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

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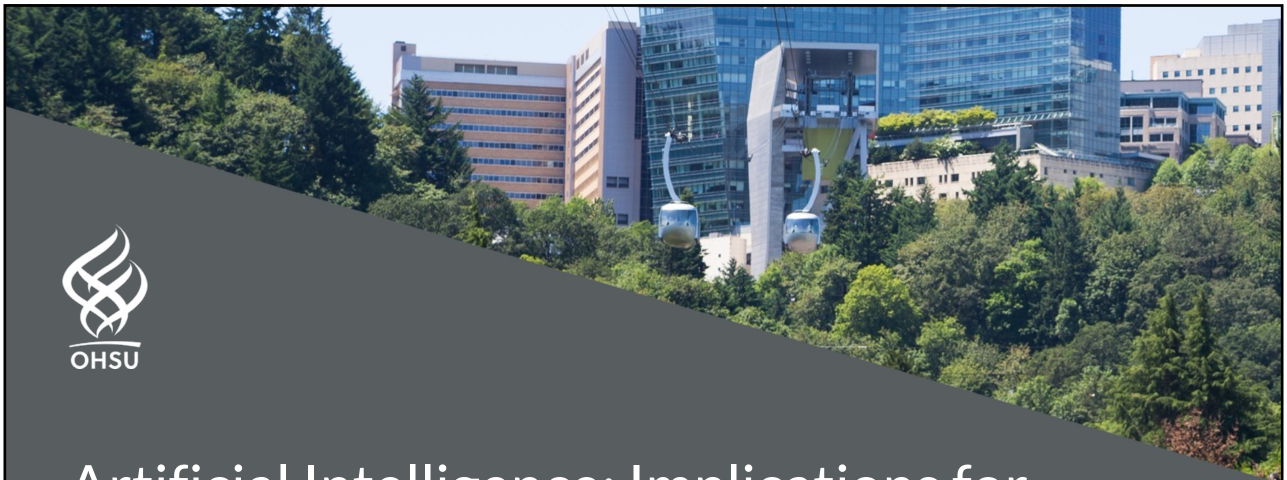

Artificial Intelligence: Implications for Healthcare Practice, Research, and Education

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Portland, OR, USA

1

Overview

- About myself and my connection to UCT
- Uses, successes, and limitations of AI in medicine
- Evidence base for AI
- AI in medical education
- AI impacts on how we find and apply information

2

About myself and my connection to UCT

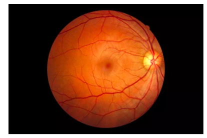
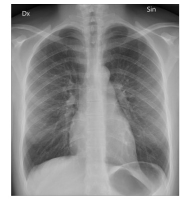
- Personal history
  - Trained in medicine (MD, residency in internal medicine)
  - Completed postdoc in medical informatics
  - At Oregon Health & Science University (OHSU) since 1990
    - Inaugural Chair, Department of Medical Informatics & Clinical Epidemiology
    - Inaugural Director, Biomedical Informatics Graduate Program
    - Research program focused on information retrieval (IR, aka search)
    - Development of educational programs and courses, including online
- Connections to UCT
  - Served on Scientific Advisory Board of H3ABionet (Nicky Mulder, UCT, PI)
  - Currently funded by US NIH in Computational Omics and Biomedical Informatics Program (COBIP – Hocine Bendou, contact PI)

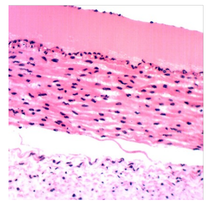
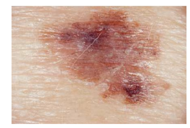
Artificial intelligence (AI) – biomedical perspective

- Biomedical applications played large role in first era of AI (20th century AI)
  - Early success of expert systems
  - Not clinically useful or scalable
- Included in resurgence in second era of AI (21st century AI)
  - 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.)

