# Artificial Intelligence: Implications for Healthcare Practice, Research, and Education

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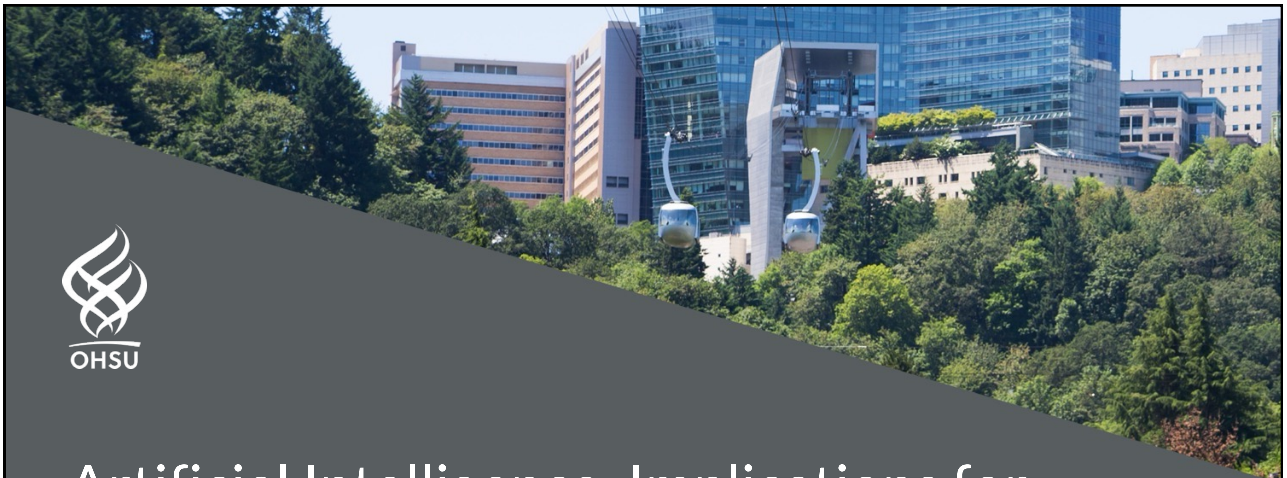

# Artificial Intelligence: Implications for Healthcare Practice, Research, and Education

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1

## Overview

- Uses, successes, and limitations of AI in medicine
- AI in education
- AI impacts on how we find and apply information



2

# Artificial intelligence (AI)

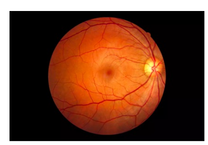
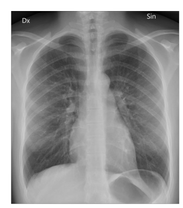
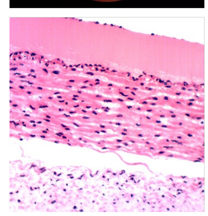
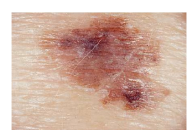
- AI – information systems and algorithms capable of performing tasks associated with human intelligence (Glover, 2024)
- Some classify AI into two broad categories (Rose, 2025)
  - Predictive AI – use of data and algorithms to predict some output (e.g., diagnosis, treatment recommendation, prognosis, etc.)
  - Generative AI – generates new output based on prompts (e.g., text, images, etc.)
- A large part of modern success of AI due to machine learning (ML) – “computer programs that learn without being explicitly programmed” (McCarthy, 1990, attributed to Samuel, 1959; Shah, 2023)
  - Most success with deep learning, based on many-layered neural networks



3

# Predictive AI in medicine

- “Predictive AI” driven by advances in ML, increasing availability of data, and more powerful computers and networks (Topol, 2019; Rajpurkar, 2022)
  - Deep learning in imaging breakthroughs by Hinton (2006) – led to Nobel Prize for Physics 2024
- Most success in image interpretation (Rajpurkar, 2023); examples include
  - Radiology – chest x-rays for diagnosis of pneumonia and tuberculosis
  - Ophthalmology – retinal images for diagnosis of diabetic retinopathy
  - Dermatology – skin lesions for diagnosis of cancer
  - Pathology – breast cancer slides to predict metastasis



