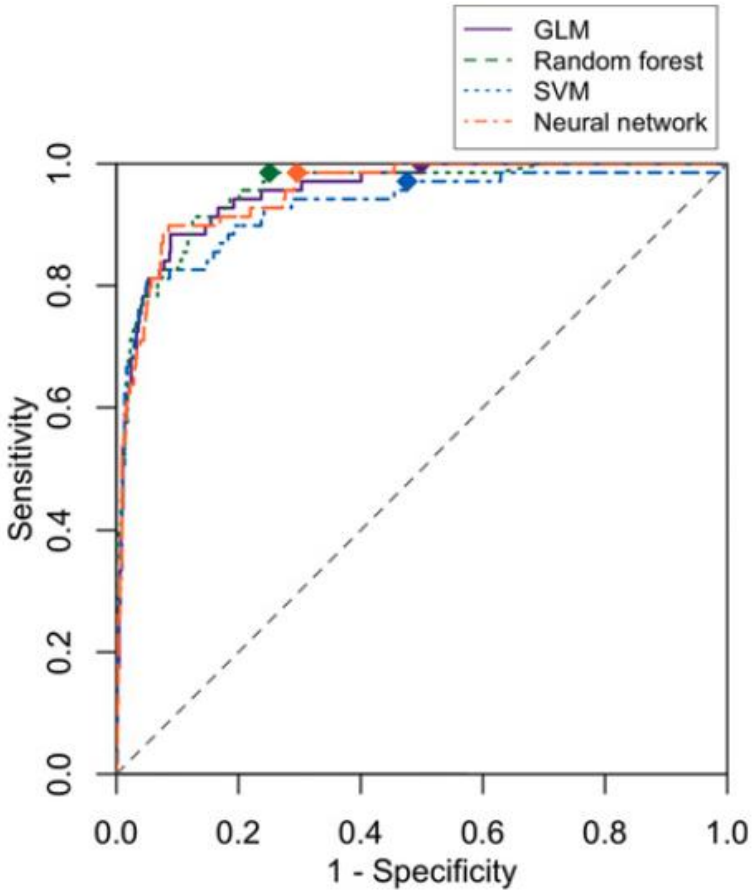
- Usually embedded in the EMR
- Standard order sets and templates
- Alarms, alerts, and reminders

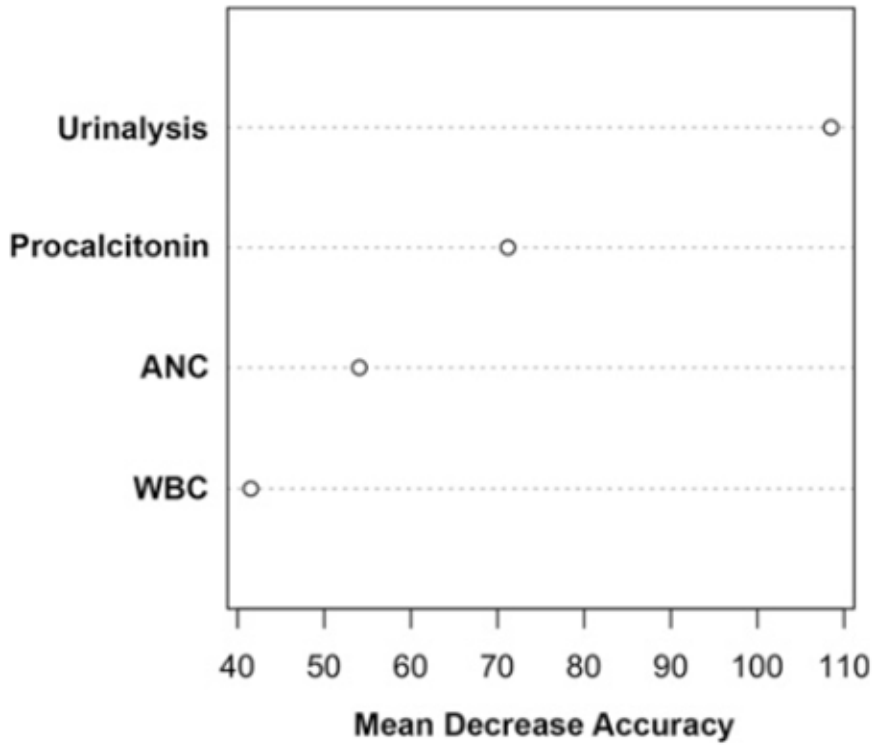
Classic Clinical Decision Support

Sparse or inappropriate evidence base	• May not even be based on pediatric data
Insufficient updating	• Too infrequent • Non-transparent
Does not promote personalized medicine	• Fails to account for individual disease variability
Disruptive to care	• Information overload • “Alert fatigue”

Clinical Decision Support:
Educating Providers on Best Practices Alerting Them to Danger

