

Leveraging Artificial Intelligence and Machine Learning to Support Diagnostic Reasoning

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Internal Medicine, Pediatrics, and Learning Health Sciences

I do not have any disclosures

Artificial Intelligence

- Use of computers to perform tasks that require objective reasoning and understanding
- Multiple domains
 - Machine learning, deep learning, natural language processing, etc.
 - Subdomains
- Narrow (task specific) vs general/generative
- “Three Epochs”

Figure. Artificial Intelligence (AI) 1.0, 2.0, and 3.0



Howell MD, Corrado GS, DeSalvo KB. Three epochs of artificial intelligence in health care. *JAMA*. 2024;331(3):242-244.

Epoch



Epoch I:
Feature engineering

Value



Encoding
human knowledge

Data



Rule-based tools
Tabular data

DXplain

An Evolving Diagnostic Decision-Support System

G. Octo Barnett, MD; James J. Cimino, MD; Jon A. Hupp, MD; Edward P. Hoffer, MD

SPECIAL ARTICLE

***INTERNIST-I*, AN EXPERIMENTAL COMPUTER-BASED DIAGNOSTIC CONSULTANT FOR GENERAL INTERNAL MEDICINE**

RANDOLPH A. MILLER, M.D., HARRY E. POPLER, JR., PH.D., AND JACK D. MYERS, M.D.

Buchanan
Shortliffe

**RULE-
BASED
EXPERT
SYSTEMS**

**RULE-BASED
EXPERT SYSTEMS**
THE **MYCIN** EXPERIMENTS OF THE STANFORD
HEURISTIC PROGRAMMING PROJECT

Bruce G. Buchanan
Edward H. Shortliffe

Khera R, Oikonomou EK, Nadkarni GN, et al. Transforming Cardiovascular Care With Artificial Intelligence: From Discovery to Practice: JACC State-of-the-Art Review. *J Am Coll Cardiol*. 2024;84(1):97-114.



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Epoch II: Deep learning

Representation learning

Augmenting
human knowledge

Task-specific, unimodal tasks



Unstructured and structured data

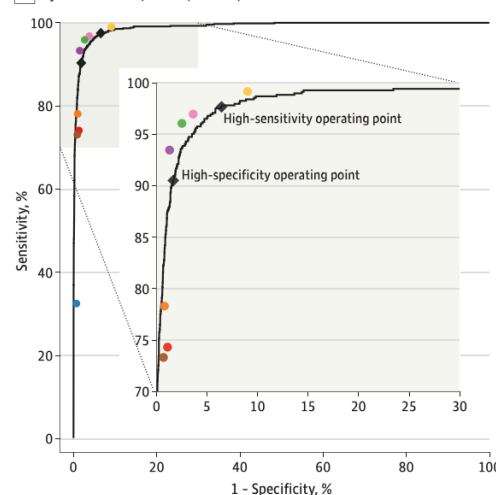
Research

JAMA | **Original Investigation** | **INNOVATIONS IN HEALTH CARE DELIVERY**

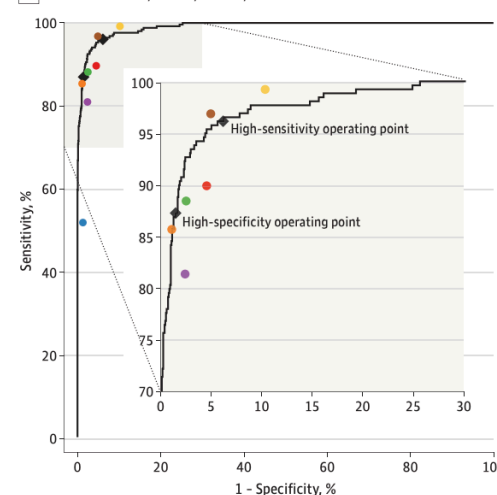
Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs

Varun Gulshan, PhD; Lily Peng, MD, PhD; Marc Coram, PhD; Martin C. Stumpe, PhD; Derek Wu, BS; Arunachalam Narayanaswamy, PhD; Subhashini Venugopalan, MS; Kasumi Widner, MS; Tom Madams, MEng; Jorge Cuadros, OD, PhD; Ramasamy Kim, OD, DNB; Rajiv Raman, MS, DNB; Philip C. Nelson, BS; Jessica L. Mega, MD, MPH; Dale R. Webster, PhD

A EyePACS-1: AUC, 99.1%; 95% CI, 98.8%-99.3%



B Messidor-2: AUC, 99.0%; 95% CI, 98.6%-99.5%



Khara R, Oikonomou EK, Nadkarni GN, et al. Transforming Cardiovascular Care With Artificial Intelligence: From Discovery to Practice: JACC State-of-the-Art Review. *J Am Coll Cardiol*. 2024;84(1):97-114.