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# Predictive AI not limited to imaging

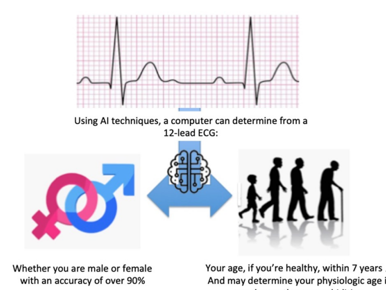
- Adverse events in hospitalizations from electronic health record (EHR) data (Rajkomar, 2018)
- Protein folding from amino acid sequences (Jumper, 2021) – led to Nobel Prize for Chemistry 2024
- Semantic reconstruction of continuous language from fMRI brain recordings (Tang, 2023)
- Map chemicals to odors perceived by humans (Lee, 2023)
- Predict Alzheimer's Disease from EHR data up to 7 years before diagnosis (Tang, 2024)
- Voice as a biomarker in Parkinson's Disease, Alzheimer's Disease, cognitive impairment, COVID-19, and others (Idrisoglu, 2023; Bensoussan, 2024)

- The list goes on and on, especially with addition of generative AI…



# Also success in "seeing" where humans cannot (Topol, 2022)

- Retinal images
  - Age, biological sex, and cardiovascular risk determination from retinal images (Poplin, 2018)
  - Race (Coyner, 2023)
- Electrocardiograms (ECGs)
  - Age and biological sex determination (Attia, 2019)
  - Chronic kidney disease (Holmstrom, 2023)
- Chest x-rays
  - Race (Gichoya, 2022)
  - Diabetes (Pyrros, 2023)
  - Correlation with chronological age in healthy cohorts and, for various chronic diseases, difference between estimated age and chronological age (Mitsuyama, 2023)
  - Cardiac risk as accurately as common models, e.g., atherosclerotic cardiovascular disease (ASCVD) (Weiss, 2024)
  - Risk of future heart failure (Dhingra, 2025)



# And now, generative AI

- Introduction of ChatGPT on November 30, 2022 brought new type of AI into focus: generative AI
- Based on large language models (LLMs) processed by deep neural networks using large amounts of training data and tuned for specific tasks (Omiye, 2024)
  - Trained on massive amounts of text and other content, e.g., large Web crawls, books, Wikipedia, and more for GPT (Roberts, 2022)
  - Use transformer models that predict words in sequence from billions/trillions of words and add measure of importance to “attention” words (Shao, 2024)
  - Fine-tuned with reinforcement learning from human feedback (RLHF) (Lambert, 2022)
  - Activated by (and importance of) prompting (Liu, 2023; Meskó, 2023)