AI in Prediction of Critical Illness Sepsis

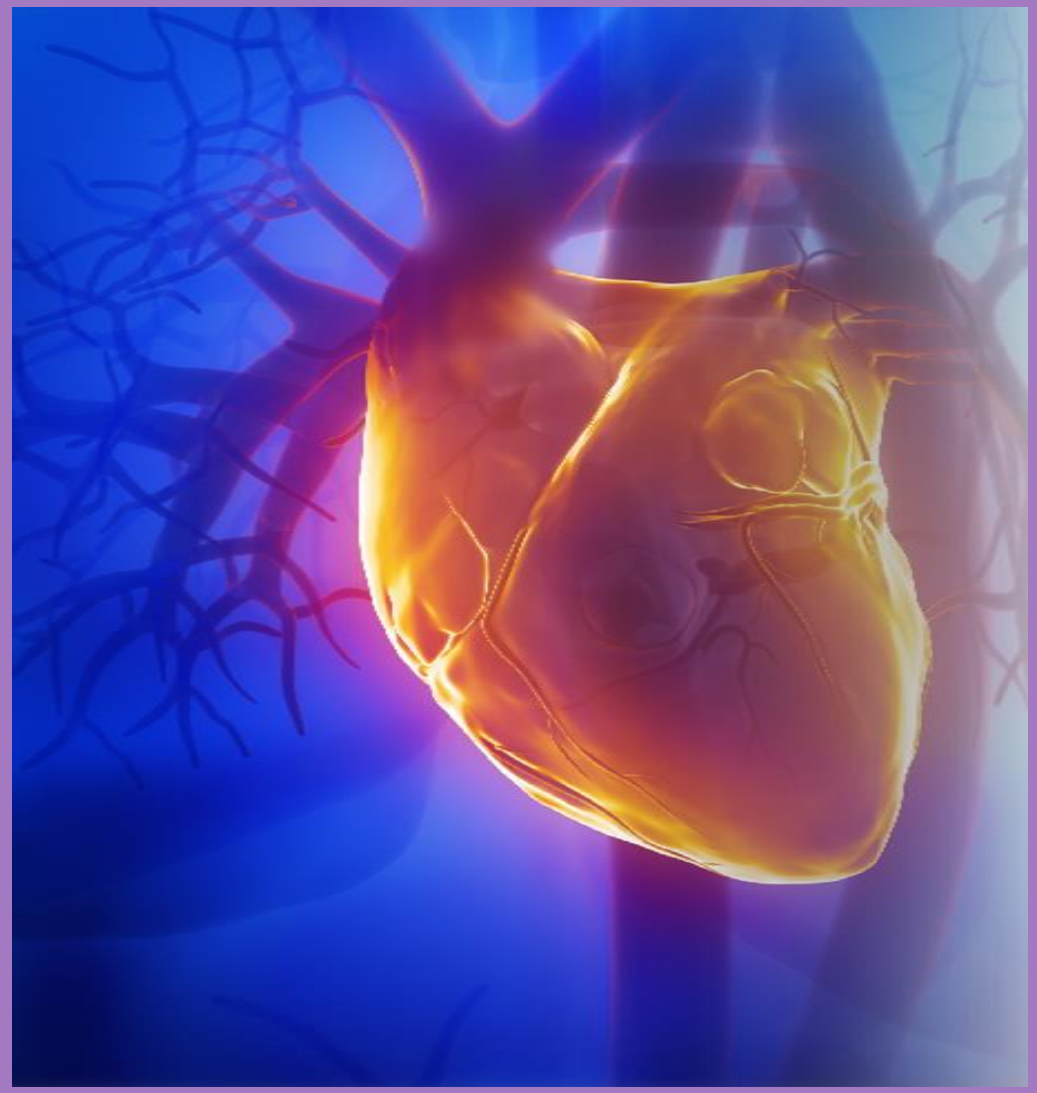




Ramgopal S, et al. Pediatrics. 2020 Sep;146(3)

Big Data The 4 Vs

"The information asset characterized by such a high **v**olume, **v**elocity and **v**ariety to require specific technology and analytical methods for its transformation into **v**alue."

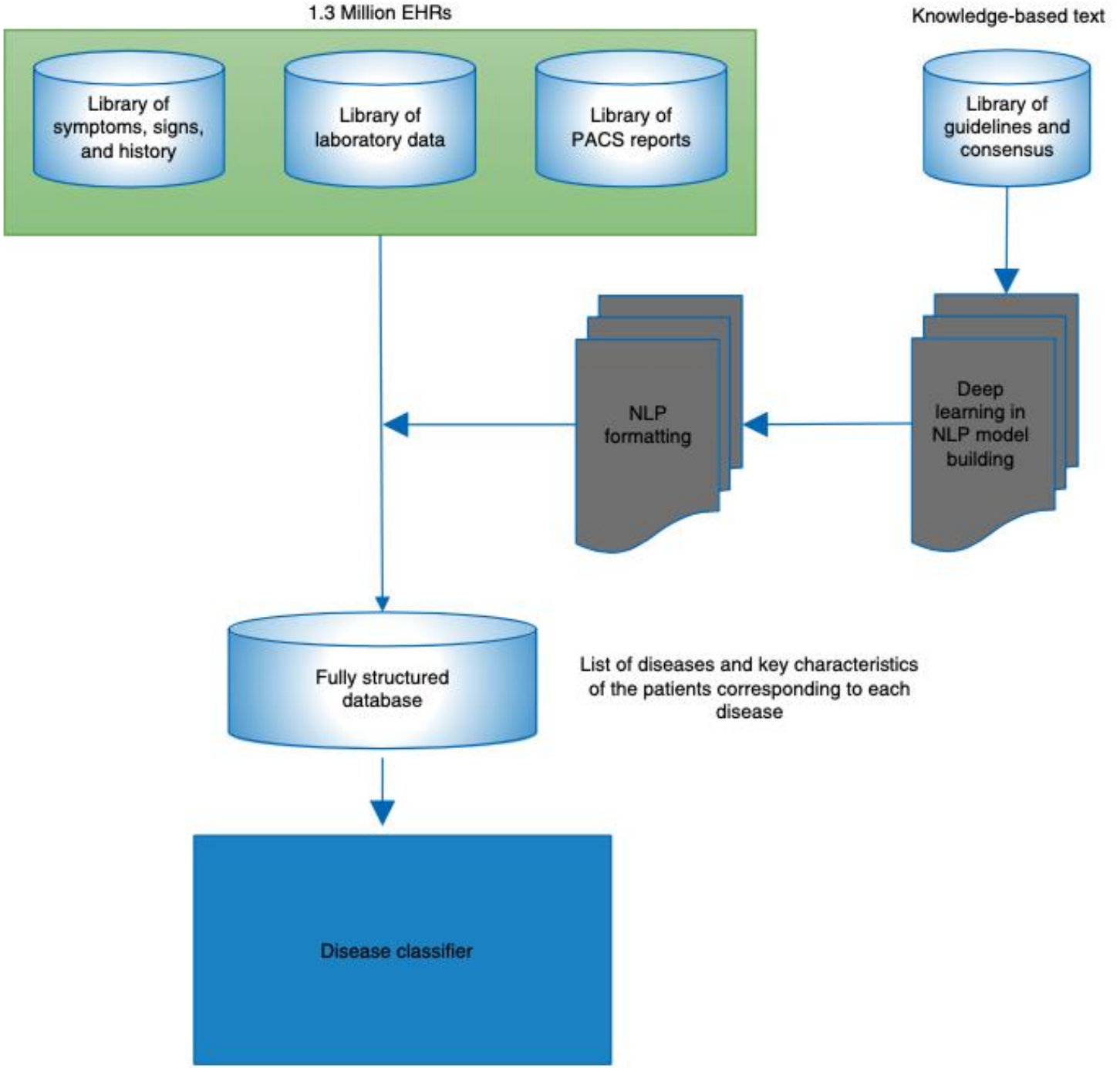


De Mauro A, Greco M, Grimaldi M. Library Review. 2016


Optimizing Big Data Utilization
Full Context Machine Learning
Silo Demolition
Or…. Connecting everything we know

