AI in Clinical Practice: Transforming Patient Care

CTSI Biomedical AI Symposium

UCLA, Dec 4, 2024

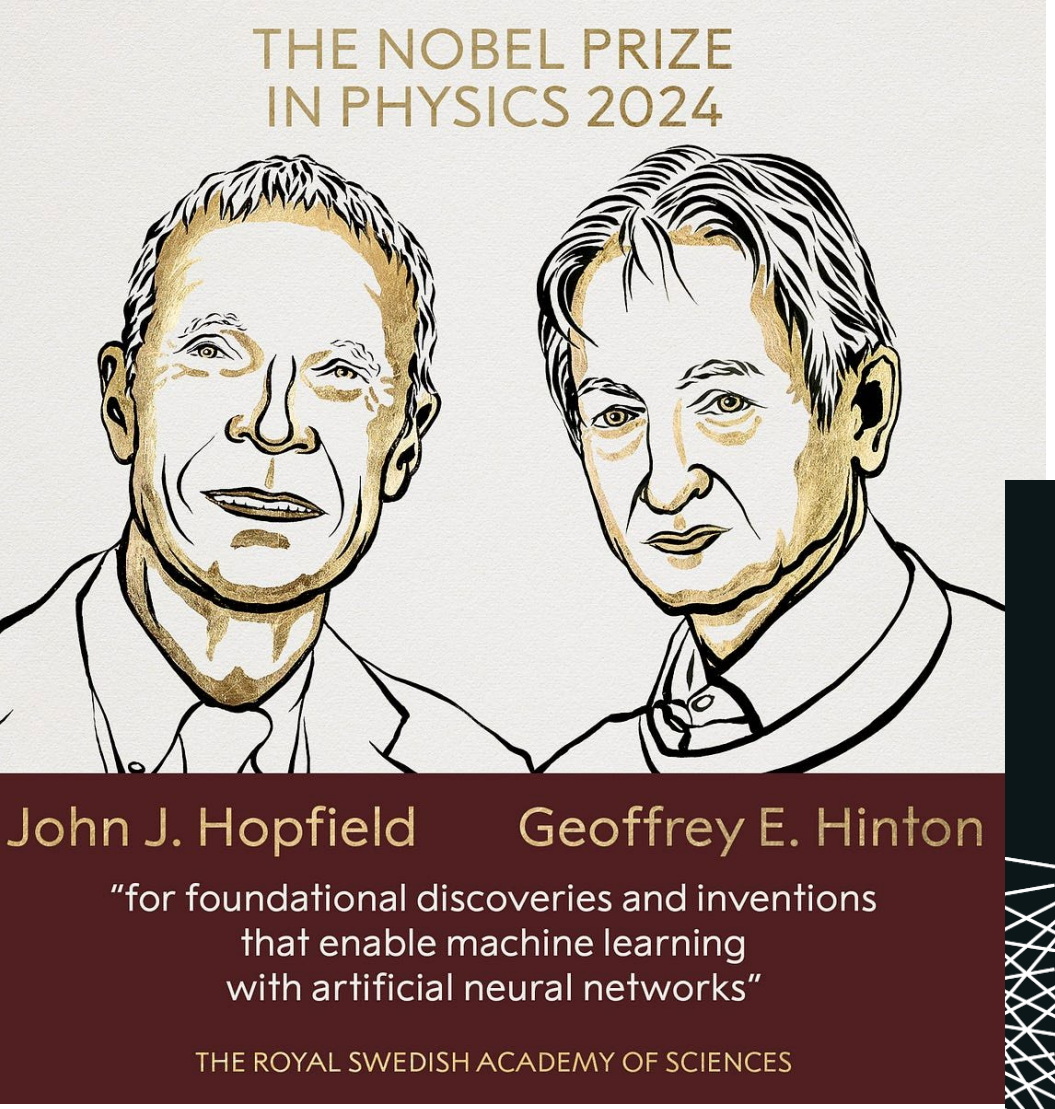
Sumeet S. Chugh MD

Price Professor & Associate Director, Smidt Heart Institute
Director, Division of Artificial Intelligence, Department of Medicine

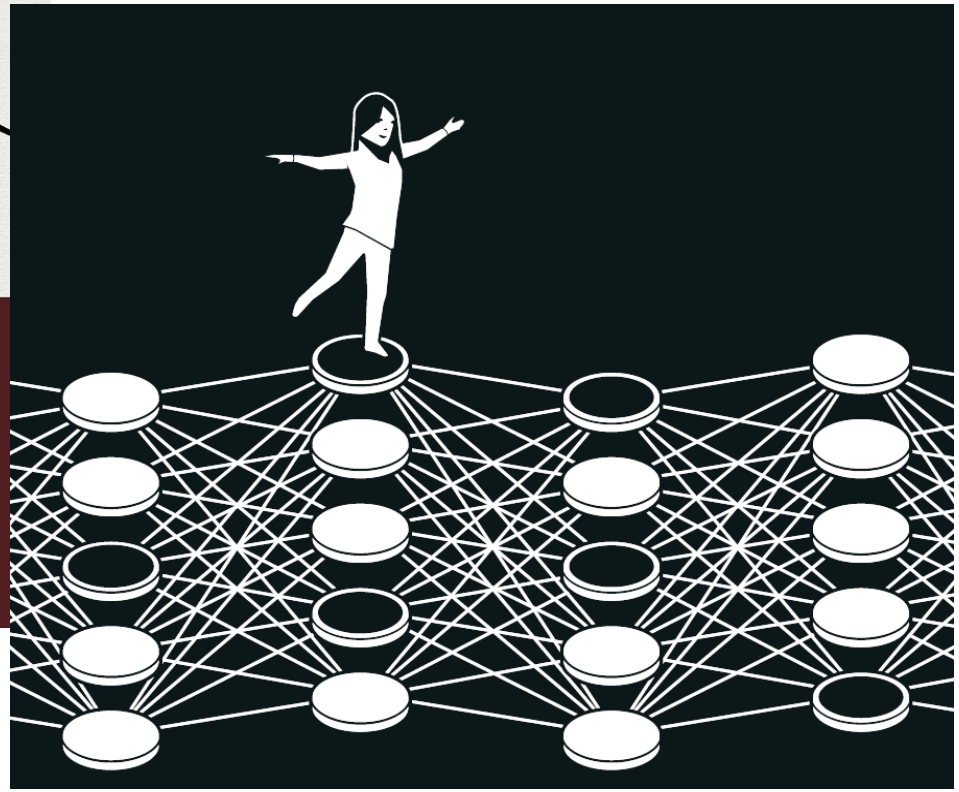
Cedars-Sinai Health System, Los Angeles, CA, USA

Cedars Sinai

Artificial Intelligence in Medicine

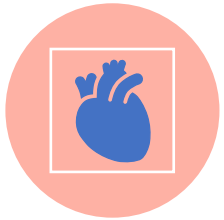


Hinton: *"I'm hoping AI will lead to tremendous benefits, to tremendous increases in productivity and to a better life for everybody. I'm convinced that it will do that in health care."*



"My worry is that it may also lead to bad things, and in particular, when we get things more intelligent than ourselves, no one really knows whether we're going to be able to control them."

AI in Clinical Practice: Transforming Patient Care



AI REVOLUTION IN MEDICINE (HEART DISEASE)

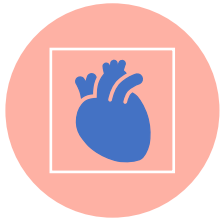
WHY IS IT IMPORTANT?

CHALLENGES AND HOW TO CONFRONT (“BAD THINGS”)?

IS THE RATE OF PROGRESS WHAT WE EXPECTED?

THE ONE CONCEPT THAT WILL TRANSFORM PATIENT CARE

AI in Clinical Practice: Transforming Patient Care



AI REVOLUTION IN MEDICINE (HEART DISEASE)

WHY IS IT IMPORTANT?

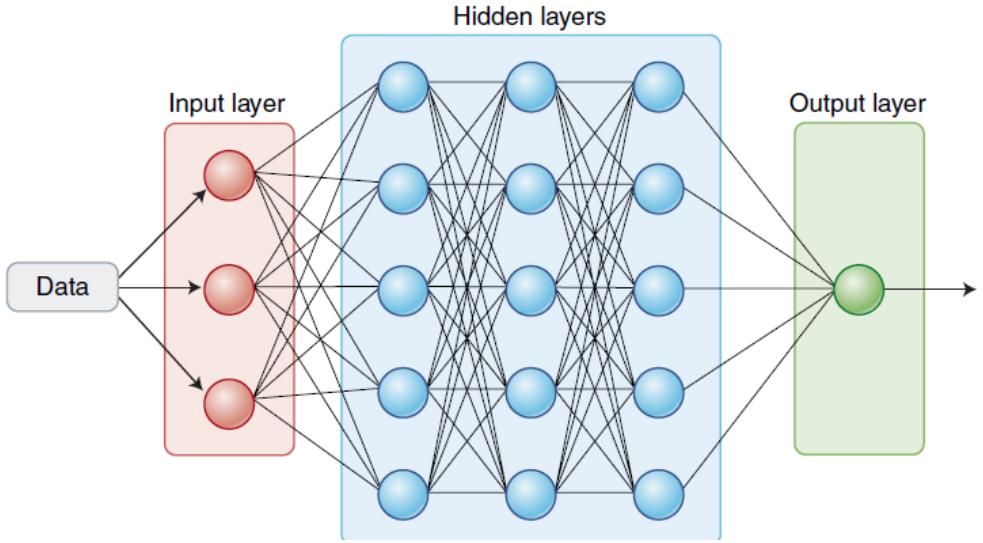
CHALLENGES AND HOW TO CONFRONT (“BAD THINGS”)?

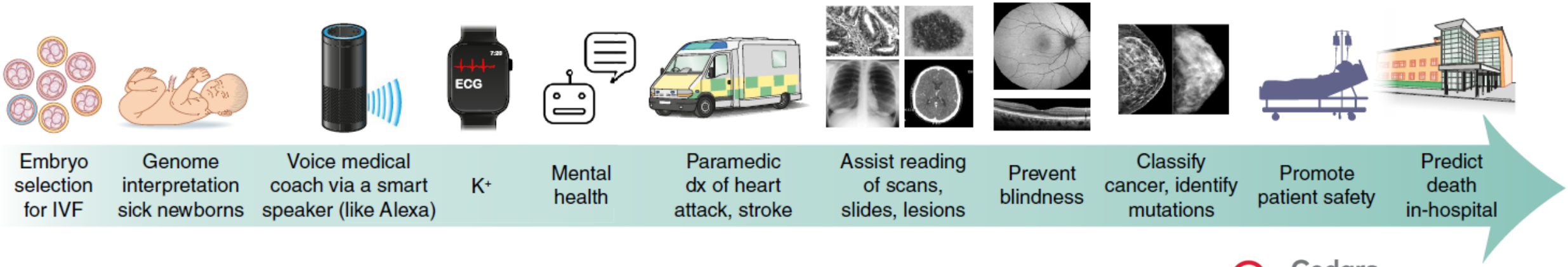
IS THE RATE OF PROGRESS WHAT WE EXPECTED?