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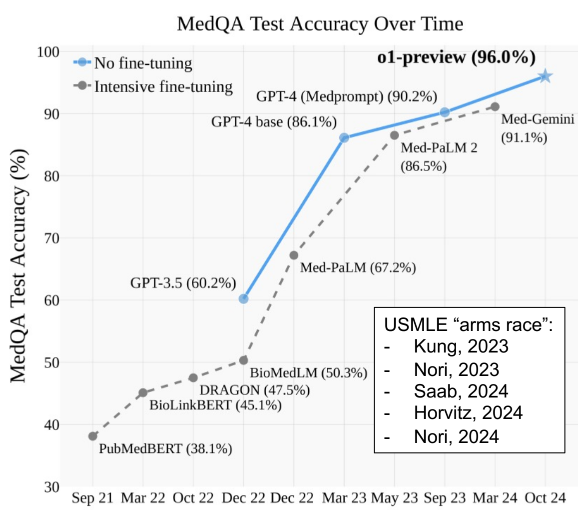
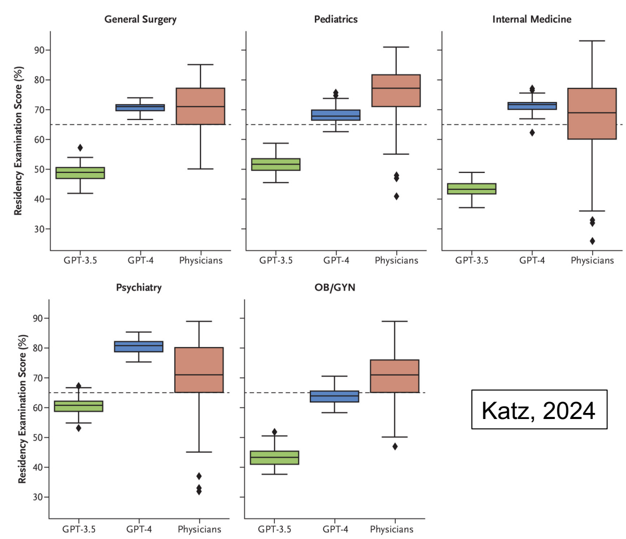
# Some successes of generative AI in medicine – medical board exams




Katz, 2024



8

# Successes of LLMs – solving clinical cases

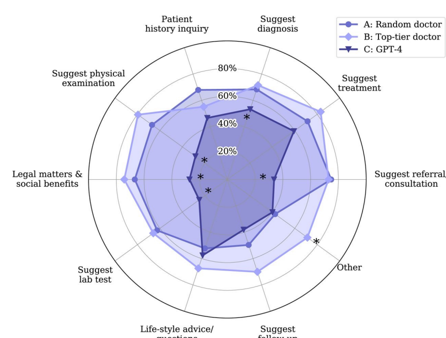
- Comparable to but not better than expert humans (Kanjee, 2023; Rao, 2023; Chen, 2023)
- In simulated (text-based) objective structured clinical exam (OSCE) format, Google's Articulate Medical Intelligence Explorer (AMIE) outperformed primary care physicians in text-based dialogue in history-taking, diagnostic accuracy, management reasoning, communication skills, and empathy (Tu, 2024)
- For 20 clinical cases, GPT-4 performed comparable to attending physicians and residents in diagnostic accuracy, correct clinical reasoning, and cannot-miss diagnosis inclusion (Cabral, 2024)
- In randomized vignette study of diagnostic reasoning (Goh, 2024)
  - Physicians scored comparably with or without GPT-4 (76.3% vs. 73.7%, NS)
  - GPT-4 alone did better (92.1%, SS)





# Successes of LLMs – solving cases, mixed results

- Comparison of responses from ChatGPT-4 and physicians for cases from Swedish family medicine specialist examination, scored by blinded reviewers (Arvidsson, 2024)
  - Higher scores for average physicians than GPT-4 or GPT-4o
- Conversational Reasoning Assessment Framework for Testing in Medicine (CRAFT-MD) focuses on natural dialogues, using simulated agents to interact with LLMs in controlled environment (Johri, 2025)
  - Performed worse in "conversational" than "examination-based" settings



## Successes of LLMs (cont.)

- Communicating with patients
  - Answering questions in public forums (Sarraju, 2023; Ayers, 2023)
  - Writing letters with comparable or better empathy (Ali, 2023, Ayers, 2023)
- Closing the loop with predictive AI
  - Classifying CXR findings based on previous images and reports (Xu, 2023)
  - Predicting cardiovascular risk comparable to Framingham models (Han, 2023)
  - Designing and validating easily synthesizable antibiotics (Swanson, 2024)
  - Predicting acuity of patients in emergency department (Williams, 2024)