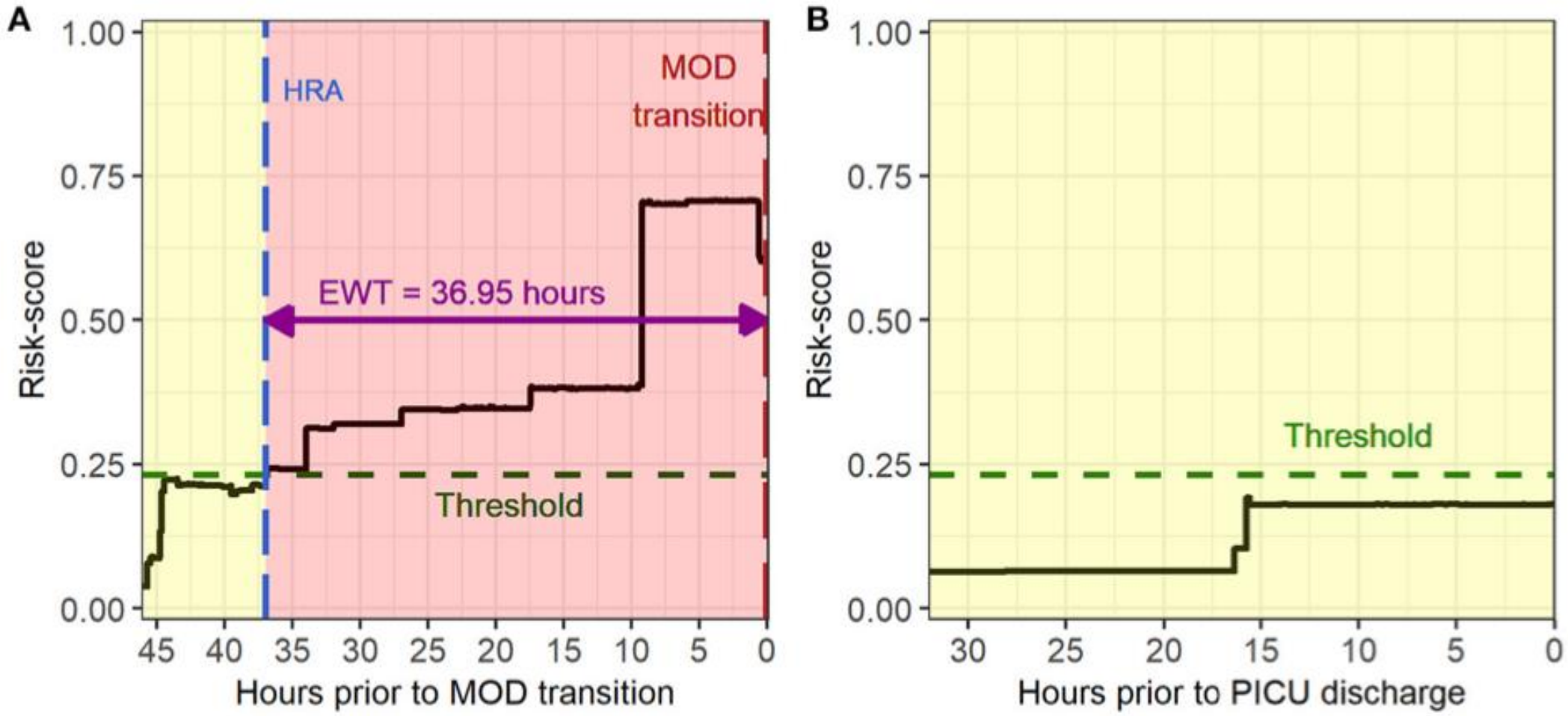
AI in Pediatric Disease Identification

From EMR to Diagnosis



Liang H, et al Nat Med. 2019 Mar;25(3):433-438.

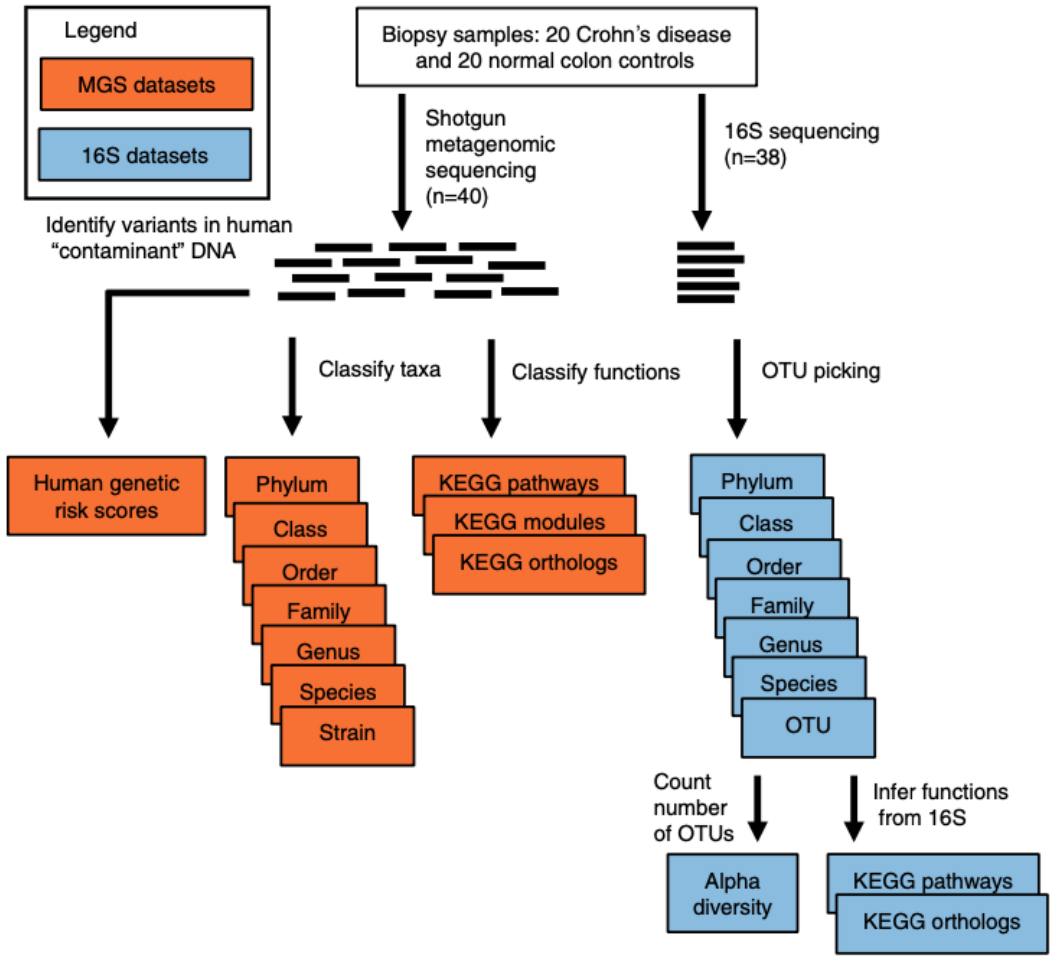
AI - Continuous Input Multiple Organ Dysfunction