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)
- 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

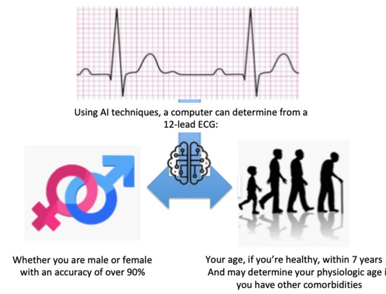
Predictive AI not limited to imaging

- Adverse events in hospitalizations from electronic health record (EHR) data (Rajkomar, 2018)
- Protein folding from amino acid sequences (Jumper, 2021)
- Model based on past ICD-10 codes and lab results to predict future diagnoses in office visits (Mukherjee, 2023)
- 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)
  - Cardiac function and valvular heart diseases (Ueda, 2023)
  - 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)



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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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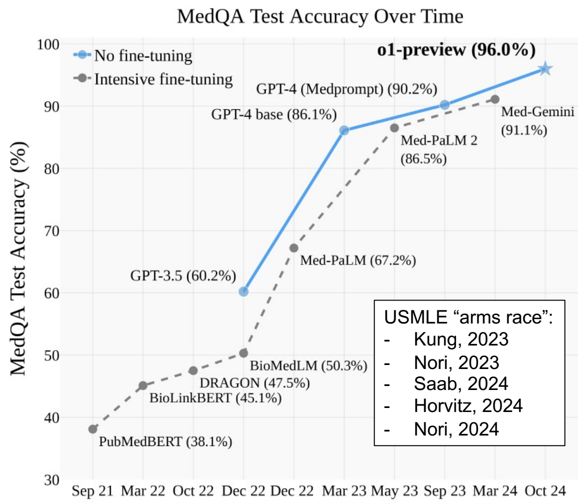
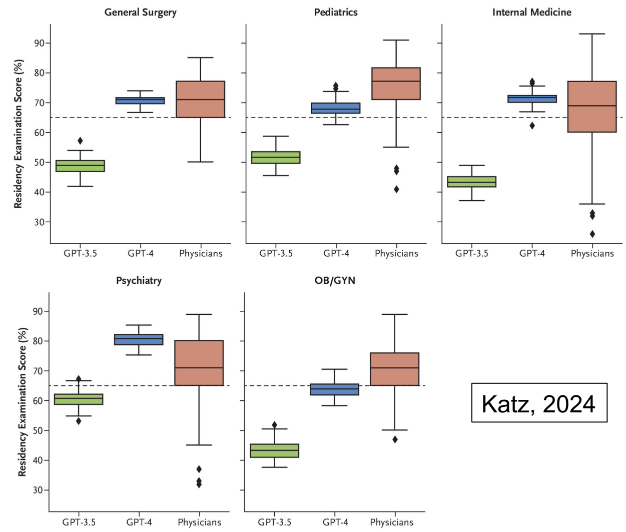
Some successes of generative AI in medicine – medical board exams





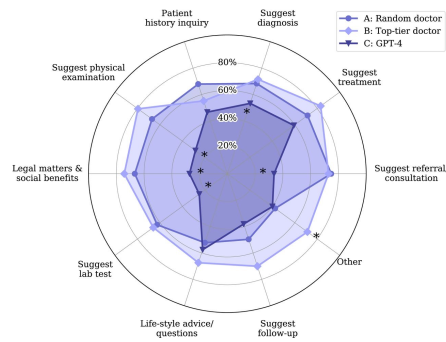
Katz, 2024

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)

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)

OHSU

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)

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Will AI help or hinder healthcare?

- Real-world use still modest; most prominent 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 (Owens, 2024)
- "AI won't replace radiologists, but radiologists who use AI will replace radiologists who don't," (Langlotz, 2019)
  - (Plug in your health profession)

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AI impacts on evidence, education, and search

- Translational AI (Hersh, 2024)
  - Generating the evidence base is a necessity and opportunity
- 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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Innovations in Health Information from the National Library of Medicine
Translational AI: A Necessity and Opportunity for Biomedical Informatics and Data Science
Posted on February 7, 2024 by Guest Author

npj | digital medicine Article
https://doi.org/10.1038/s41746-024-01251-0
Results and implications for generative AI in a large introductory biomedical and health informatics course
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*

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Translational AI: how do we "show the evidence?"

- From evidence-based medicine (EBM), best evidence for any clinical intervention is from randomized controlled trials (RCTs) or systematic reviews of RCTs
- Although not as easy to carry out as RCTs of drugs or devices (and placebos), AI must demonstrate benefit for patient outcomes and/or healthcare delivery improvement
  - Additional issues for RCTs of AI (Liu, 2020)
- As with drugs and devices, we need to move from "basic science" to "clinical science"
- Not everything can be studied in an RCT and RCTs cannot be done for every last clinical question (Greenhalgh, 2022)

What is the evidence for the benefit of AI?