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A multimodal generative AI copilot for human pathology

<https://doi.org/10.1038/s41586-024-07618-3>

Received: 11 December 2023

Accepted: 28 May 2024

Published online: 12 June 2024

Ming Y. Lu^{1,2,3,4,11}, Bowen Chen^{1,2,11}, Drew F. K. Williamson^{1,2,3,11}, Richard J. Chen^{1,2,3}, Melissa Zhao^{1,2}, Aaron K. Chow⁵, Kenji Ikemura^{1,2}, Ahrong Kim^{1,6}, Dimitra Pouli^{1,2}, Ankush Patel⁷, Amr Soliman⁵, Chengkuan Chen¹, Tong Ding^{1,8}, Judy J. Wang¹, Georg Gerber¹, Ivy Liang^{1,8}, Long Phi Le², Anil V. Parwani⁵, Luca L. Weishaupt^{1,9} & Faisal Mahmood^{1,2,3,10}✉

Epoch III: Foundation models



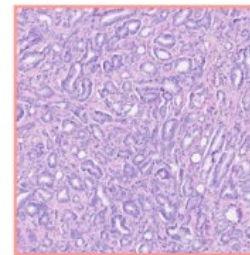
Shared representations

Generative AI, foundation models

Task-agnostic,
multimodal, never-
before-seen tasks



Unstructured and structured data



Assess the tissue morphology in this prostate resection. What Gleason patterns are present?

Human

PathChat

The tissue morphology in this prostate resection reveals a combination of two distinct Gleason patterns. The first pattern is characterized by the presence of small, well-formed glands, which is indicative of Gleason pattern 3. The second pattern is characterized by the presence of fused glands, which is indicative of Gleason pattern 4. The presence of both patterns within the same tissue sample suggests a Gleason score of 7 (3+4), which is a moderately aggressive form of prostate cancer.

Khera R, Oikonomou EK, Nadkarni GN, et al. Transforming Cardiovascular Care With Artificial Intelligence: From Discovery to Practice: JACC State-of-the-Art Review. *J Am Coll Cardiol*. 2024;84(1):97-114.



Measuring the Impact of AI in the Diagnosis of Hospitalized Patients A Randomized Clinical Vignette Survey Study

Sarah Jabbour, MSE; David Fouhey, PhD; Stephanie Shepard, PhD; Thomas S. Valley, MD;
Ella A. Kazerooni, MD, MS; Nikola Banovic, PhD; Jenna Wiens, PhD; Michael W. Sjoding, MD

Research

External Validation of a Widely Implemented Proprietary Sepsis Prediction Model in Hospitalized Patients

Andrew Wong, MD; Erkin Otles, MEng; John P. Donnelly, PhD; Andrew Krumm, PhD; Jeffrey McCullough, PhD;
Olivia DeTroyer-Cooley, BSE; Justin Pestrue, MEcon; Marie Phillips, BA; Judy Konye, MSN, RN;
Carleen Penozza, MHSA, RN; Muhammad Ghous, MBBS; Karandeep Singh, MD, MMSc



Article

<https://doi.org/10.1038/s41591-024-02850-w>

Heterogeneity and predictors of the effects of AI assistance on radiologists

Received: 22 June 2023

Accepted: 1 February 2024

Feiyang Yu^{1,2,5}, Alex Moehring^{3,5}, Oishi Banerjee¹, Tobias Salz^{4,6},
Nikhil Agarwal^{4,6} & Pranav Rajpurkar^{1,6}✉

RESEARCH

RESEARCH ARTICLE

ECONOMICS

Dissecting racial bias in an algorithm used to manage the health of populations

Ziad Obermeyer^{1,2*}, Brian Powers³, Christine Vogeli⁴, Sendhil Mullainathan^{5*}†