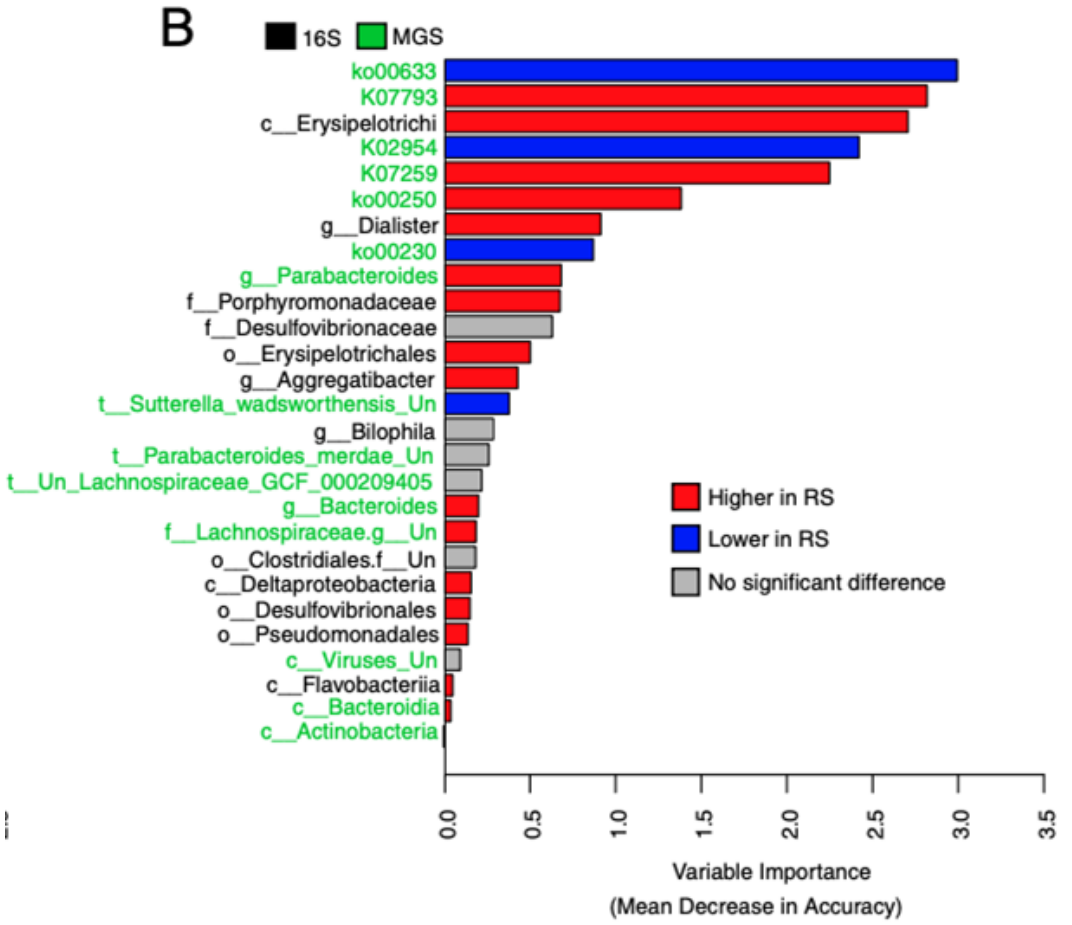


Bose SN, et al. Front Pediatr. 2021 Aug 16

AI Multi-omics for Classification and Management

Pediatric Crohn's Disease





Douglas GM, et al. Microbiome. 2018 Jan 15;6(1)

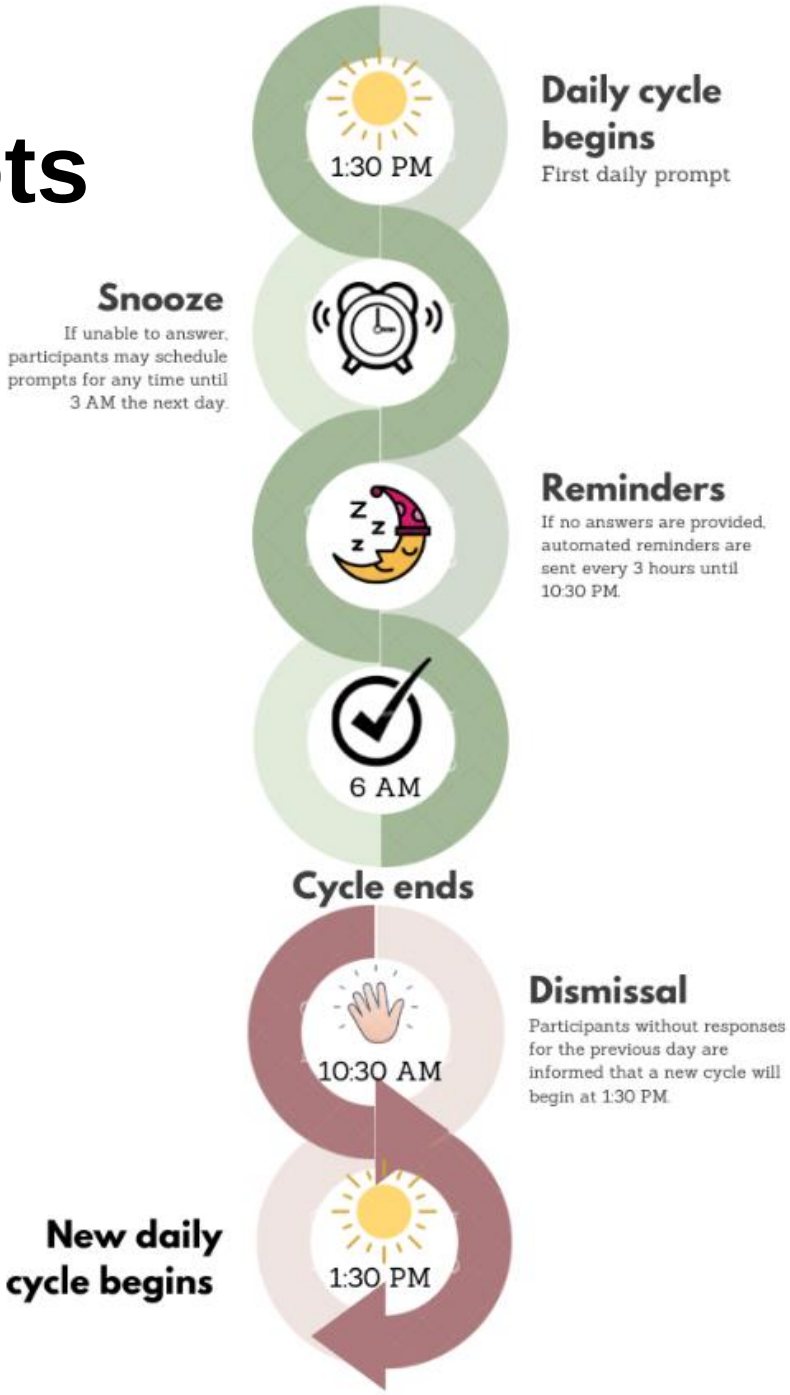
Communicating using AI

Generative Pretrained Transformer

- **Natural Language Pt Input**
  - Questions, Symptoms, Requests
- **Transformer**
  - Encoder
    - Neural Networks
    - Vocabulary
    - Syntax
  - Response Formulation
    - Complex Trained NN's
      - Medical Literature
      - Patient Records
      - Encounter Transcripts
  - Decoder NN's
- **Natural Language GPT Output**