## But some downsides to generative AI

- Dictionary.com 2023 word of year: *hallucinate* (Norlen, 2023)
- Fabrication and errors in the bibliographic citations – asked to produce short literature reviews on 42 multidisciplinary topics (Walters, 2023)
  - 55% of GPT-3.5 citations and 18% of GPT-4 citations fabricated
  - 43% of real (non-fabricated) GPT-3.5 citations and 24% of real GPT-4 citations include substantive errors

## Downsides to generative AI (cont.)

- 8 clinical questions asked of 4 LLMs recapitulated "harmful, race-based medicine" (Omiye, 2023)
- Automated GPT detectors have mixed results (Sadasivan, 2023; Odri, 2023; Desaire, 2023; Tang, 2024)
  – More likely to classify non-native English writing as AI-generated (Liang, 2023)
  – Humans not able to discern AI writing either (Dell'Acqua, 2023)
- Attempts at fine-tuning can go awry, e.g., Grok (Hagen, 2025)



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## And some downsides to AI in general

- After clinical models deployed, performance may decline due to actual real-world use (Vaid, 2023; Palmer, 2023)
- Implementing diabetic retinopathy screening in rural Thailand and India found (Widner, 2023)
  – Challenges related to equipment operation, workflows, and image quality
  – Need for training and attention to human factors
- ML algorithms, especially generative AI, have large carbon footprints, although details sometimes not known due to lack of company transparency (Kirkpatrick, 2023)
  – One estimate is that electricity consumption of AI request is 10-fold more than Google search (de Vries, 2023)



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# Downsides to AI in general (cont.)

- Variable impacts on different levels of radiologists, leading to automation bias and detrimental effects of incorrect AI (Dratsch, 2023; Yu, 2024)
- Concerns about reproducibility (Ball, 2023)
  - Data bias (especially from EHR – Lewis, 2023; Chin, 2023)
  - Data leakage (Kapoor, 2023)
  - Data drift/shift (Finlayson, 2021; Li, 2024; Nelson, 2025)



# More recent advances in generative AI

- Retrieval augmented generation (RAG) (Gao, 2024; Kimothi, 2025)
  - Training large models consumes time and resources; cannot be done frequently
  - RAG allows new information (articles, Web pages, and even books) to be entered into context window of LLM to augment prompt
- Agentic AI (Powell, 2025; Zou, 2025)
  - Interaction of AI systems (agents) to solve specific tasks, e.g., medical diagnoses, treatment recommendations, etc.

## What is ultimate role for AI in healthcare?

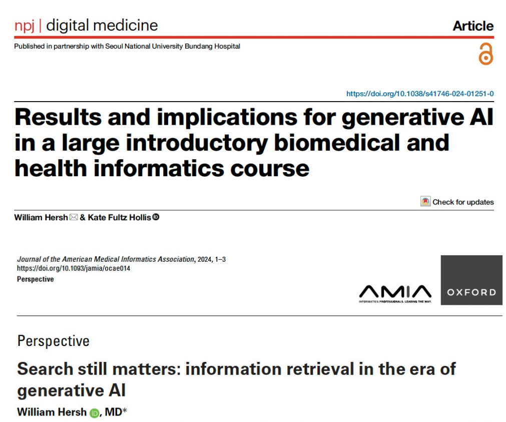
- Real-world use still modest; most widely used applications include
  - Predictive models, e.g., sepsis (Gorecki, 2024; Yin, 2024)
  - Drafting replies to patient messages (Yan, 2024; Baxter, 2024; Small, 2024; Tai-Seale, 2024)
  - Ambient dictation (Shah, 2025; Ma, 2025; Duggan, 2025; Stults, 2025)
- "AI won't replace radiologists, but radiologists who use AI will replace radiologists who don't," (Langlotz, 2019)
  - (Plug in your health profession)





## AI impacts on education and search

- Impact on education (Hersh, 2024)
  - How do we learn and assess what we learn?
- Search still matters (Hersh, 2024)
  - In many circumstances, who said what is more important than providing a generated answer



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**Results and implications for generative AI in a large introductory biomedical and health informatics course**