THE ONE CONCEPT THAT WILL TRANSFORM PATIENT CARE

Convergence of human and artificial intelligence: High-performance medicine

2019: Examples of AI applications across the human lifespan

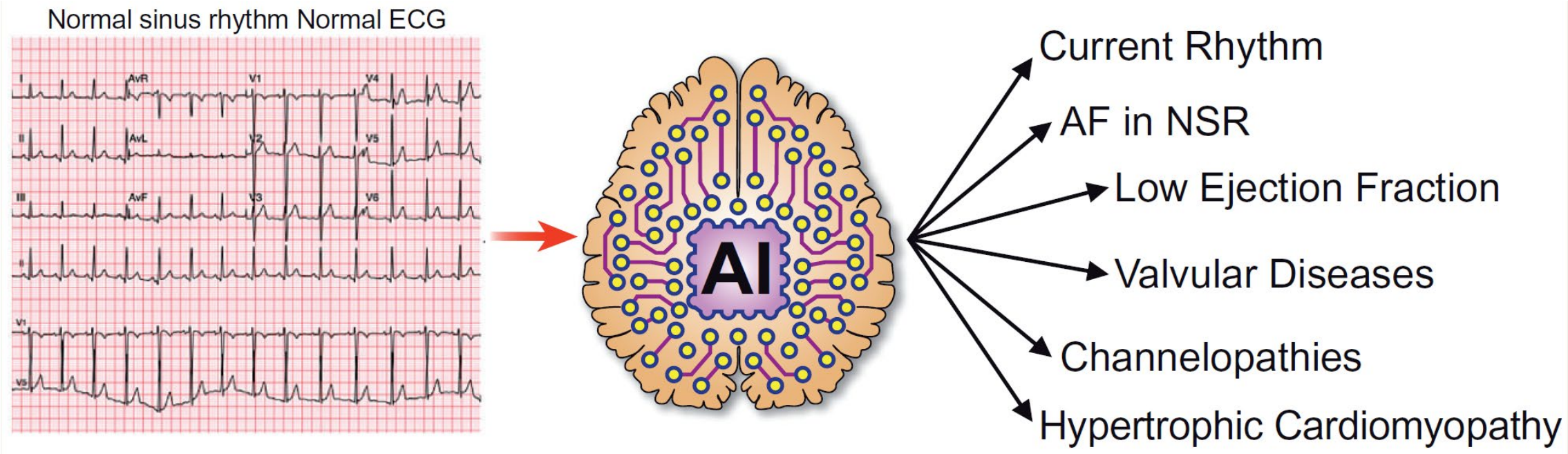




Topol, EJ. Nature Medicine 2019

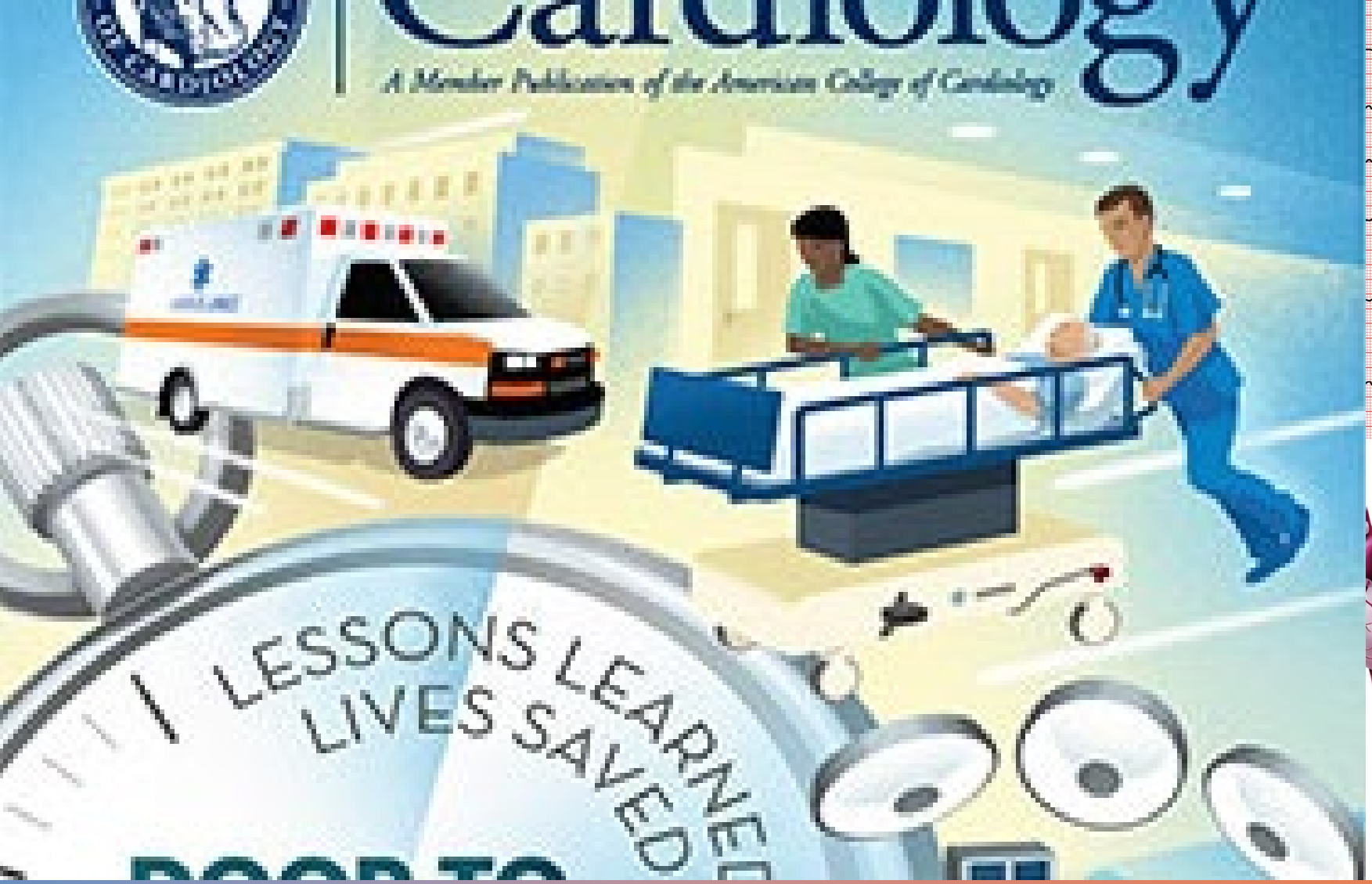
Cedars Sinai
Artificial Intelligence in Medicine

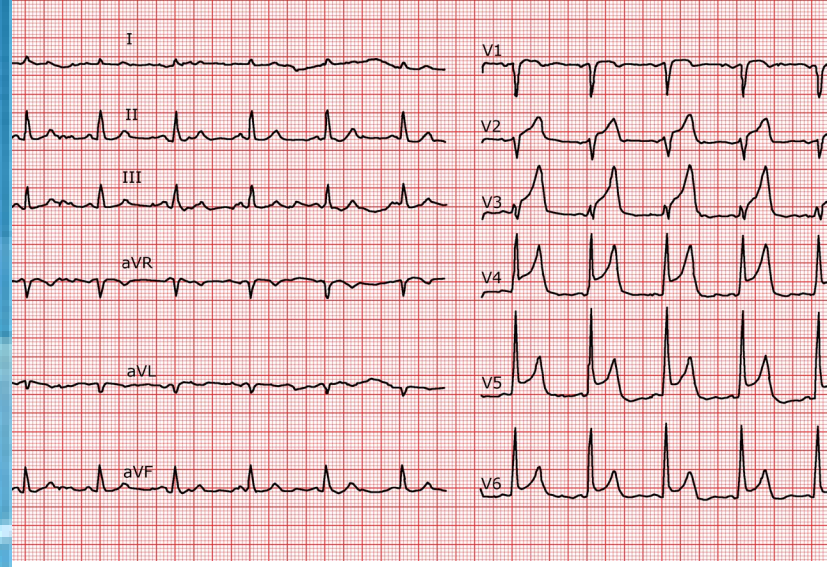
Discoveries Lead to Ongoing AI Revolution in Medicine
Standalone Digital 12-lead ECG Predicts and Diagnoses Multiple Conditions

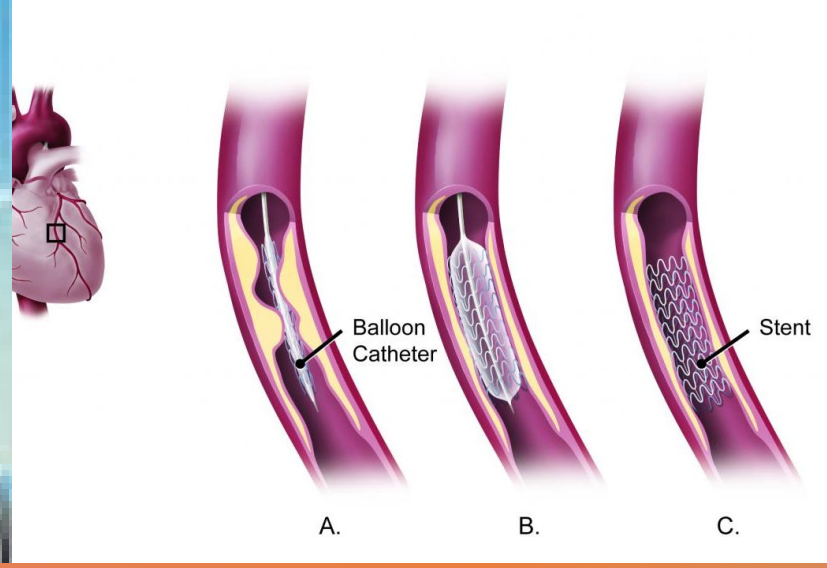


Attia ZI, et al. European Heart Journal (2021)

Cedars Sinai
Artificial Intelligence in Medicine



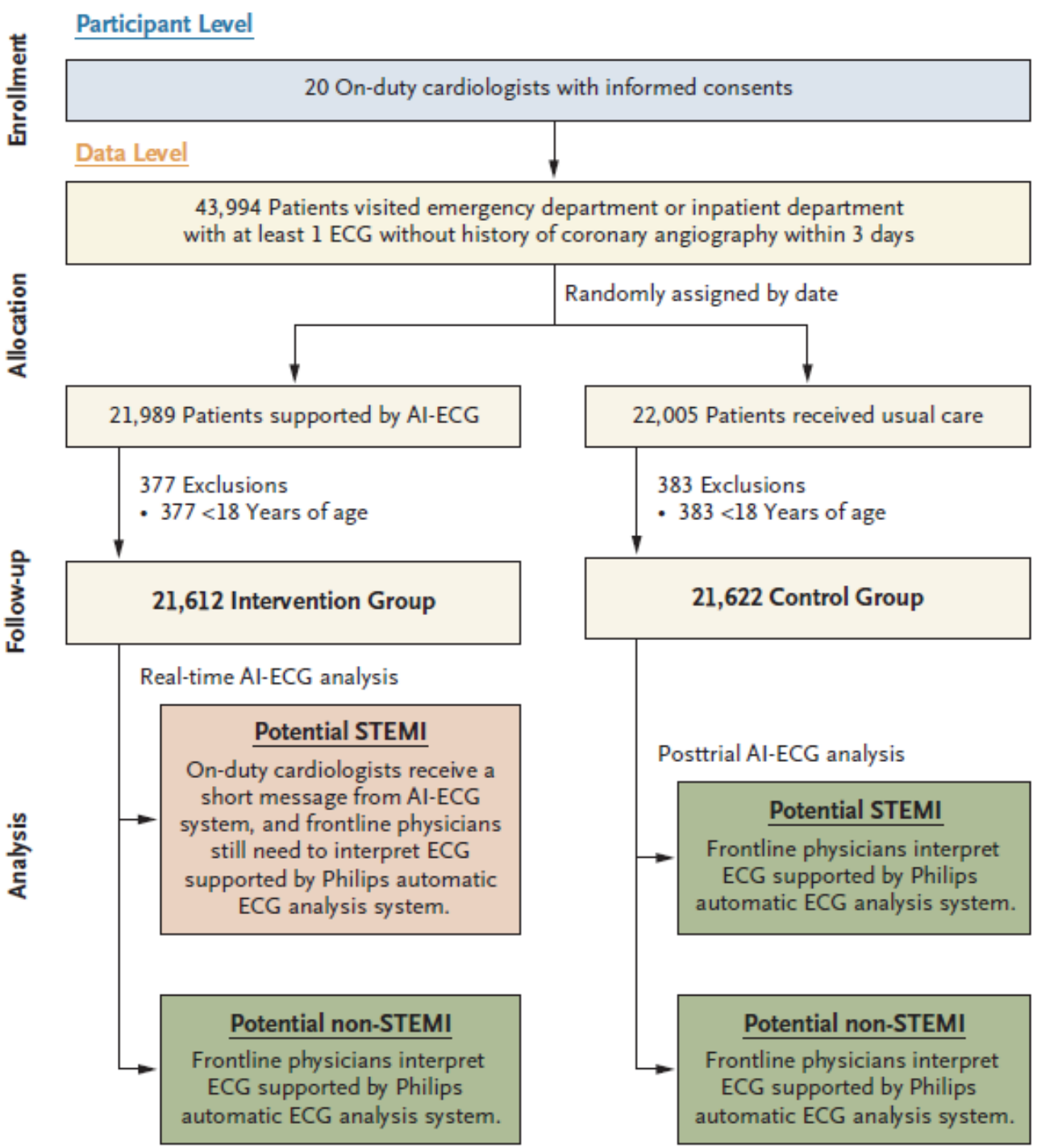




Rx of ST-elevation MI: Shorter door to balloon time = better outcome (90 minutes or less)

Am. College Cardiology; Ottawa Heart Institute

AI Revolution in Medicine

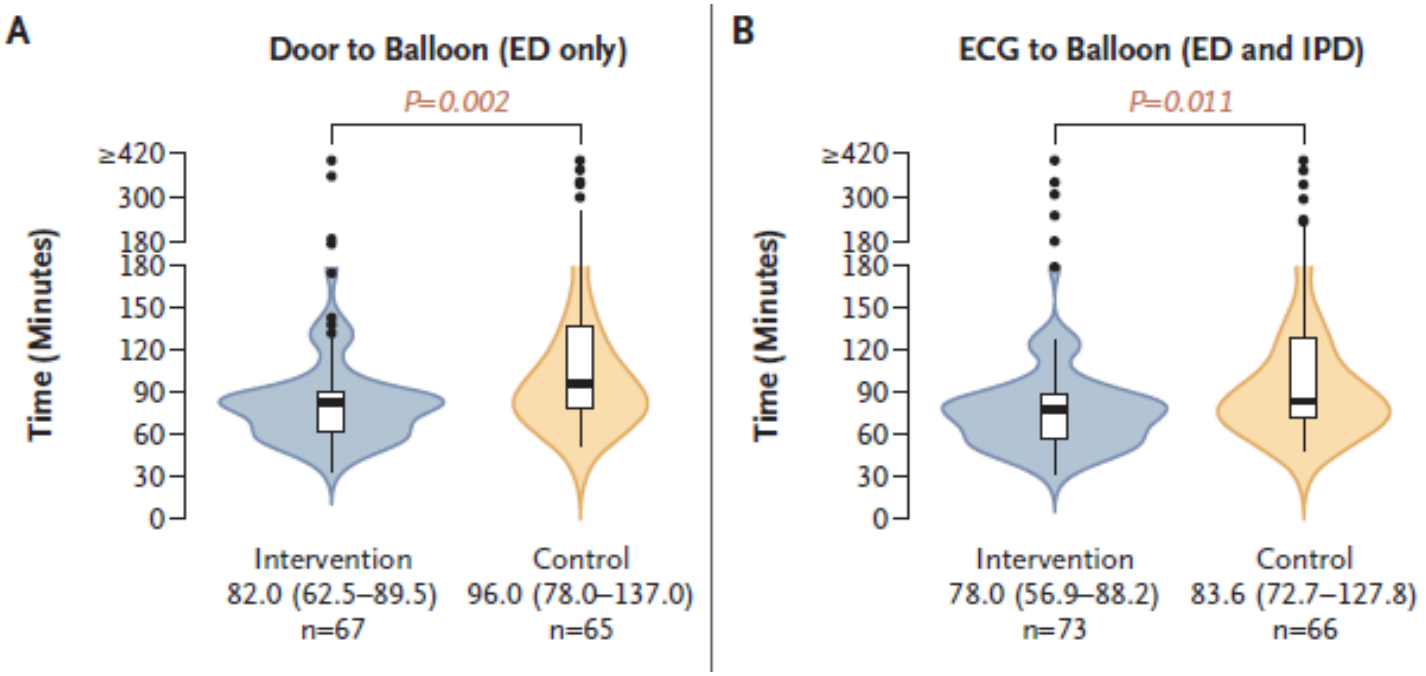


A Pragmatic Randomized Controlled Trial AI–Powered Rapid Identification of ST-Elevation MI via ECG (ARISE) :