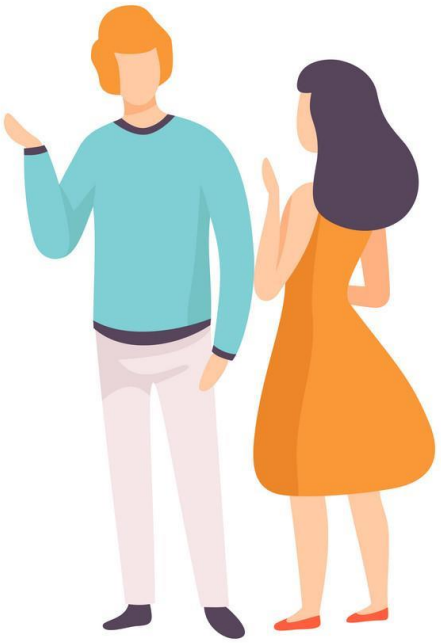
AI Generative Algorithms / Chatbots
Adolescent Depression

- **140 Brazilian Adolescents in the IDEA-RISCO Study**
  - Developed IDEABot for Data Collection via WhatsApp
- **Acceptance** – 81% (first wave) to 92% (second wave)
- **Attrition** – About 1% over 2-3 years
- **Compliance**
  - Response to elicited prompts 91%
  - Successful Interactions 76%



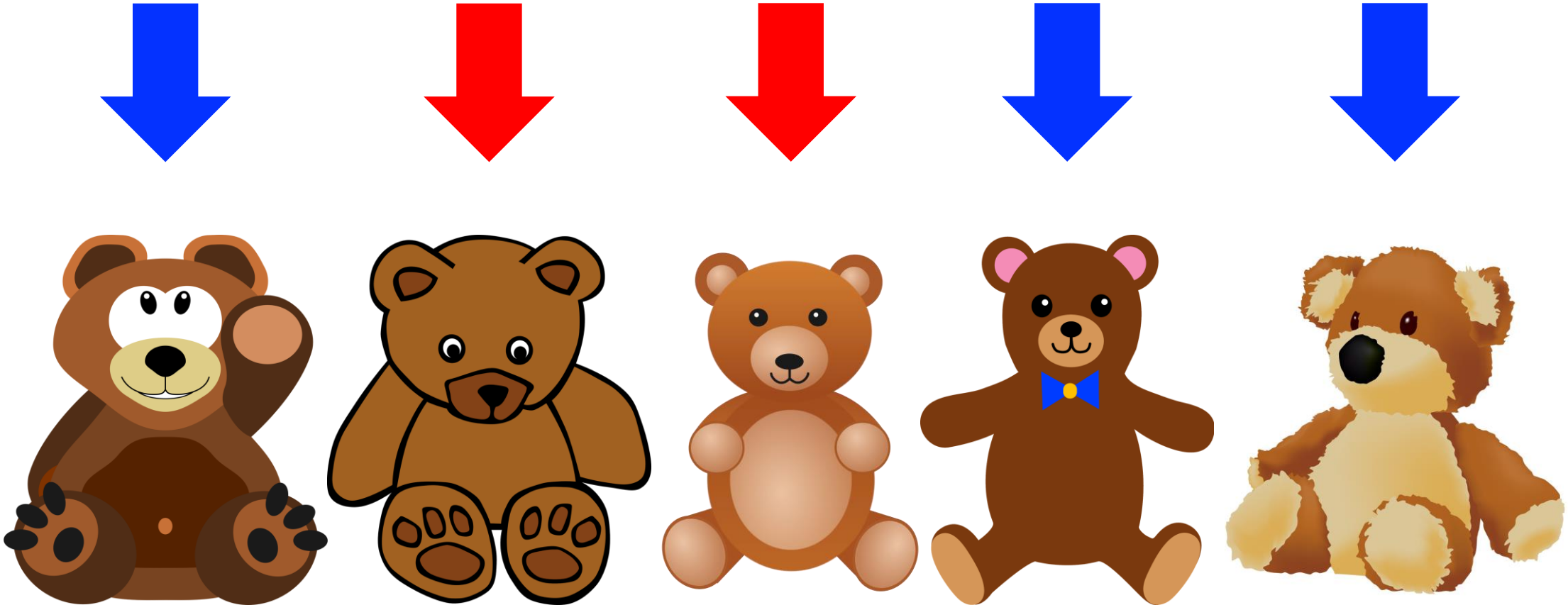
Viduani A et al. JMIR Hum Factors. 2023 Aug

Do you know about any RCTs that provide evidence that we should use RCTs?