Check for updates

William Hersh & Kate Fultz Hollis

*Journal of the American Medical Informatics Association*, 2024, 1–3
https://doi.org/10.1093/jamia/ocae014
Perspective

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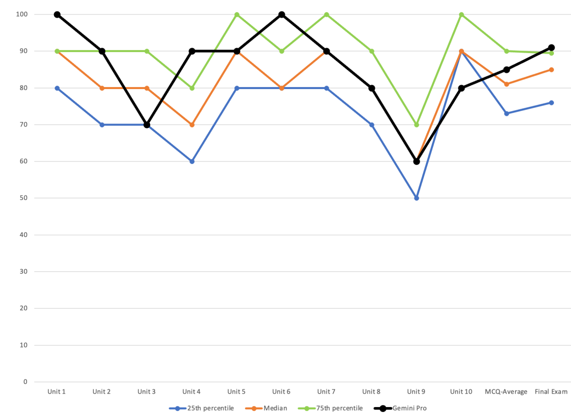
Perspective

**Search still matters: information retrieval in the era of generative AI**

William Hersh, MD*

# Impact on education in biomedical informatics

- Well-known, highly subscribed introductory course taught at graduate, continuing education, and medical student levels (Hersh, 2024)
  - Commercial LLMs prompted using interactive Web interface for multiple-choice and final exam questions from 2023 course materials
  - Highest score by Gemini Pro at about 75th percentile for 139 students, other LLMs close behind
- GitHub CoPilot in health informatics programming course (Avramovic, 2024)
  - For problems in SQL and Python, generated solutions worked well for simple tasks but less so for complex ones
  - Some solutions correct but not most efficient approach

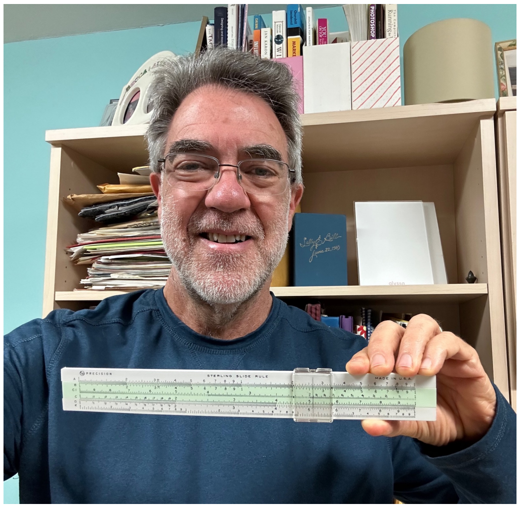





# Challenges for educators in many disciplines

- May be causing "homework apocalypse" (Mollick, 2023) but also provides opportunity to improve teaching and learning (Mollick, 2024)
- Impact in many disciplines beyond medicine, including
  - Passing college entrance and AP exams (Dubey, 2024)
  - Writing computer programs (Poldrack 2024; Denny, 2024; Johnson, 2024)
  - Creating data science pipelines (Cheng, 2024; Hong, 2024)
  - Writing legal briefs (Choi, 2023)
  - In 5 undergraduate psychology courses, scored above average among students on take-home exams with only 6% detection (Scarfe, 2024)

# Now what? Educational cusps in my lifetime



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# Also critical is education of clinicians and informaticians

- AI should build on competencies in clinical informatics (Hersh, 2014; Hersh 2020; Hersh, 2023)
- Others note
  - Clinicians must be prepared to practice in a world of AI (James, 2022)
  - Medical schools face dual challenges of needing to teach about AI in practice but also adapt to its use by learners and faculty (Cooper, 2023)