- >40K Patients randomly assigned
- EITHER AI-powered ECG algorithm OR standard care
- Tested the effect of AI-ECG interpretation and automated SMS notification
- On treatment delays and diagnostic accuracy for patients STEMI

Lin C, et al. NEJM.AI 2024

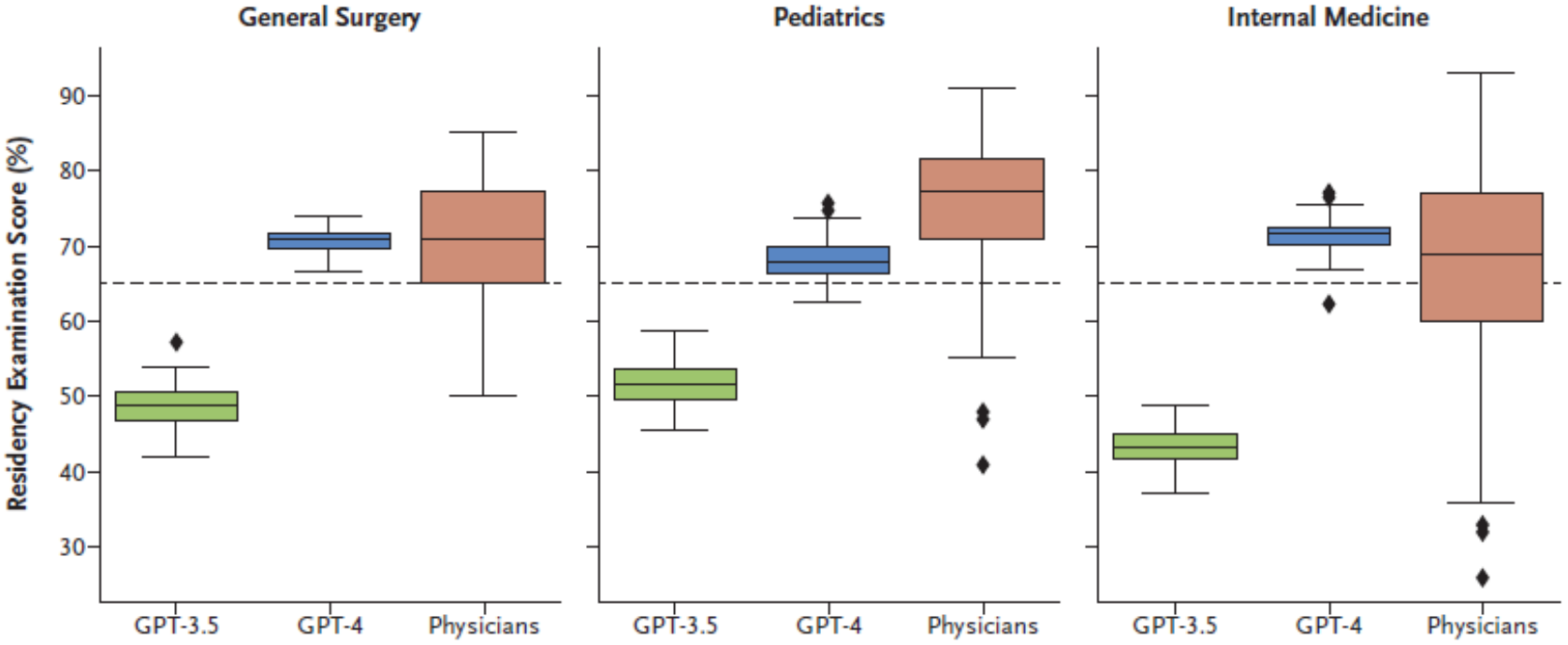
AI–Powered Rapid Identification of ST-Elevation MI via ECG (ARISE) : Results

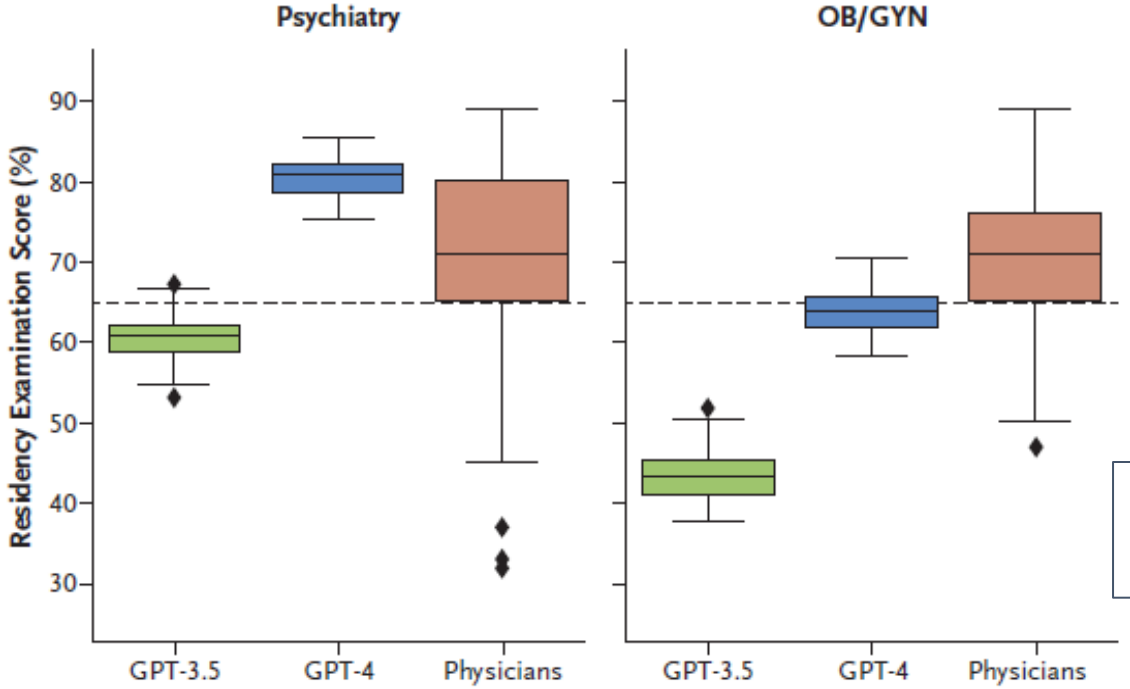


- AI-ECG cut the median door-to-balloon time by 14 minutes (96 to 82 min, P<0.001)
- Cut ECG-to-balloon time by 6 minutes (from 84 to 78 min, P<0.001) for hospitalized patients
- High positive and negative predictive value (89.5% and 99.9%), greater accuracy
- Compelling evidence for the integration of AI-ECG into clinical practice for management of STEMI

Lin C, et al. NEJM.AI 2024

Cedars Sinai
Artificial Intelligence in Medicine





AI Revolution in Medicine

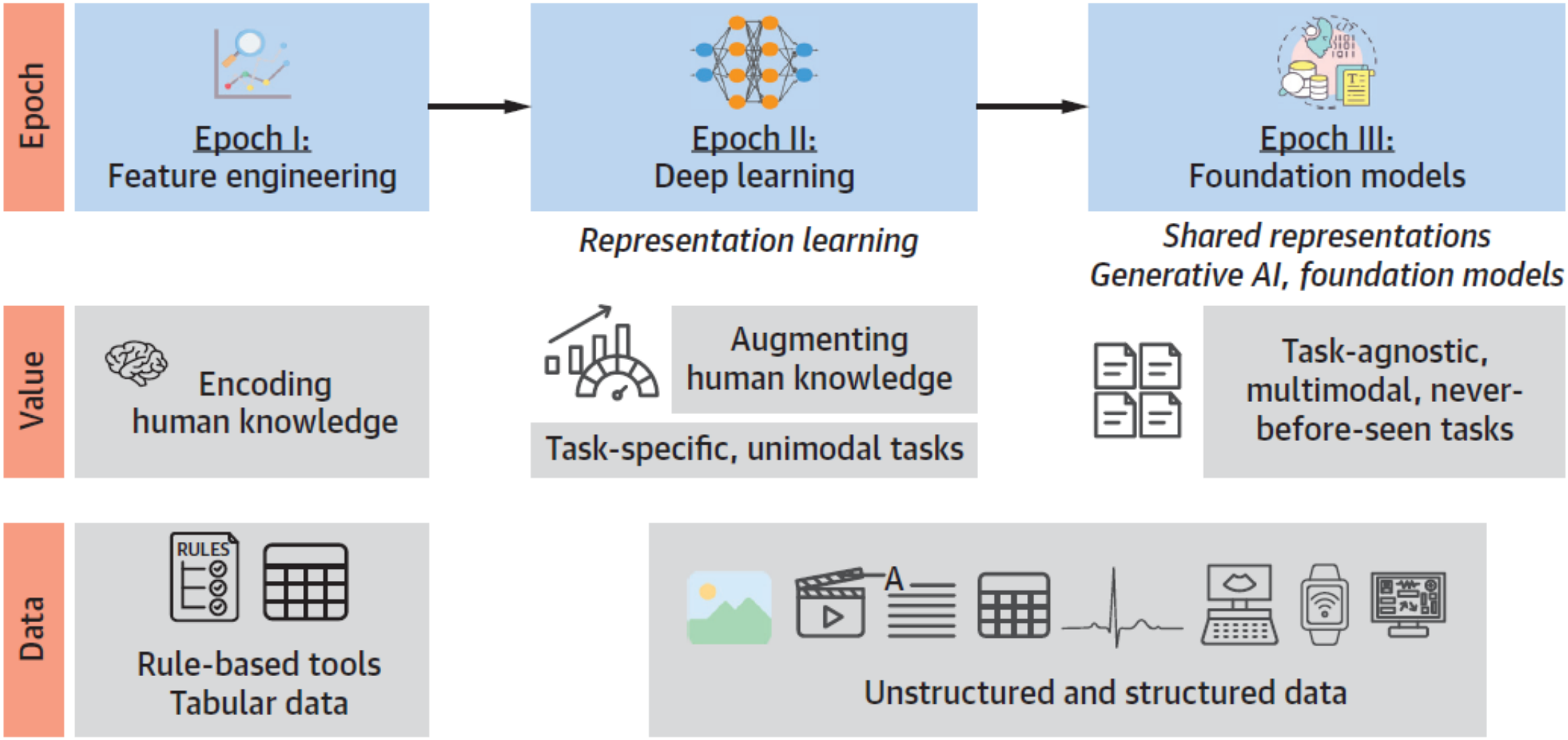
Performance of GPT 3.5/4 vs. Resident Physicians on the Board Examination

- GPT-4 performance was comparable with physicians (except Peds, Ob/Gyn)
- GPT-3.5 to GPT-4 marks a critical milestone of the maturity of LLM
- Potential synergy between LLM and physicians holds tremendous promise
- Adoption of LLMs in clinical practice is imminent

Tel Aviv University
Israel Medical Association

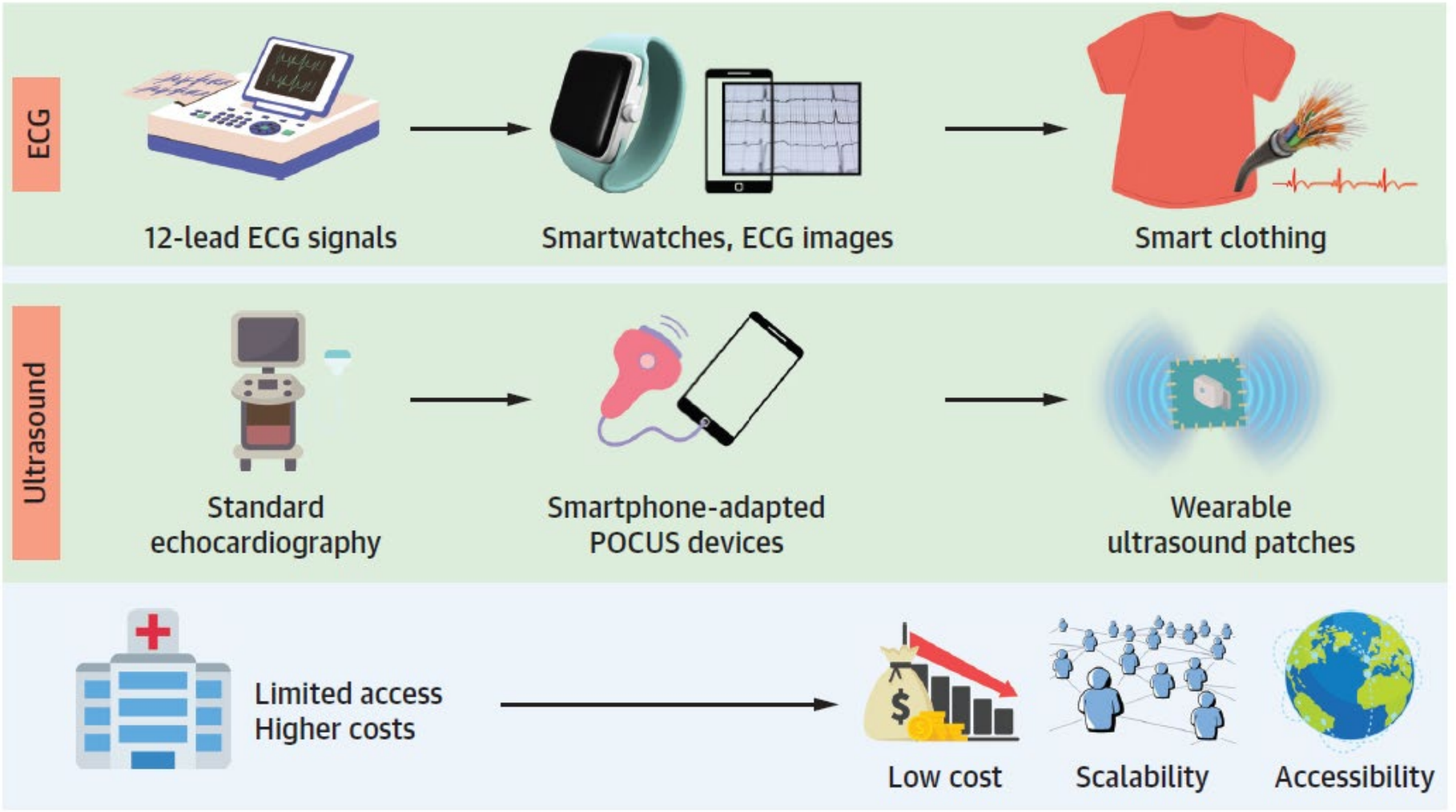
Katz U, et al. NEJM.AI 2024

The Technical Evolution of Medical AI

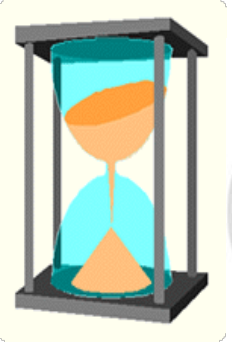


Howell MD, et al. JAMA 2024

Evolving Landscape of Scalable and Globally Accessible Technologies for Cardiovascular Disease Screening and Diagnosis