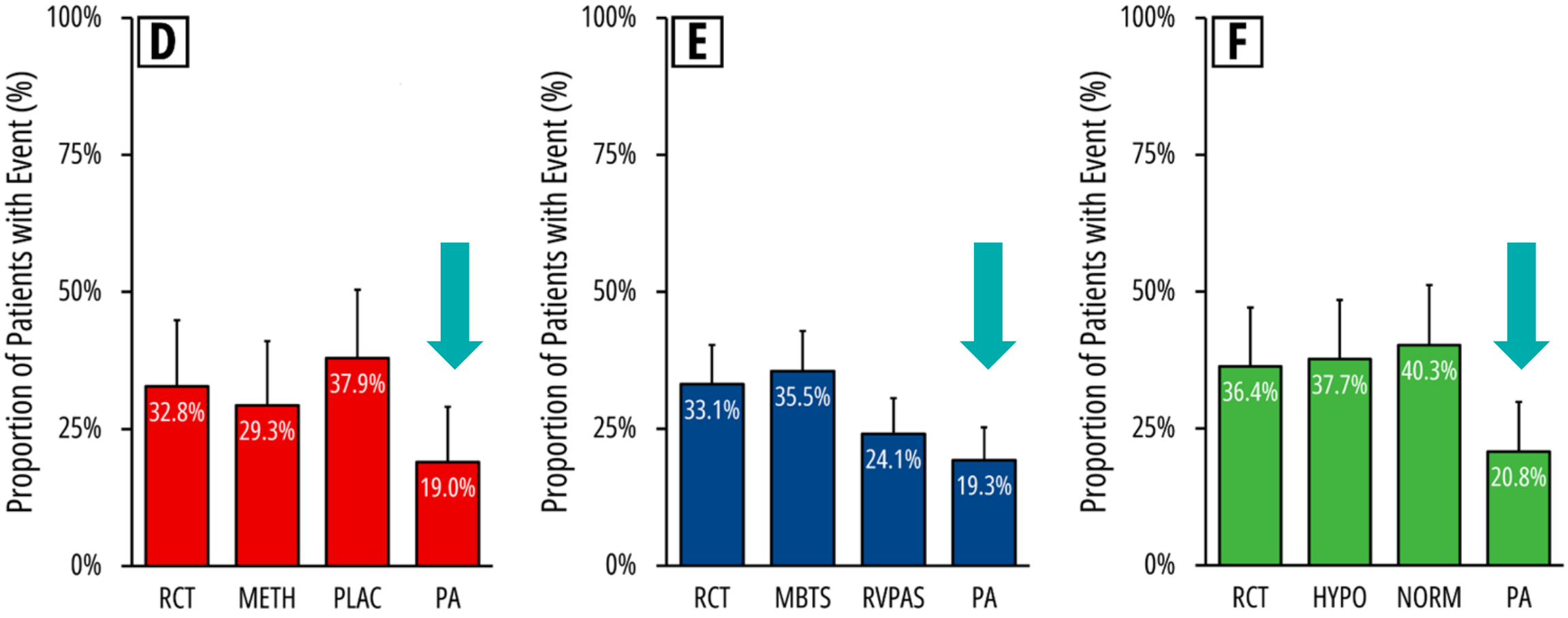


The Concept of the Heterogenous Treatment Effect

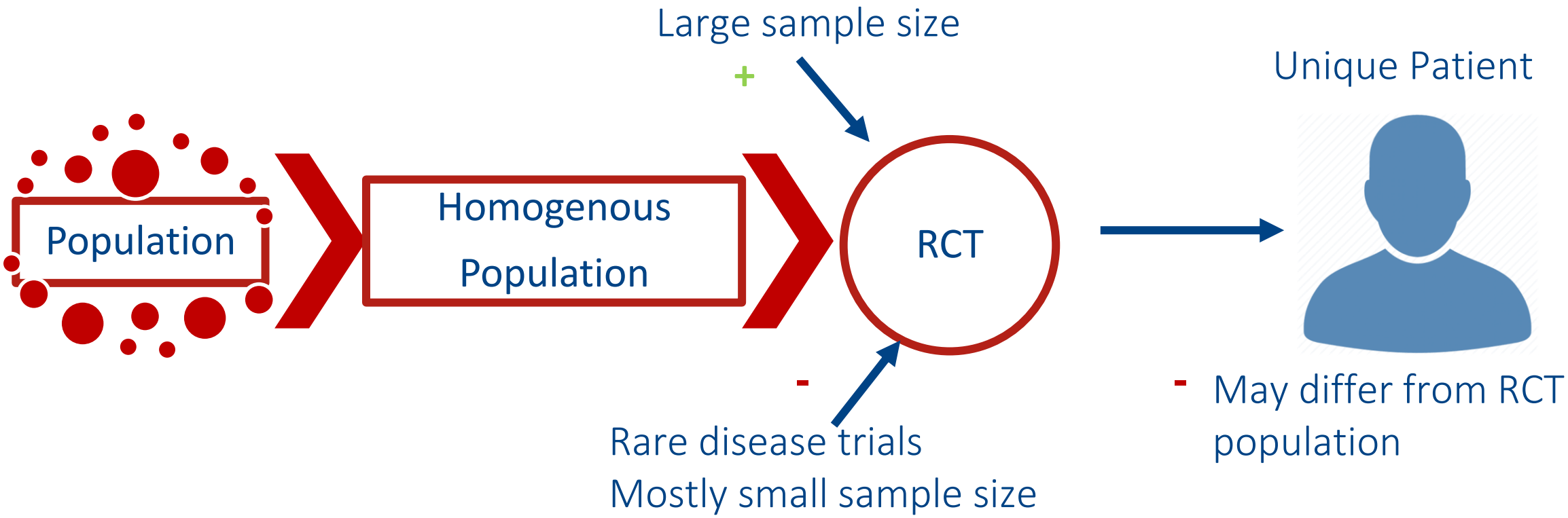
The research question: If we develop a predictive model to distinguish red arrow bears from blue arrow bears, and allocate treatment accordingly, would our bears do better overall?



Simulated Results of Predictive Allocation



Big Data and Cardiac Imaging: Beyond the RCT and Evidence Based Medicine



Can deep learning help?

Information Collected

- Clinical Information
- Environmentome
- Microbiome
- Organ/tissue physiology
- Imageome
- Cell biology
- Proteome and metabolome
- Epigenome and transcriptome
- Genome