AI and Clinicians

- Continuum of interaction
 - Assist vs Automate
 - Task-dependent

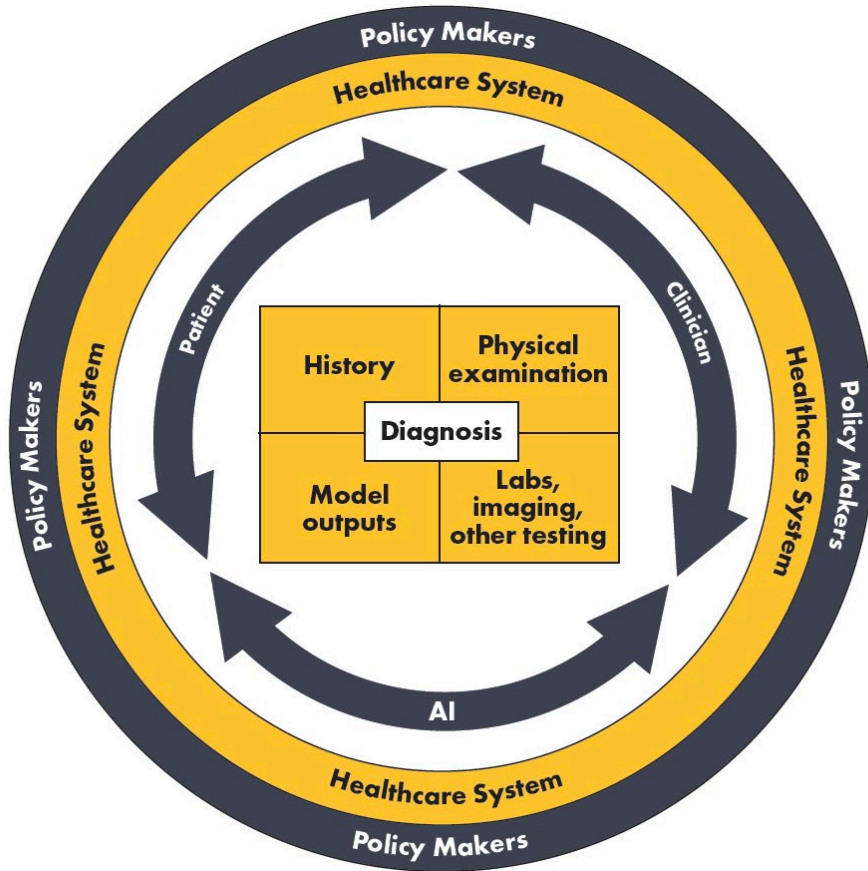
- Patient and physician autonomy

- Human (clinician/patient) “in the loop”

	Assistive AI algorithms		Autonomous AI algorithms		
	Level 1	Level 2	Level 3	Level 4	Level 5
	 Data presentation	 Clinical decision-support	 Conditional automation	 High automation	 Full automation
Event monitoring	AI	AI	AI	AI	AI
Response execution	Clinician	Clinician and AI	AI	AI	AI
Fallback	Not applicable	Clinician	AI, with a backup clinician available at AI request	AI	AI
Domain, system, and population specificity	Low	Low	Low	Low	High
Liability	Clinician	Clinician	Case dependent	AI developer	AI developer
Example	AI analyses mammogram and highlights high-risk regions	AI analyses mammogram and provides risk score that is interpreted by clinician	AI analyses mammogram and makes recommendation for biopsy, with a clinician always available as backup	AI analyses mammogram and makes biopsy recommendation, without a clinician available as backup	Same as level 4, but intended for use in all populations and systems

Adler-Milstein J, Aggarwal N, Ahmed M, et al. Meeting the Moment: Addressing Barriers and Facilitating Clinical Adoption of Artificial Intelligence in Medical Diagnosis. *NAM Perspect.* 022:10.31478/202209c.