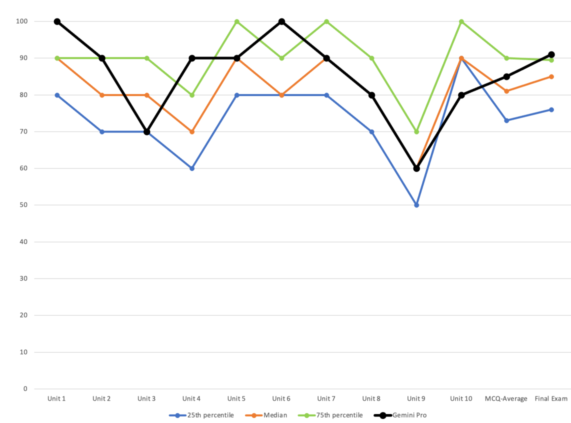
- Many, many papers published about models and simulated use (basic science), including systematic reviews of those papers
- Very few RCTs demonstrating value from real-world use (clinical science) – systematic reviews of RCTs show (Zhou, 2021; Plana, 2022; Han, 2024)
  - Much smaller numbers of RCTs – about 100, depending on how we count
  - 65-82% of RCTs showed positive outcomes
  - Many RCTs showed aspects of "risk of bias"

Perspective from some specific examples

- Computer-aided detection (CADe) of polyps in colonoscopy
  - One of earliest and most widely-studied applications of AI
  - Systematic review shows polyps missed by colonoscopists are discovered, but mostly small and clinically inconsequential (Hassan, 2023)
  - RCT of CADe found no increased detection of advanced neoplasias (Mangas-Sanjuan, 2023)
- RCT to assess whether use of previously validated hospital-acquired venous thromboembolism (HA-VTE) prognostic model, together with pediatric hematologist review, could reduce pediatric inpatient rates of HA-VTE (Walker, 2023)
  - No difference for intervention group randomized to use model
  - Reluctance to use model by primary physicians – used only 26% of time
  - For children in intervention arm, model mostly not used, AI's "Cassandra problem" (Wilson, 2023)?
- More failure of successful models to improve clinical outcomes
  - Hospital readmissions (Donzé, 2023)
  - Chronic kidney disease (Vazquez, 2024)

Impact on education: generative AI is a challenge

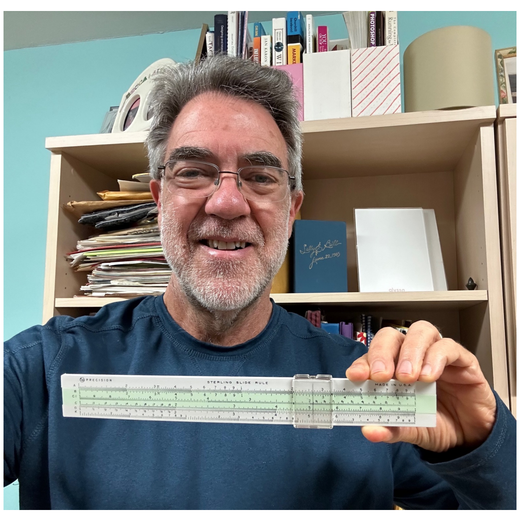
- Well-known, highly subscribed introductory course taught at graduate, continuing education, and medical student levels (Hersh, 2024)
  - Commercial LLMs prompted using interactive Web interface for multiple-choice and final exam questions from 2023 course materials
  - Highest score by Gemini Pro at 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



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)

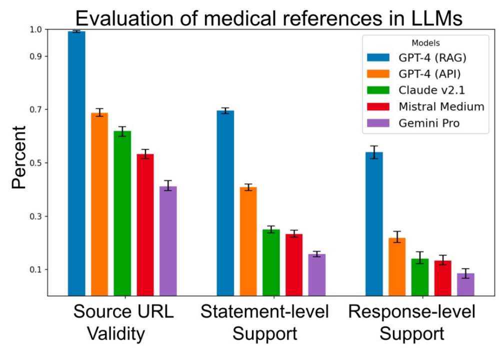
1. Find, search, and apply knowledge-based information to patient care and other clinical tasks
2. Effectively read from, and write to, the electronic health record (EHR) for patient care and other clinical activities
3. Use and guide implementation of clinical decision support (CDS)
4. Provide care 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

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

How well do LLMs cite their sources?

- Best LLM with retrieval-augmented generation (RAG) (GPT-4 in CoPilot) achieved about 70% statement-level support and <50% for others (Wu, 2024)
- Further research in Text Retrieval Conference (TREC) Biomedical Generative Retrieval (BioGen) Track (Gupta, 2024)



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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