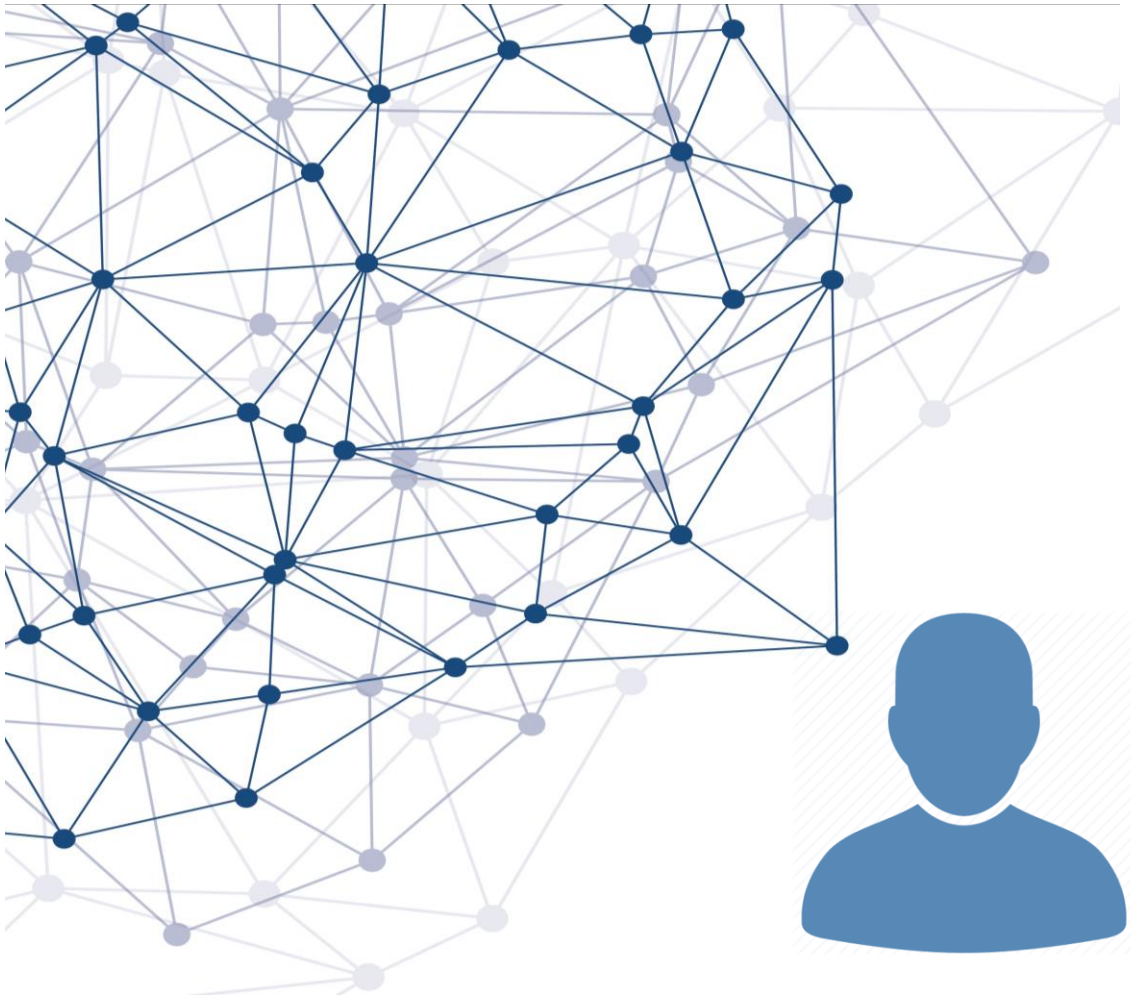
Lifetime

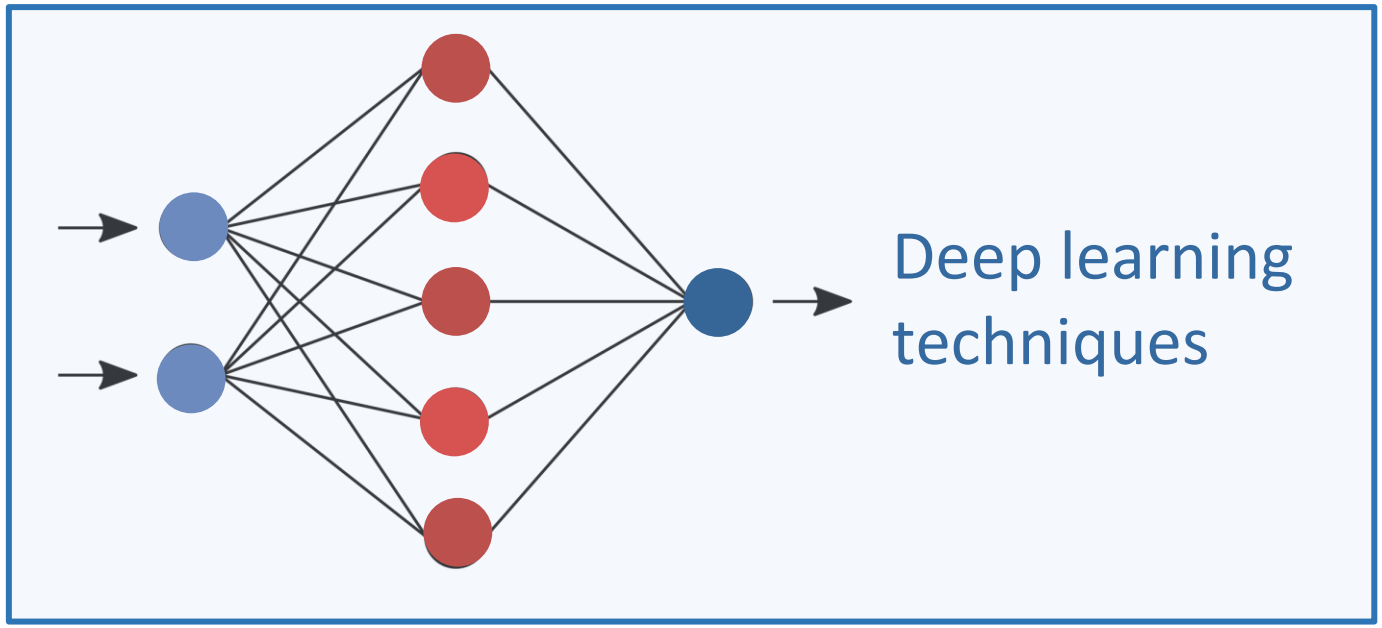
Big Data and Echocardiography: Medicine Based Evidence (MBE)

Interogation of a library of "approximate matches"

Van den Eynde J, Kutty S et al. Front Cardiovasc Med, 2021.

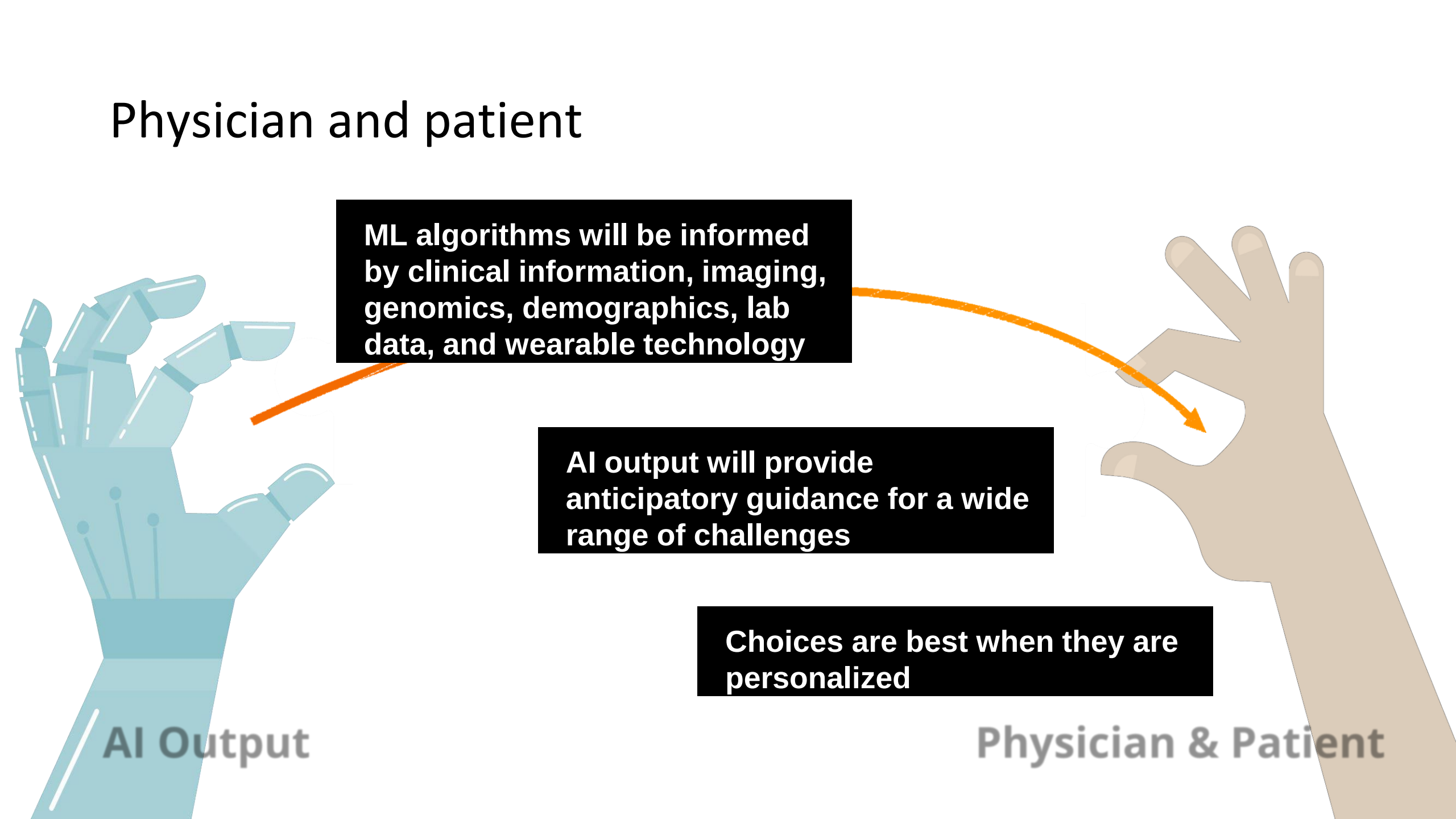
Big Data and Imaging - Medicine Based Evidence