Khera, R. JACC. 2024



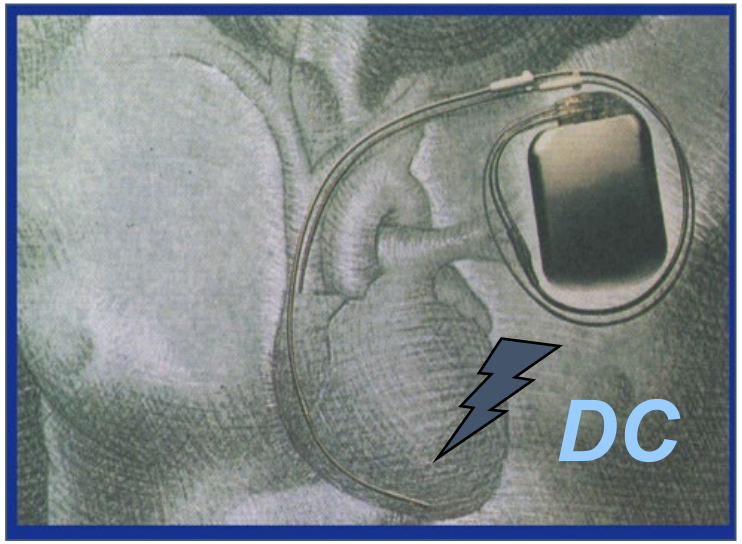
Cardiac Arrest Chain of Survival

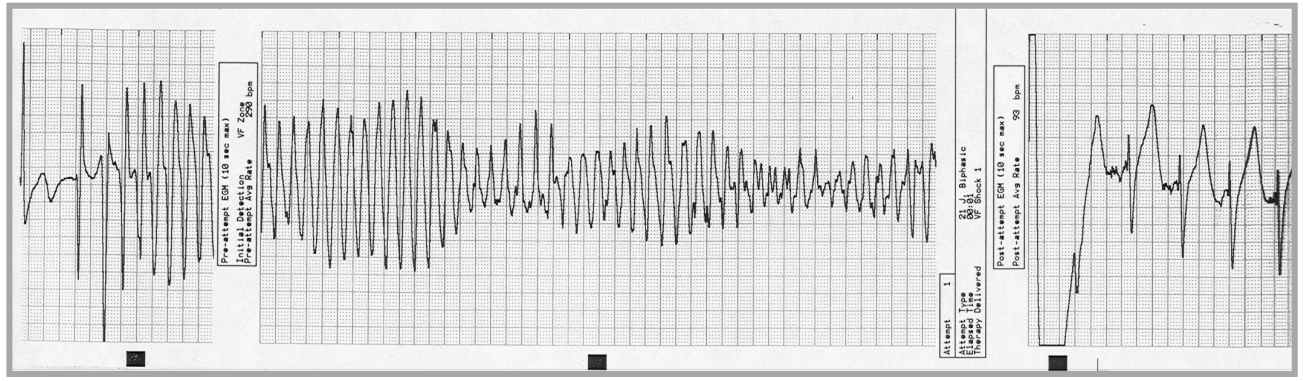
By the time 911 is called, too late for >90%
Out of 360K → 40K lives saved

Key Role for Prediction and Prevention

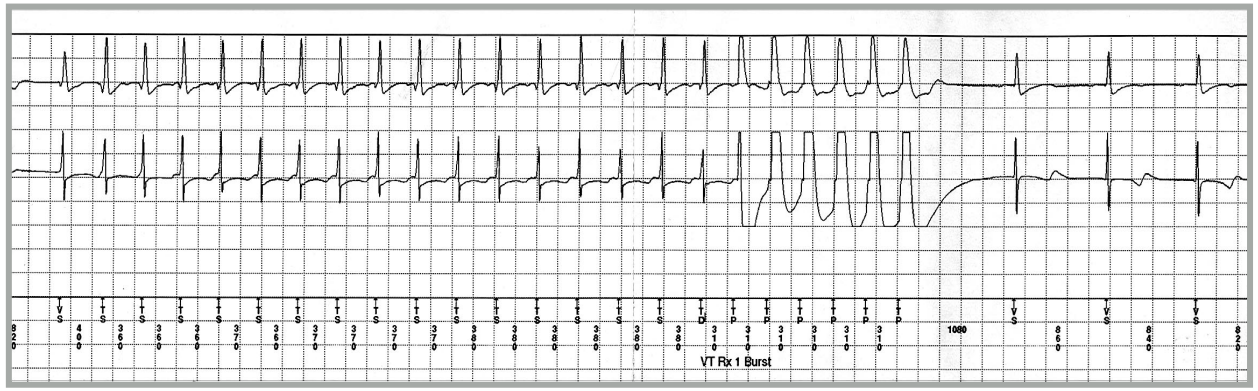
Cedars Sinai
SMIDT HEART INSTITUTE

Primary prevention Implantable Cardioverter-Defibrillator (ICD) Treats Sudden Cardiac Arrest with Immediate DC Shock





Main predictor of SCD risk:
LV ejection fraction <35%
No Longer Adequate

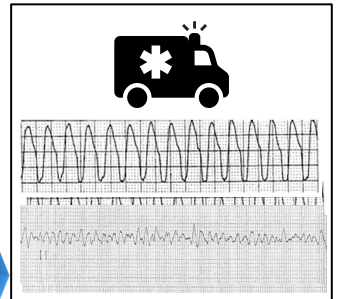


Cedars Sinai
SMIDT HEART INSTITUTE

SCA Risk Prediction Score Beyond the Ejection Fraction

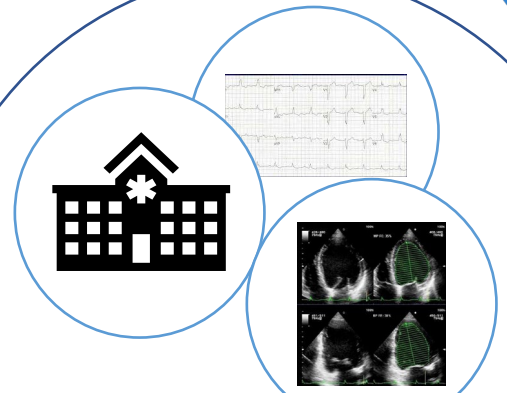
VFRisk Score (4000 subjects, 13 predictors, AUC 0.81; LVEF <35% AUC 0.64)

Community
(~ 1 million)



Out-of-hospital sudden cardiac arrest cases with documented VF/VT (33%)

Control group
(intermediate risk)



Analysis of lifetime clinical records, ECG, echocardiogram

Prediction Modeling

"VF*Risk*"
(13-variable VF/VT risk prediction score)

Internal Validation

External Validation
Separate Community
(~ 850K)

Equally effective across LVEF spectrum

Enhanced SCD risk stratification especially for mid-range & preserved LVEF

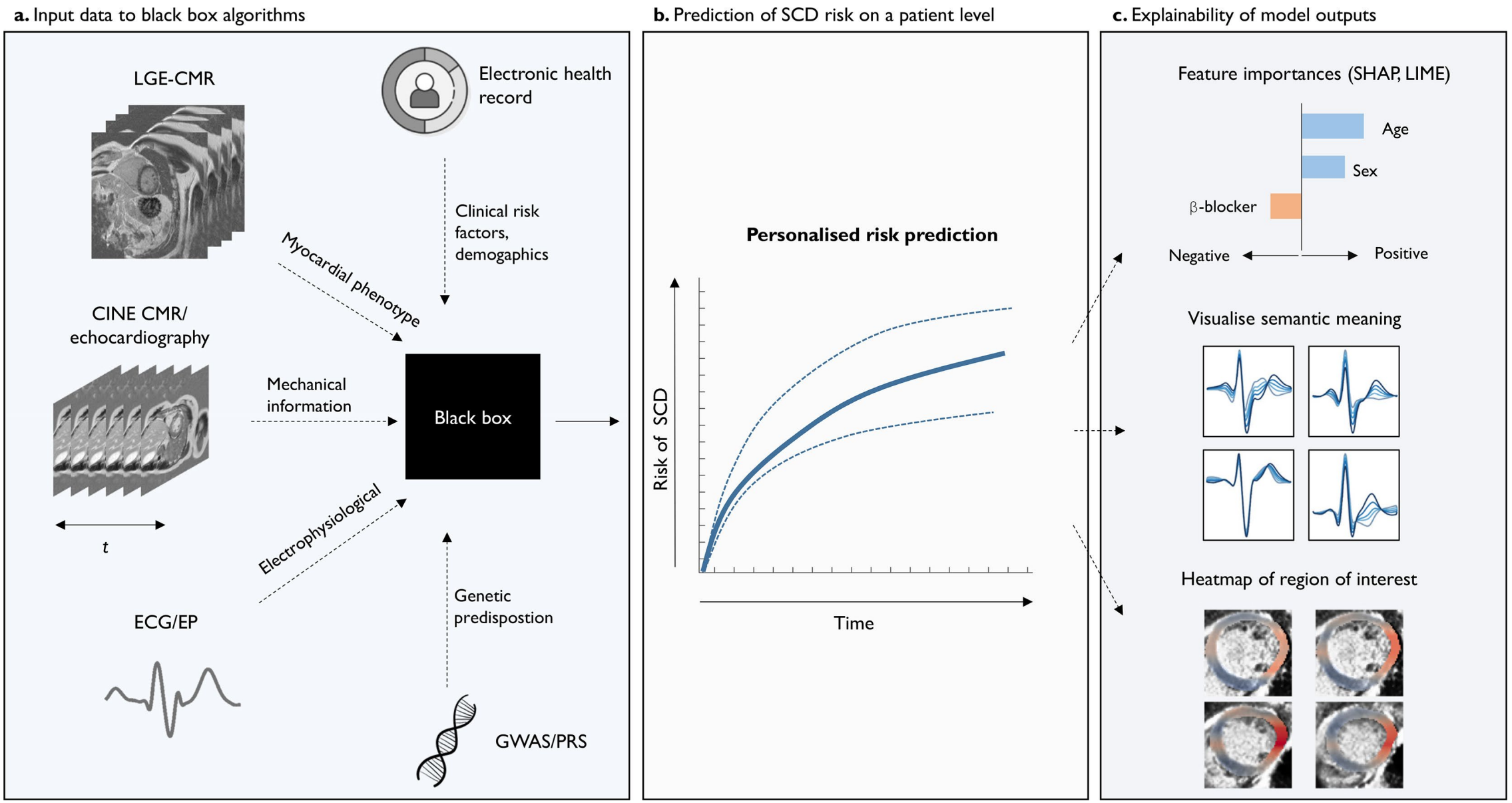
Novel clinical prediction algorithm for "Avertable SCD"

Cedars Sinai

Center for Cardiac Arrest Prevention
& Division of Artificial Intelligence

Chugh SS, et al. JACC Clinical Electrophysiology 2022

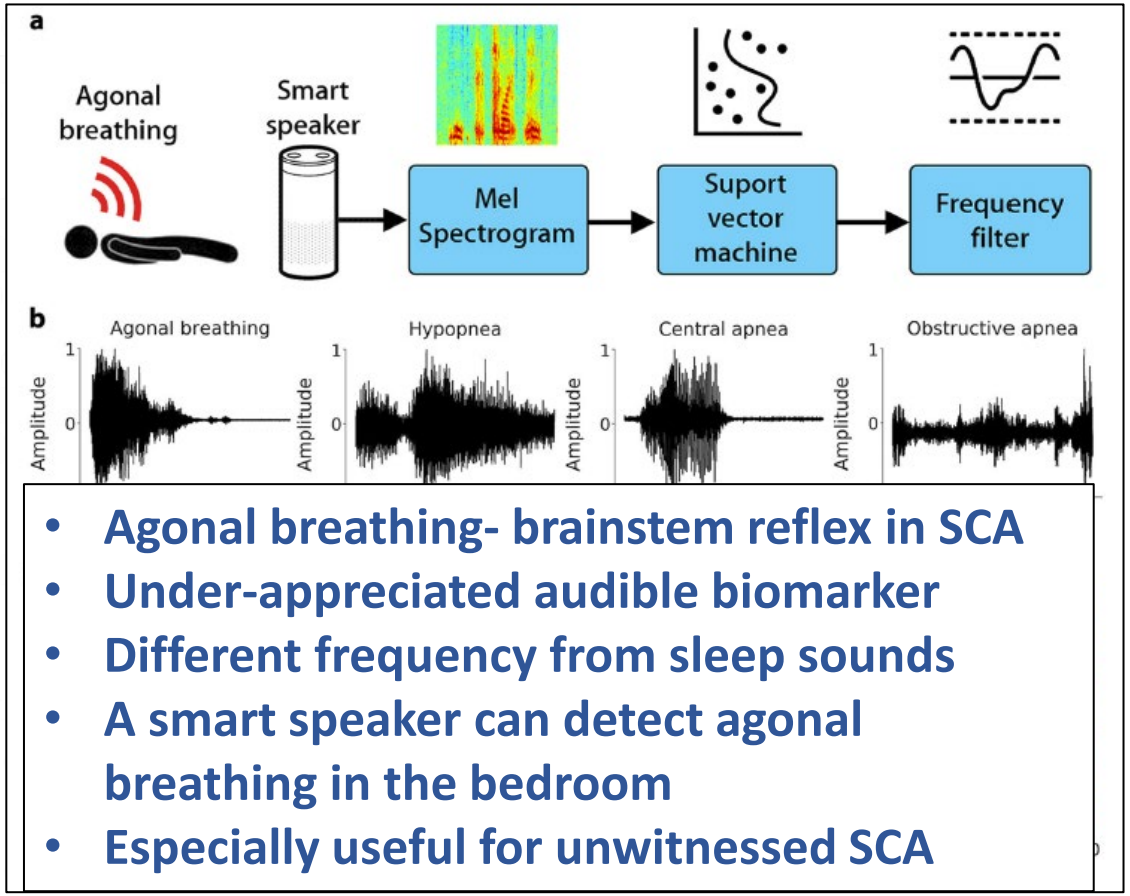
Multimodal AI-driven Prediction Models for Sudden Cardiac Arrest