| |
|---|
| 1. Find, search, and apply knowledge-based information to patient care and other clinical tasks |
| 2. Effectively read from, and write to, the electronic health record (EHR) for patient care and other clinical activities |
| 3. Use and guide implementation of clinical decision support (CDS) |
| 4. Provide care using population health management approaches |
| 5. Protect patient privacy and security |
| 6. Use information technology to improve patient safety |
| 7. Engage in quality measurement selection and improvement |
| 8. Use health information exchange (HIE) to identify and access patient information across clinical settings |
| 9. Engage patients to improve their health and care delivery though personal health records and patient portals |
| 10. Maintain professionalism in use of information technology tools, including social media |
| 11. Provide clinical care via telemedicine and refer patients as indicated |
| 12. Apply personalized/precision medicine |
| 13. Participate in practice-based clinical and translational research |
| 14. Use and critique artificial intelligence (AI) applications in clinical care |



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# Search still matters (Hersh, 2024)

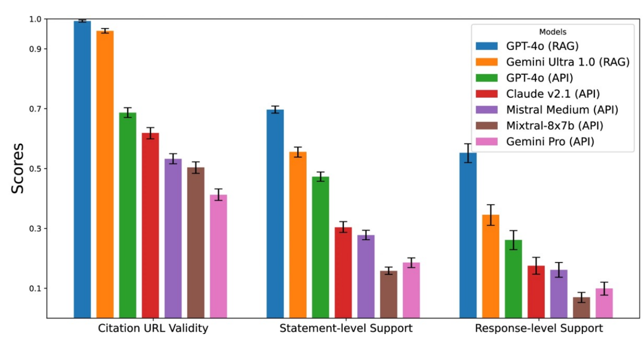
- Generative AI systems such as ChatGPT can be very useful but
  - For some tasks that many of us do, need more than answers, e.g.,
    - Clinical – patient-care questions
    - Research – methods and insights
    - Teaching – synthesizing knowledge for our students
  - Where the information comes from is as important what it says



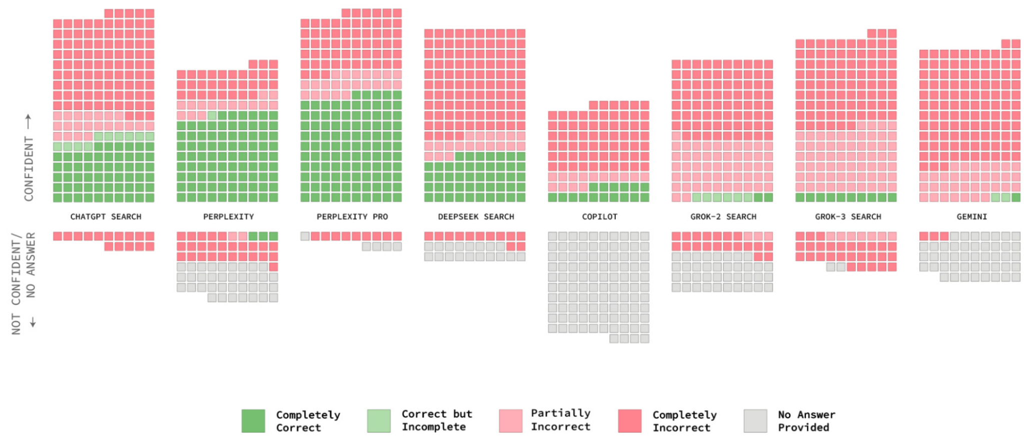


# Citation of relevant references (Wu, 2025)

- Questions extracted from well-known Web health information sources
- Validation from clinician experts
- Latest LLMs using RAG did best, with high URL validity but lower statement-level and resource-level support
- Other issues
  - Grounded vs. correct claims
  - Sources behind paywalls



# Problem not limited to medicine (Jaźwińska, 2025)








# Conclusions

- AI will profoundly impact the practice and education of all health professions
- Translational AI is a necessity and opportunity for clinicians, researchers and others
- Educators must develop new approaches to teaching and student assessment in era of generative AI
- Healthcare, informatics, and educational professionals must be competent with AI as much as any other tool in clinical practice
- Generative AI systems must provide attribution for their assertions

# Questions?

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