Digital twin with
mechanistic models

Physician and patient



Some assembly required

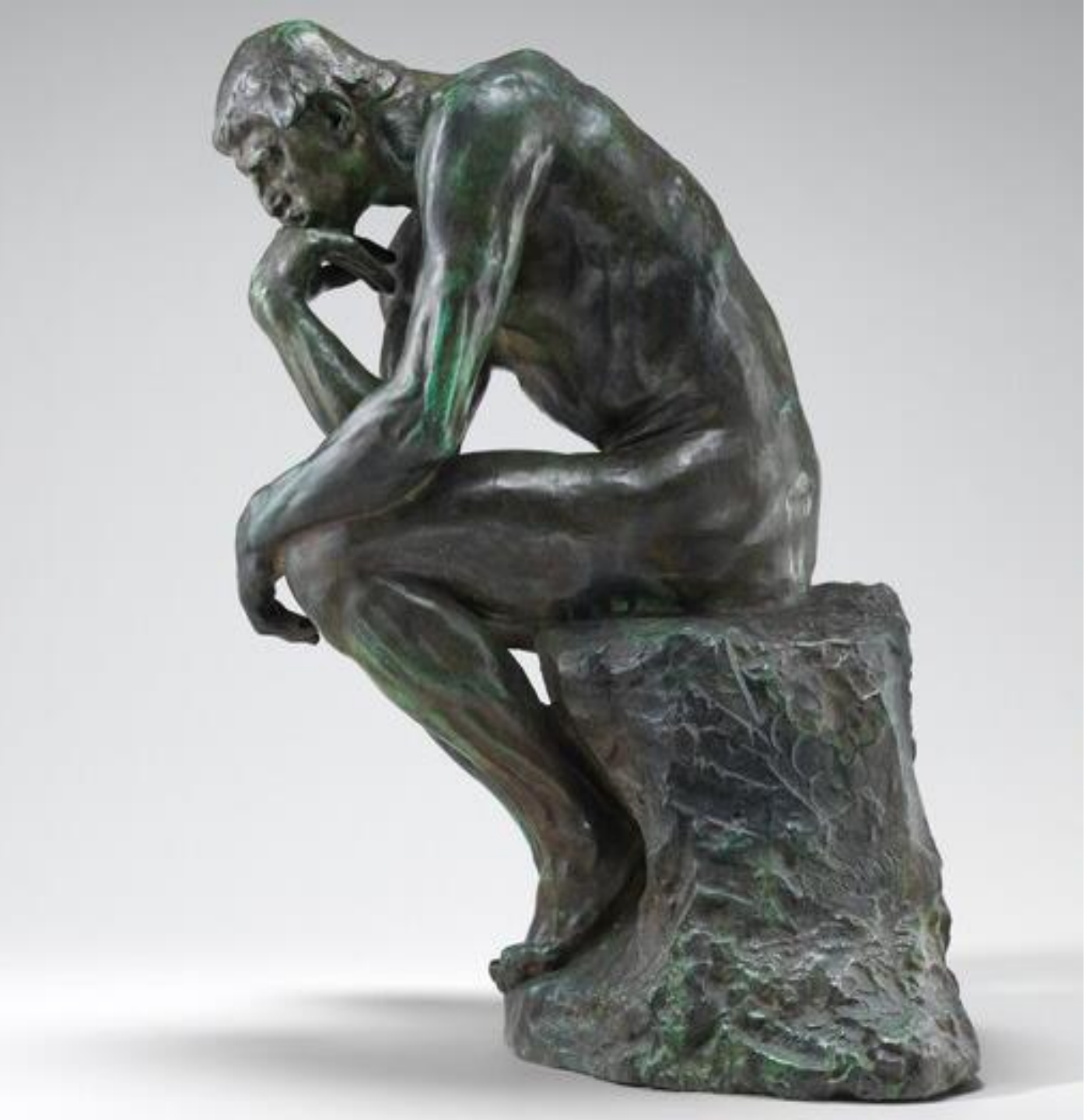
7 We have not yet realized….

8

AI in healthcare presents specific challenges

ETHICAL		LEGAL	
Regulation	Transparency	Governance	Accuracy
Privacy	Relevance	Confidentiality	Decision-making
Mitigation of Bias		Liability	

Derived from Gerke S, et al. Academic Press, 2020 | Naik et. al, Frontiers in Surgery.2022



- The pediatrics of the future will be more data-driven than it is today
- Professionally, we will be aiming higher than simple universal consistency to comply with guidelines, and instead we will reach for case-by-case quality outcomes

The New Pediatrics

More Intelligent? Precise? Personalized?

Summary

- **Machine Learning Algorithms**
  - **Connect Data from Diverse Sources**
  - **Produce Accurate, Relevant Predictions**
  - **Clinical Decision Support**
- **Personalization and Precision Care**
  - **Generative AI Enhanced Communication**
  - **Predictive Allocation**
- **Some Assembly Required**
  - **Protective of the Patients We Serve**
  - **Meticulous with Our Methods**


JOHNS HOPKINS
MEDICINE
ORLEANS ST