Kolk MZH….Tjong FVY. Heart Rhythm J 2024

Early Detection

Sensors that can detect SCA quickly
Alarm → rapid deployment of AED

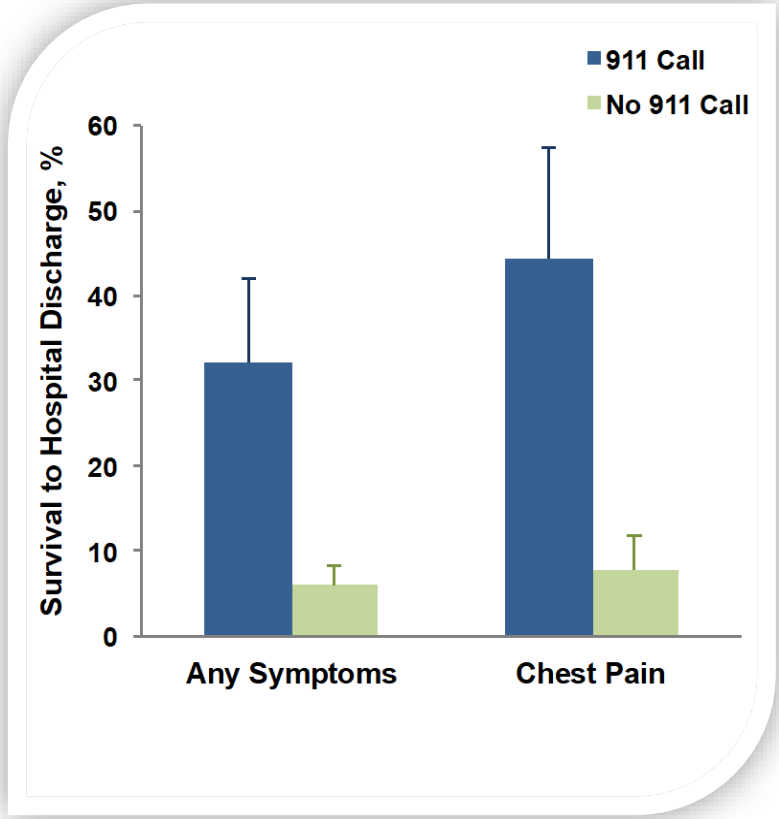


- Agonal breathing- brainstem reflex in SCA
- Under-appreciated audible biomarker
- Different frequency from sleep sounds
- A smart speaker can detect agonal breathing in the bedroom
- Especially useful for unwitnessed SCA

Chan J et al. NPJ digital medicine 2019

Early Prediction

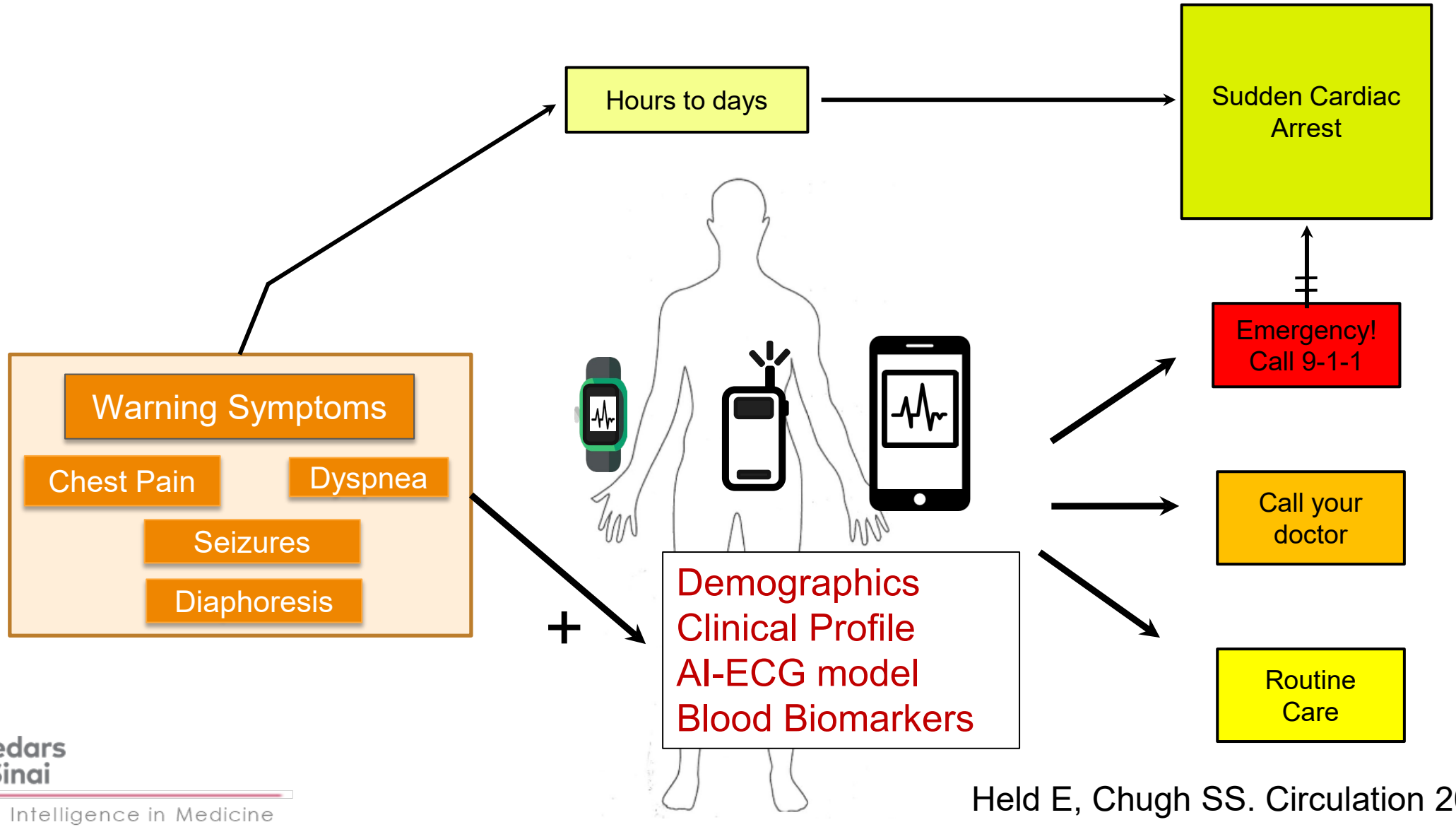
50-70% have SCA warning symptoms
Quicker response = Better survival



Marijon E....Chugh SS. Annals of Internal Med 2016

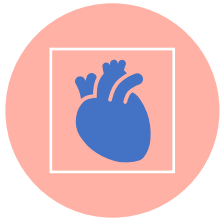
Prediction of Imminent Sudden Cardiac Arrest in the Community

Multi-modal AI: Combination of Symptoms + Clinical Profile + Biomarkers



Held E, Chugh SS. Circulation 2018

AI in Clinical Practice: Transforming Patient Care



AI REVOLUTION IN MEDICINE (HEART DISEASE)

WHY IS IT IMPORTANT?

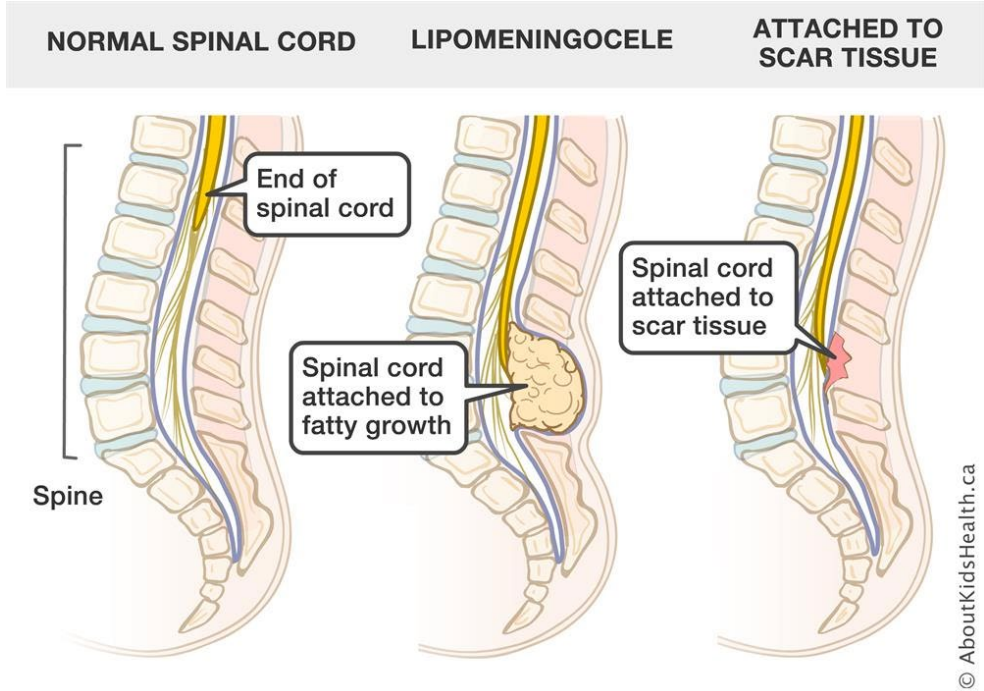
CHALLENGES AND HOW TO CONFRONT (“BAD THINGS”)?

IS THE RATE OF PROGRESS WHAT WE EXPECTED?

THE ONE CONCEPT THAT WILL TRANSFORM PATIENT CARE

A boy saw 17 doctors over 3 years for chronic pain. ChatGPT Made the Dx. Tethered Cord Syndrome: Diagnostic odyssey exposed structural issues

- Alex age 4 was experiencing pain and not meeting his milestones
- Mom: “I went line by line of everything that was in his (MRI notes) and plugged it into ChatGPT,” she says. “I put the note in there about … how he wouldn’t sit crisscross applesauce. To me, that was a huge trigger (that) a structural thing could be wrong.”



Meghan Holohan. Today magazine. Sep 2023

The need for AI to improve health care delivery should no longer be questioned

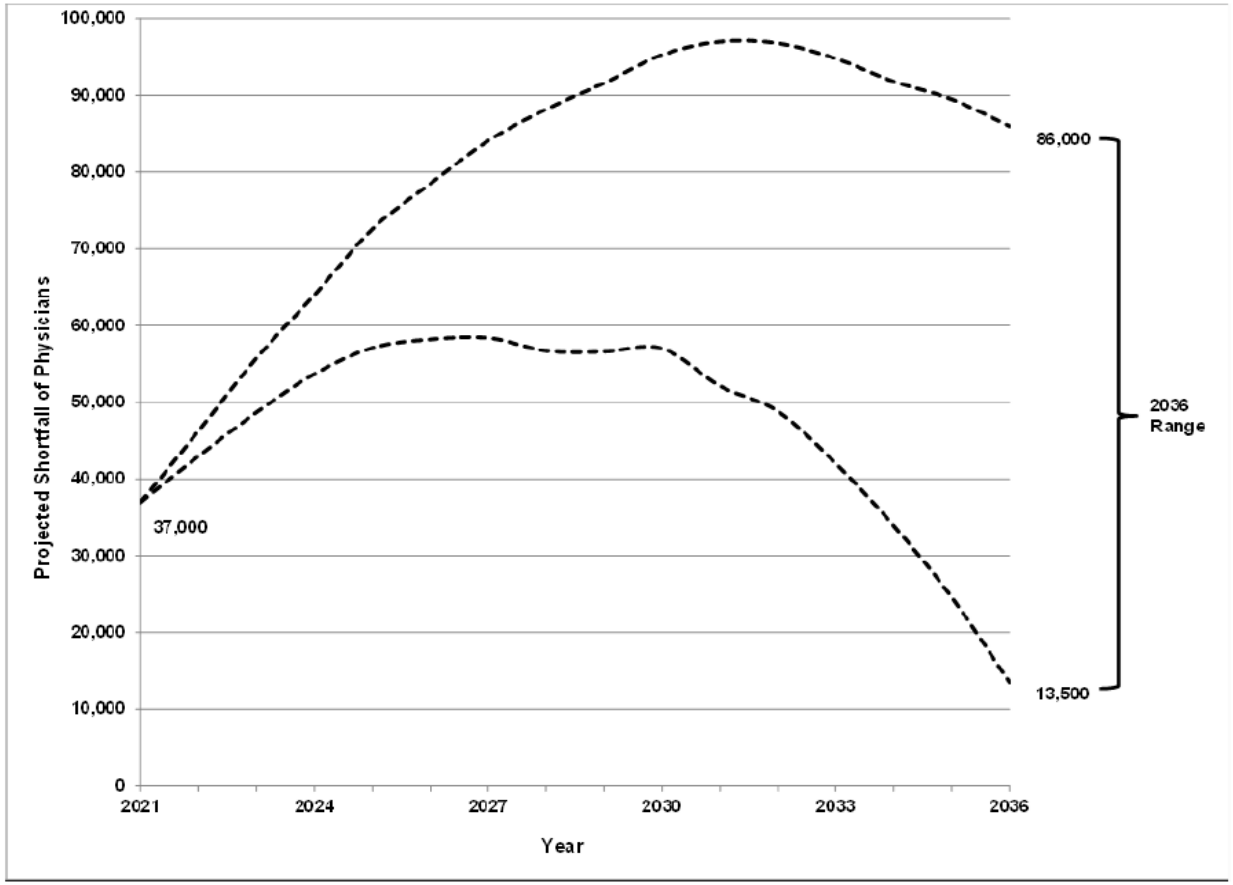
- Collective body of medical knowledge required to treat a patient: exponential ↑
- 1980: doubled every 7 years; 2010: doubled every 75 days.
- What medical students learn in their first 3 years = 6 % of known medical information at the time of their graduation
- Some knowledge still relevant, some outdated, some might not be complete
- AI has the potential to supplement a clinical team's knowledge to ensure up to date care
- Bringing that potential to reality has not been easy, but there are some successes