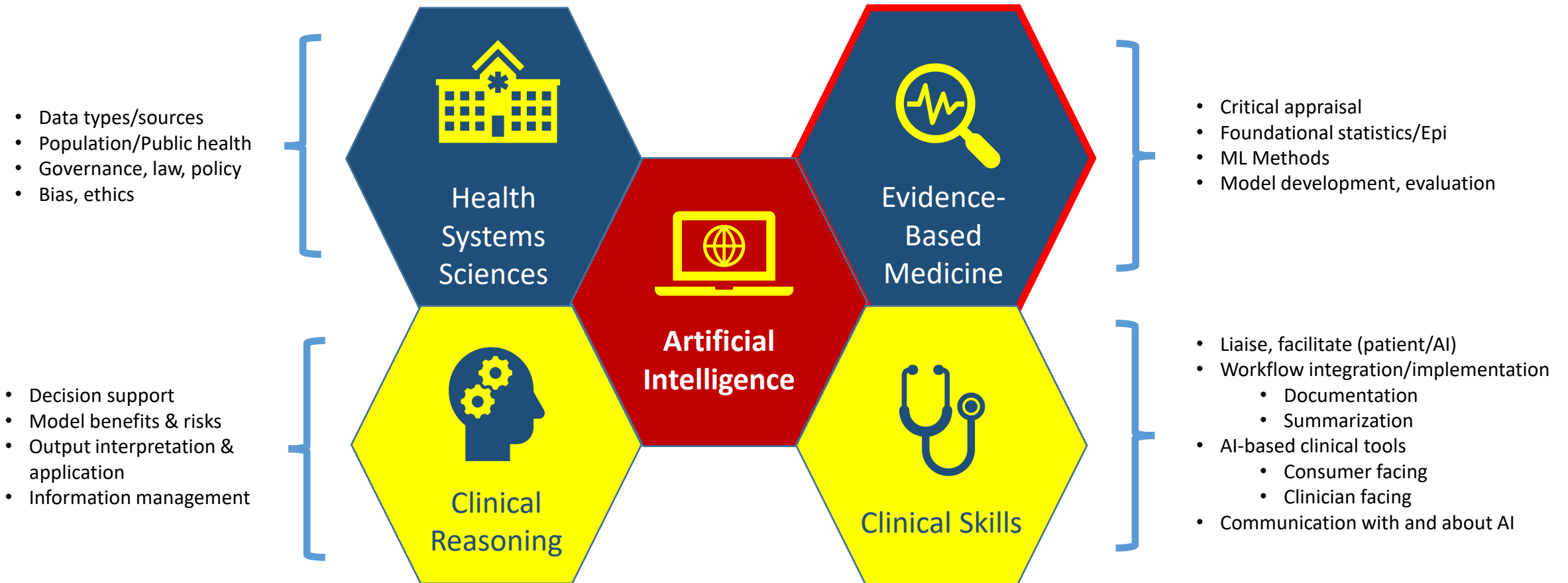
Triadic Patient-Clinician-AI Teams



- Tri-directional exchange
 - Patient-clinician-AI collaboration
- Augmented intelligence
- Distributed cognition
 - Cognitive offloading
 - Determinants, consequences
 - Administrative, clinical
 - Reskilling, upskilling, deskilling

1. James CA, Singh K, Valley TS, Wiens J. Issue Brief 13. Reimagining health care teams: leveraging the patient-clinician-AI triad to improve diagnostic safety. Rockville, MD: Agency for Healthcare Research and Quality; July 2023.
2. Grinschgl S, Neubauer AC. Supporting cognition with modern technology: distributed cognition today and in an AI-enhanced future. Frontiers in AI. 2022.

Integration



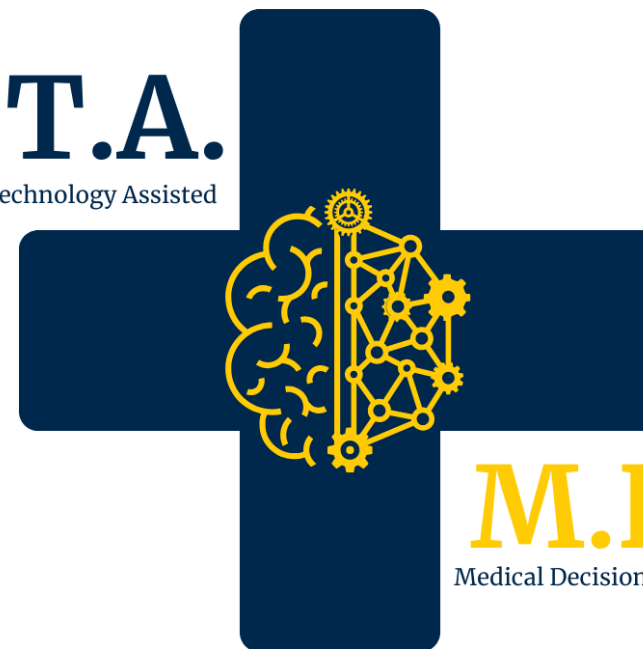
1. James CA, Wheelock KM, Woolliscroft JO. Machine learning: the next paradigm shift in medical education. *Acad Med*. 2021;96(7): 954-957.
2. James CA, Wachter RM, Woolliscroft JO. Preparing Clinicians for a Clinical World Influenced by Artificial Intelligence. *JAMA*. 2022;327(14):1333-1334.





D.A.T.A.

Data Augmented, Technology Assisted



M.D.

Medical Decision Making



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Thank You!

“Medicine is the science of uncertainty and the art of probability”

- William Osler