Sahani NR. NEJM 2023

Cedars Sinai
Artificial Intelligence in Medicine

Global Health Care Provider Shortage: USA Projections From 2021-36

Exhibit 2: Total Projected Physician Shortfall Range, 2021-2036



AAMC. Mar 2024

Sarkar U. JAMA Int Med 2024

Table. Potential Use Cases for AI in Primary Care

Use case	Examples of AI role
Inbox management	• Prioritize patient messages • Generate draft responses • Edit physician messages to optimize communication, including for literacy appropriateness
Clinician documentation	With transcription software: • Draft progress notes in real time during visits • Draft prior authorization, disability, and durable medical equipment requests • Draft a list of billing codes for visits
Between-visit panel management	• Accurately identify patients in need of cancer screening using unstructured and structured EHR data to determine exclusions • Identify patients with incomplete cancer screening (such as missed appointments), automate communication with patients, and provide scheduling and/or staff notification • Generate tailored messages to patients related to needed between-visit care needs
Individualized decision support	• Identify relevant information in structured and unstructured EHR data to prioritize differential diagnoses for new symptoms • Recommend medication options for chronic conditions, considering prior medication prescriptions, allergies, and intolerances noted in structured and unstructured EHR data

AI as a Health Care Catalyst: fundamental re-imagining of health care processes

Health Care Cost Savings: >$360 billion annually in U.S. health care

Optimize care delivery: Predictive analytics (ML) - anticipate patient needs, optimize resource allocation, and prevent adverse events.

Predict hospital readmissions: Manage patient flow in EDs through reinforcement learning algorithms

New drug therapies: *In silico* drug discovery ↓ time and associated cost

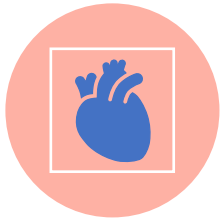
Clinical trial design optimized by AI

Ronanki R. NEJM.AI 2024

Cedars Sinai

Artificial Intelligence in Medicine

AI in Clinical Practice: Transforming Patient Care



ONGOING AI REVOLUTION IN MEDICINE (HEART DISEASE)

WHY IS IT IMPORTANT?

CHALLENGES AND HOW TO CONFRONT (“BAD THINGS”)?

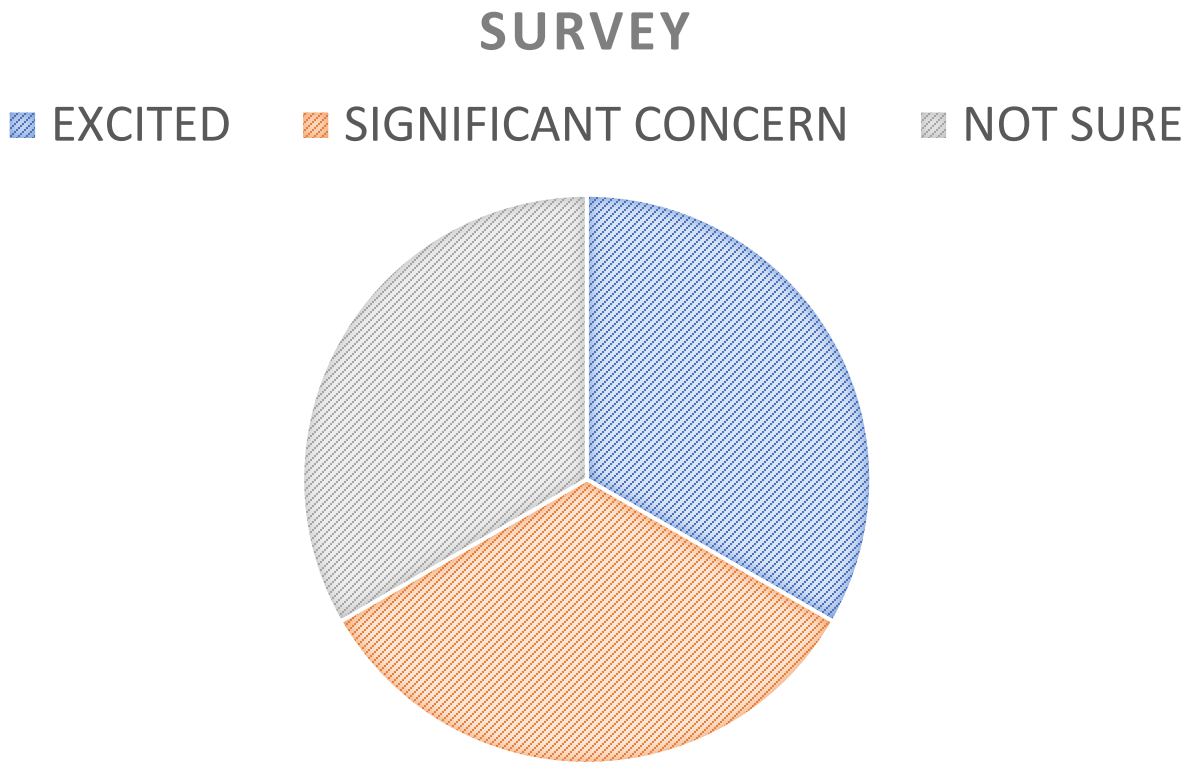
IS THE RATE OF PROGRESS WHAT WE EXPECTED?

THE ONE CONCEPT THAT WILL TRANSFORM PATIENT CARE

Skepticism Among Health Care Providers

Toward AI Integration in Health Care

AMA: Results of Augmented Intelligence in Medicine Survey



Getty Images

AMA. Augmented intelligence in medicine. April 5, 2024

Ethical challenges for AI in clinical practice

Uncertainty and distrust of AI predictions	Regulation and governance of AI	Shifts in responsibility introduced by using AI in clinical practice	Concerns about data privacy and security	Biased results that hurt marginalized groups
↓	↓	↓	↓	↓
Develop explainable algorithms and transparent model reporting	Standardize safe AI practices & establish thorough, transparent reporting	Develop frameworks for determining responsibilities and legal liability	Build infrastructure for safe data sharing	Measure & mitigate bias throughout the life cycle of medical AI

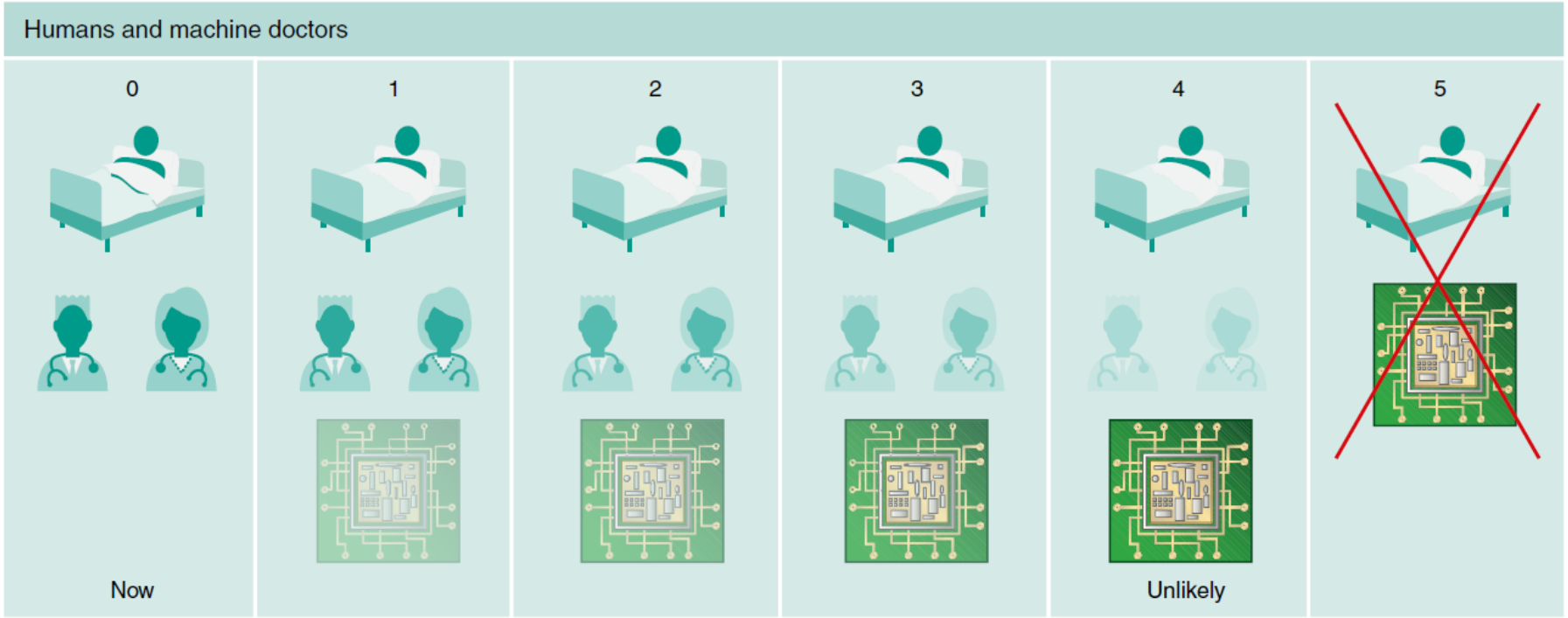
Adapted from Rajpurkar, P et al. Nature Medicine 2022

The Autonomous Car Analogy: Medical AI will not cross Level 3

Autonomous car

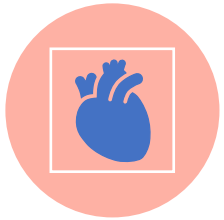
Human driver monitors environment			System monitors environment		
0	1	2	3	4	5
No automation	Driver assistance	Partial automation	Conditional automation	High automation	Full automation
The absence of any assistive features such as adaptive cruise control.	Systems that help drivers maintain speed or stay in lane but leave the driver in control.	The combination of automatic speed and steering control—for example, cruise control and lane keeping.	Automated systems that drive and monitor the environment but rely on a human driver for backup.	Automated systems that do everything—no human backup required—but only in limited circumstances.	The true electronic chauffeur: retains full vehicle control, needs no human backup, and drives in all conditions.

AI in patient care



Topol, EJ. Nature Medicine 2019

AI in Clinical Practice: Transforming Patient Care



ONGOING AI REVOLUTION IN MEDICINE (HEART DISEASE)

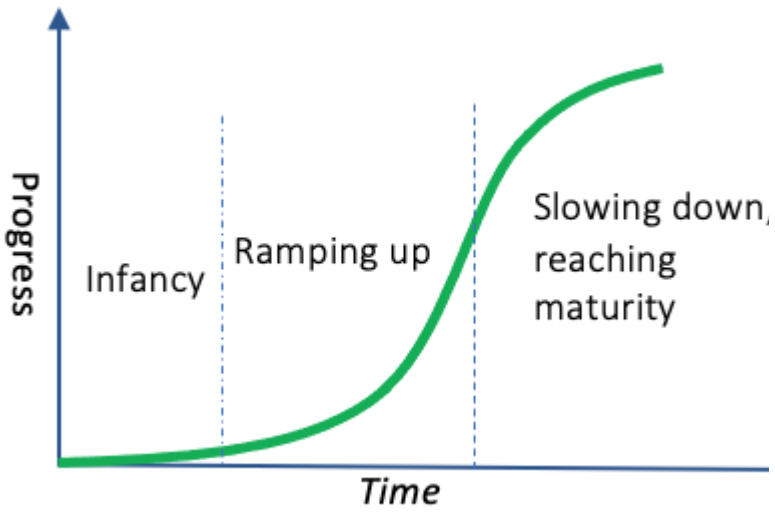
WHY IS IT IMPORTANT?

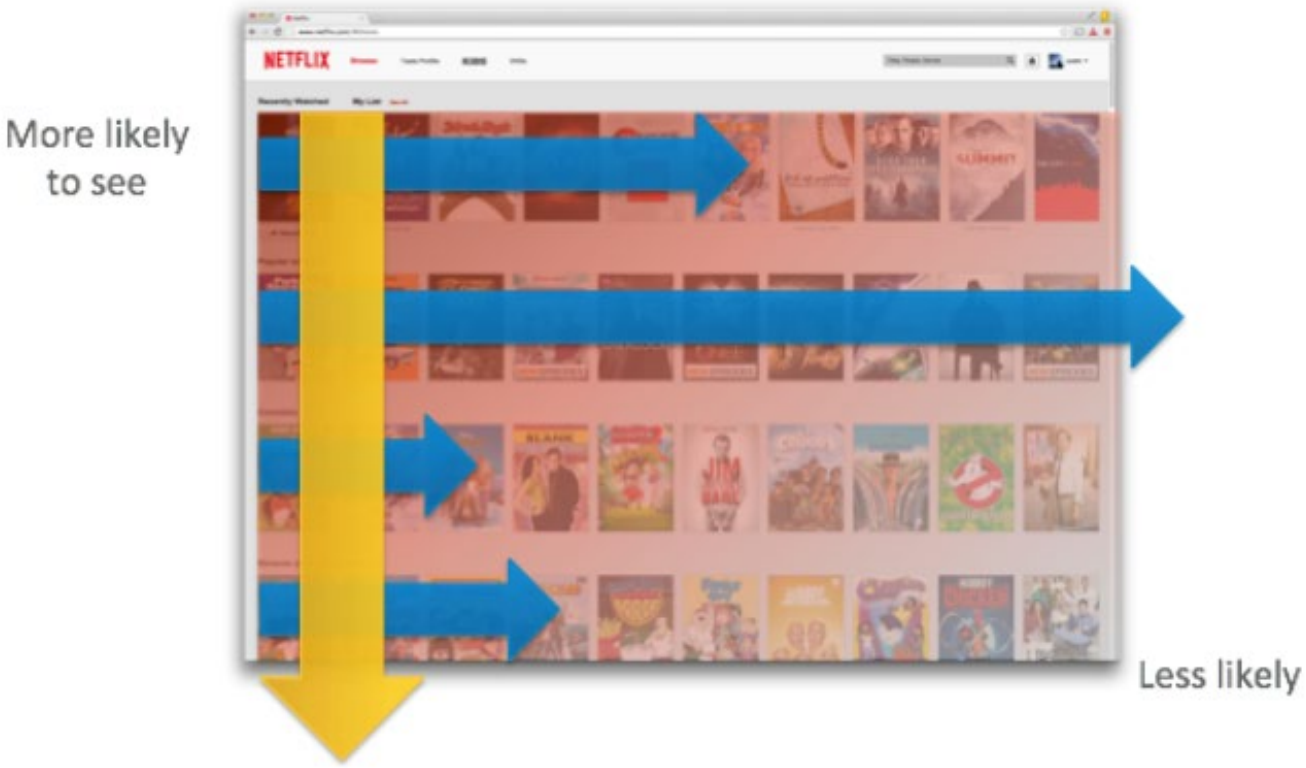
CHALLENGES AND HOW TO CONFRONT (“BAD THINGS”)?

IS THE RATE OF PROGRESS WHAT WE EXPECTED?

THE ONE CONCEPT THAT WILL TRANSFORM PATIENT CARE

Slow Adoption of AI in Health Care Delivery: Issues Outside Health Care Organizations





- Health care data is heterogeneous and variable (unlike data for movie recommendations)
- U.S uses fee-for service model but value-based payment models better for AI delivery
- Lack of patient confidence, legal issues
- Regulatory issues (FDA approval and reimbursement)

Sahani NR. NEJM 2023 (McKinsey & Co)

https://stratoflow.com/how-netflix-recommendation-algorithm-work/

Slow Adoption of AI : Finding Solutions Inside Health Care Organizations

1. *MISSION-LED ROAD MAP*
   - AI is a process/broader solution not a quick win/silver bullet
   - Focus on transformative potential not incremental opportunity
   - Focus on increased access, safety, quality, satisfaction not just financial factors
   - Pursuing selected priority domains with multiple uses of AI rather than many domains
2. *TALENT*
   - In an AI work force, long-term plan, make them AI-literate
3. *AGILE DELIVERY*
   - Develop institutional culture/consensus around AI, supported by adequate funding
4. *TECHNOLOGY & TOOLING*
   - Sufficient investment in infrastructure and tools for technology and data preparation
5. *DATA MANAGEMENT*
   - Minimize gaps, address data biases, availability/scale, establish governance
6. *CHANGE IN OPERATING MODEL OF THE ORGANIZATION*
   - Change management, workflow integration, cross-functional teams, transparency, operational output easy to understand, formal operational governance structure for implementation and management

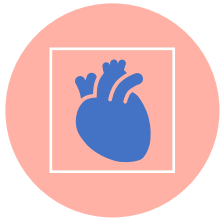
Sahani NR. NEJM 2023 (McKinsey & Co)

Low & Middle-Income Countries Upending the Model of AI Adoption

- 2016: Hinton predicted radiologists' extinction within 5 years
- 8 years later, radiologists have yet to be replaced, and radiology AI slow to be implemented in many high-income countries
- In high-income countries, business case for AI predicated on profit-driven models, vendors must show that AI will increase bottom line or reduce health-care costs
- LMIC faster due to philanthropic funding
- Starlink (satellite broadband) accessed in Everest Basecamp to detect HAPE
- Smartphone imaging with ultrasound (attach probe to the base, high resolution imaging) rapid Dx of pneumonia and HF
- *One day US health care might implement AI for chest x-rays just to catch up with Africa*

Jha, S. Lancet 2023

AI in Clinical Practice: Transforming Patient Care



ONGOING AI REVOLUTION IN MEDICINE (HEART DISEASE)

WHY IS IT IMPORTANT?

CHALLENGES AND HOW TO CONFRONT (“BAD THINGS”)?

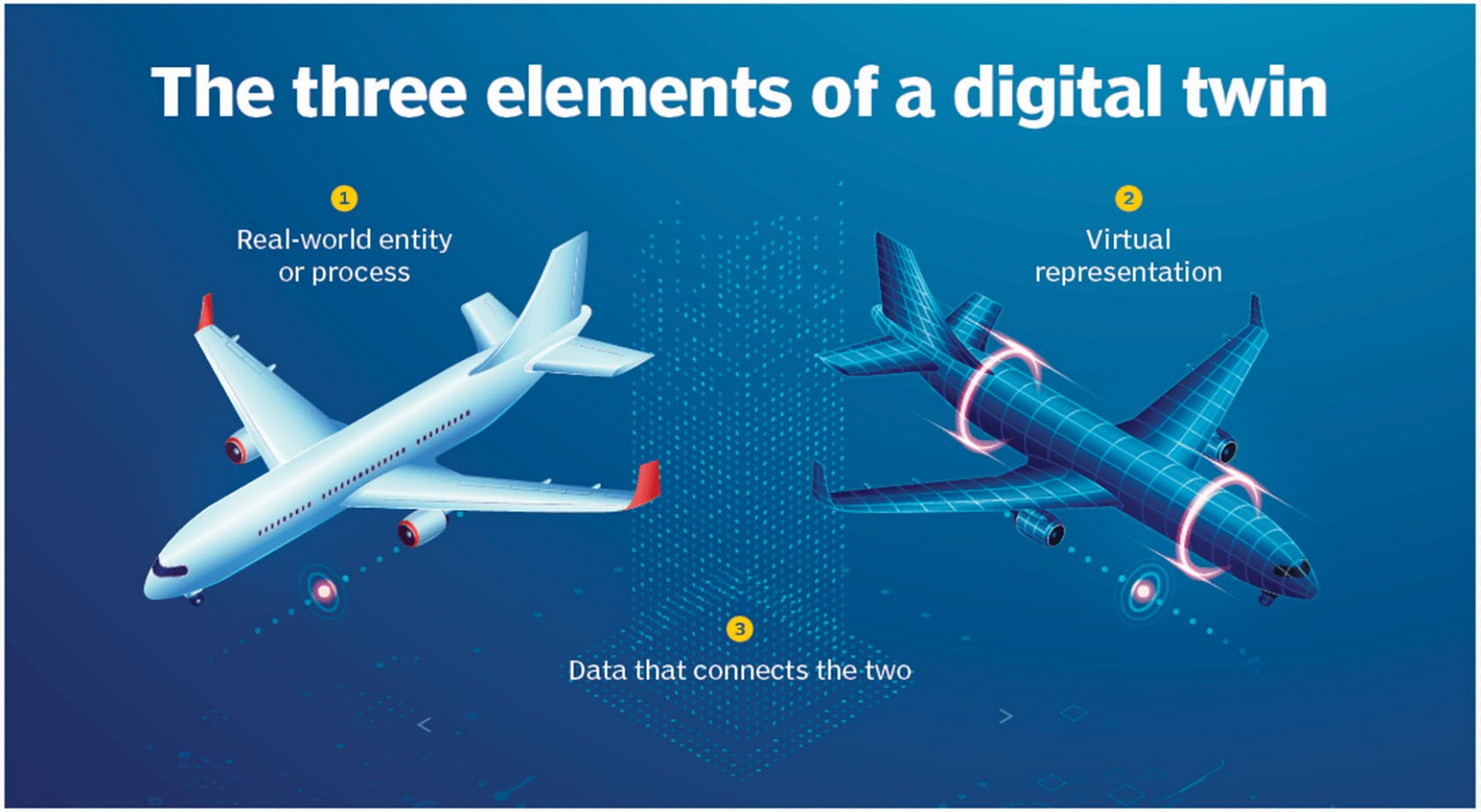
IS THE RATE OF PROGRESS WHAT WE EXPECTED?

THE ONE CONCEPT THAT WILL TRANSFORM PATIENT CARE

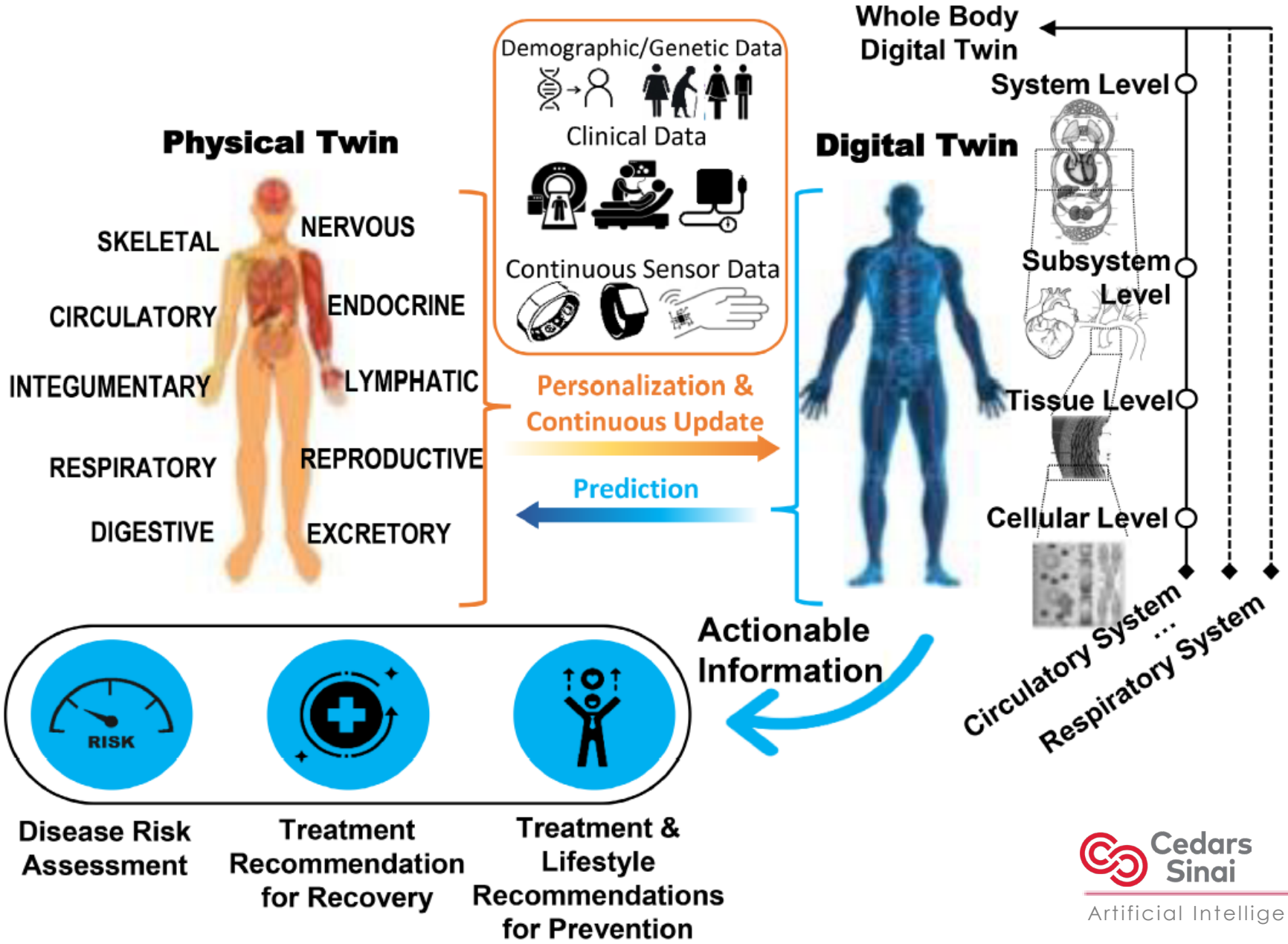

Dunland
Isengard
North-South Road
Fords of Isen
WESTFOLD
Helm's Deep
Edoras
Snowbourn

Digital Twin Technology

First used in NASA's Apollo in 1970s; GE created Digital Twin model for aircraft engines



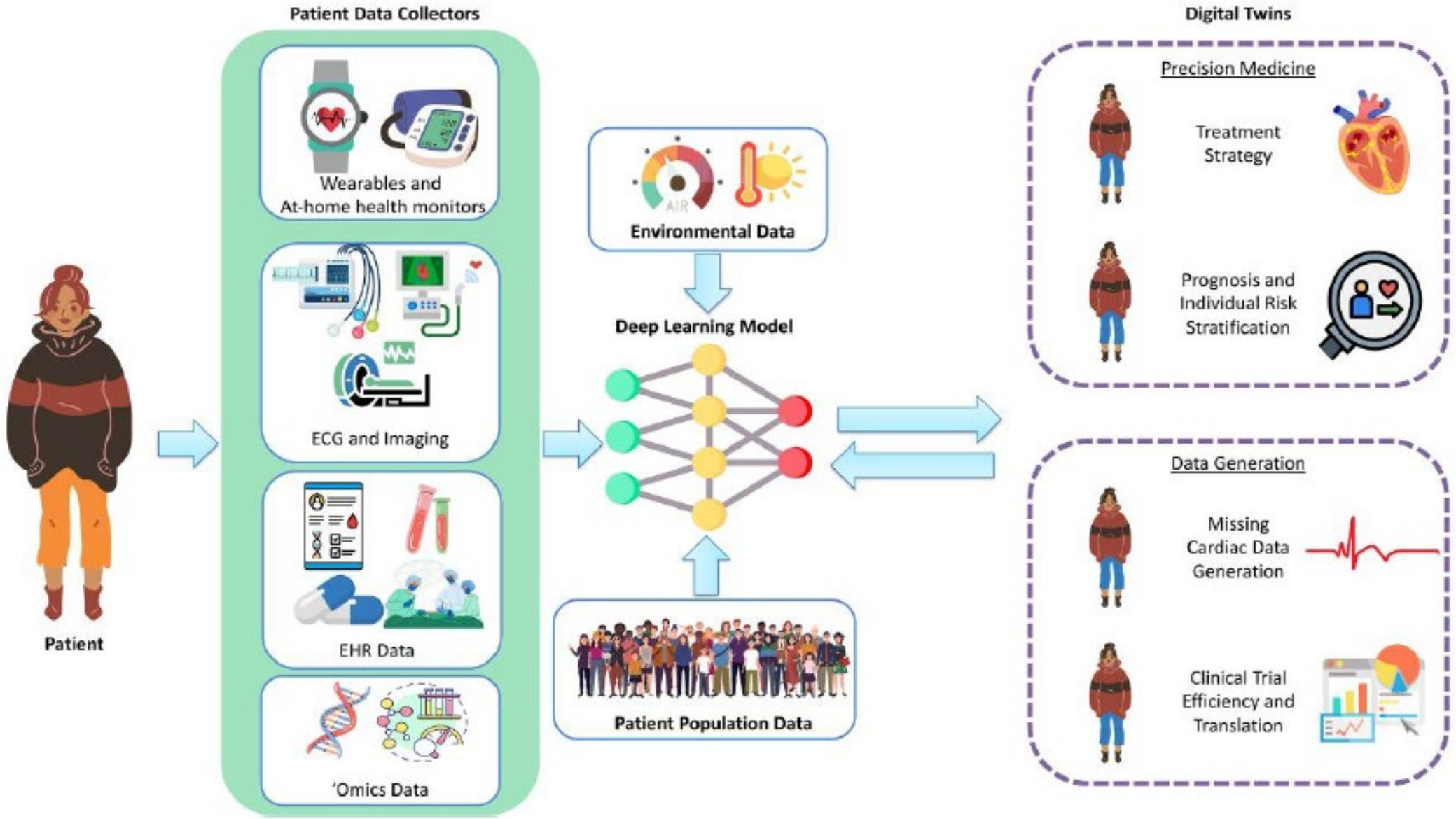
The Whole-body Digital Twin Concept



Sel, K et al. JAHA 2024

Cedars Sinai
Artificial Intelligence in Medicine

Potential cardiovascular clinical applications of digital twins



Thangaraj PM, et al. Eur Heart J 2024

A step-by-step clinical vignette modeling the future of healthcare with digital twins

Ms. K is a 76-year-old woman with heart failure with preserved ejection fraction (HFpEF), type 2 diabetes, hypertension, and obesity and is currently walking outside.

Her smartwatch detects and records in her medical digital twin:

- *A 6-second episode of atrial fibrillation*
- *A modest decrease in oxygen saturation*
- *An outdoor temperature of 35°C with 70% humidity, Air Quality Index: 125*

Her wireless blood pressure cuff records in her digital twin: 170/93

Her arrhythmia and elevated blood pressure have triggered her EHR to run an LLM extracting:

- *Relevant medical history, vital signs, ECGs, cardiac imaging, medications*
- *A previous echocardiogram report noting: "diastolic dysfunction" and an "enlarged left atrium"*
- *A recent clinic note recommending: "Pause HCTZ due to a decrease in potassium and rise in uric acid."*

The digital twin model has determined: Ms. K is likely to experience a heart failure exacerbation. It then:

- *Runs simulations of different blood pressure and diuretic medications on her outcome*
- *Compares this patient's digital twin to others who are similar in profile*
- *Draws on its knowledge of relevant randomized clinical trials and guidelines.*

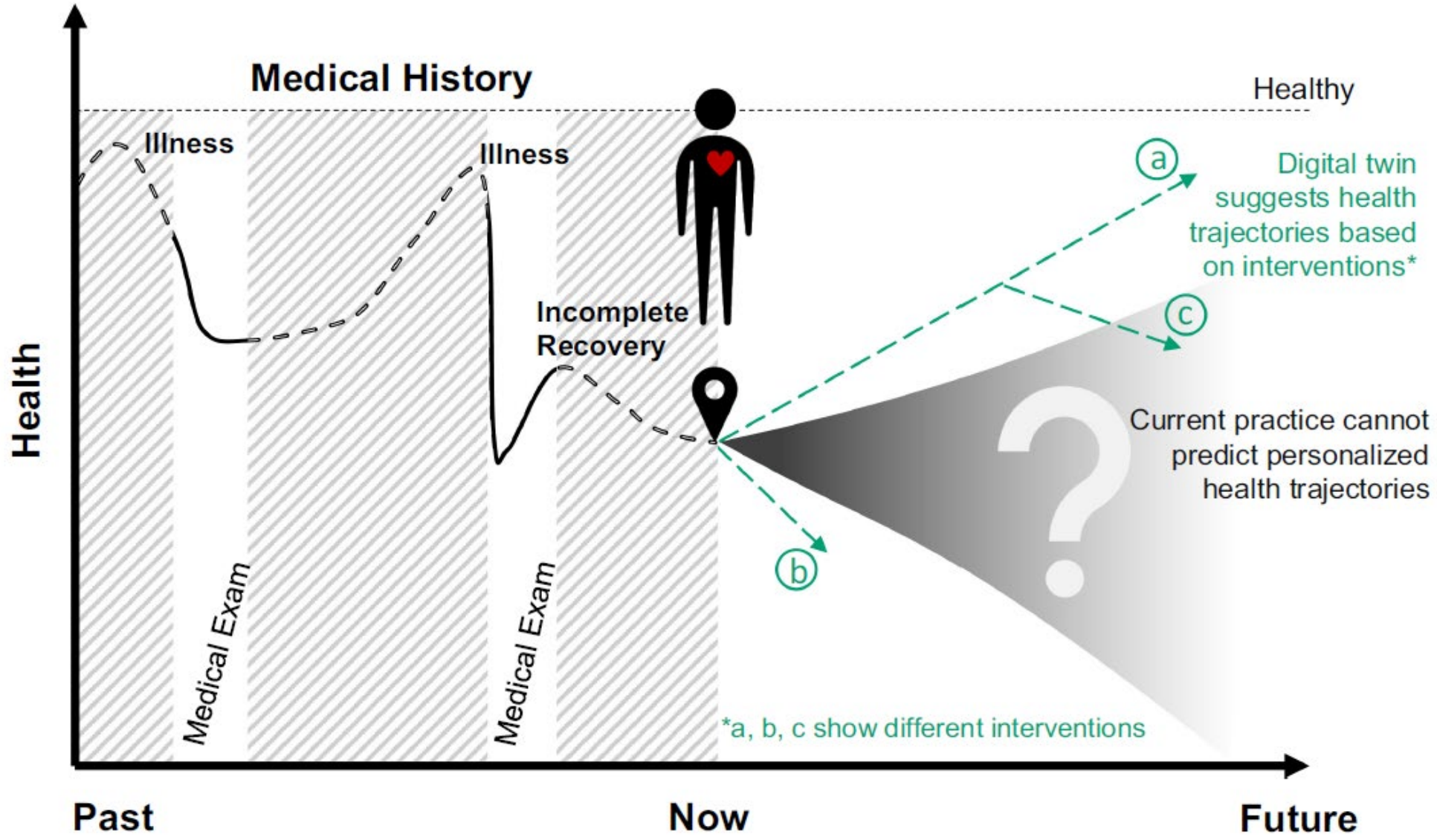
The digital twin Ms. K's physician with a recommendation:

- *Undergo a basic metabolic panel*
- *Restart HCTZ, initiate low-dose furosamide, and start an SGLT2 inhibitor and spironolactone*

Ms. K's physician then verifies the recommendation summary and contacts Ms. K with a plan. The model finally updates its training with this episode to inform future predictions.

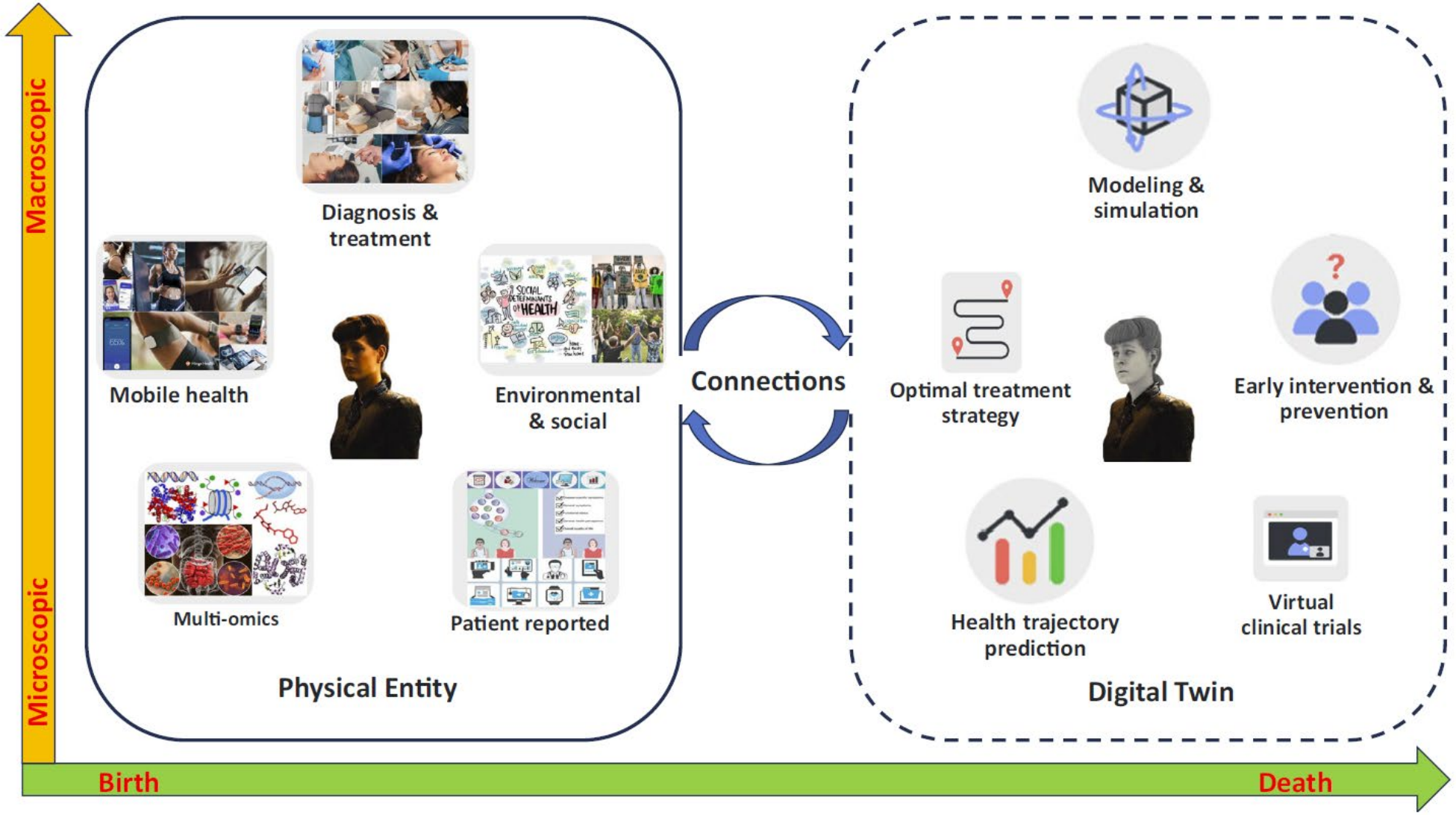
Thangaraj PM, et al. Eur Heart J 2024

Digital Twin: Prediction of personalized health trajectories



Sel, K et al. JAHA 2024

The Ultimate Digital Twin: Health Avatar for Life



Katsoulakis E, et al. NPJdigmed 2024

AI in Clinical Practice: Transforming Patient Care
Summary

- AI clearly has the potential to transform patient care; the AI in Medicine revolution is here
- We are applying the discoveries of the first and second epochs, but adoption of newer applications has been slower than anticipated
- As we move to more advanced AI tools, we will require higher quality, real-world data that is unbiased, interoperable and secure.
- In addition to ongoing AI discovery, we need to focus on solutions to challenges in the larger environment as well as within our institutions
- In the short term we can enable this patient care transformation by developing meaningful AI applications that achieve measurable improvements in outcomes and costs
- In the medium to long term, ongoing evolution of the Digital Twin will be the key to transforming patient care in clinical practice

Cedars Sinai

Artificial Intelligence in Medicine

Cedars Sinai

SMIDT HEART INSTITUTE