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

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

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Overview and disclosures

- Uses, successes, and limitations of AI in biomedicine
- Evidence base for AI
- AI in medical education
- AI impacts on how we find and apply information

- Disclosures
  - None

2

Artificial intelligence (AI)

- AI – information systems and algorithms capable of performing tasks associated with human intelligence (Copeland, 2024)
- Some classify AI into two broad categories (Khare, 2023)
  - 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

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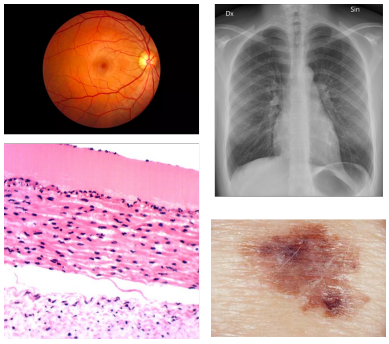
Predictive AI in medicine

- "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



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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)
- 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…

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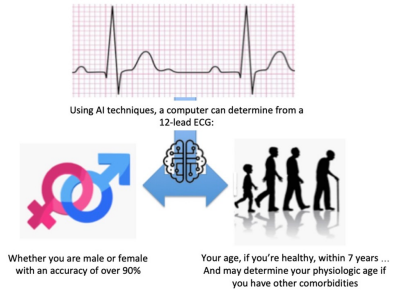
Also success in "seeing" where humans cannot (Topol, 2022)

- 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 (Raschka, 2023)
  - 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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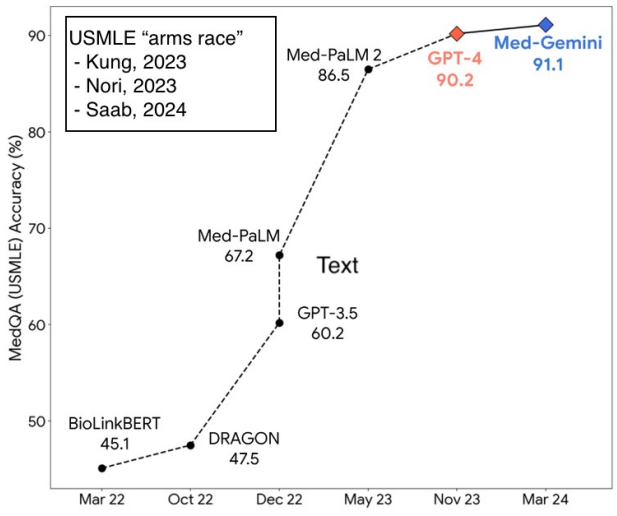
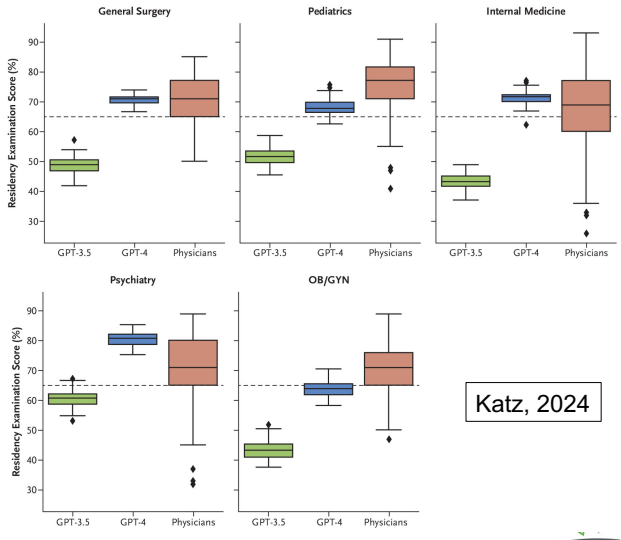
Success of generative AI – medical board exams





Katz, 2024

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Success of LLMs (cont.)

- Solving clinical cases – comparable to but not better than expert humans (Levine, 2023; Kanjee, 2023; Rao, 2023; Benoit, 2023; Chen, 2023; Levkovich, 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)

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Success 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)
  - Generating surgical consent forms better than surgeons (Decker, 2023)
- Closing the loop with predictive AI
  - Classifying CXR findings based on previous images and reports (Xu, 2023)
  - Generating CXR reports from new images in ED from prior images and reports (Huang, 2023)
  - Predicting cardiovascular risk comparable to Framingham models (Han, 2023)
  - Designing and validating easily synthesizable and structurally novel antibiotics (Swanson, 2024)
  - Predicting acuity of patients in emergency department (Williams, 2024)

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But there are some downsides to generative AI

- Dictionary.com 2023 word of year: hallucinate
  - https://content.dictionary.com/word-of-the-year-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

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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)

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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)

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)

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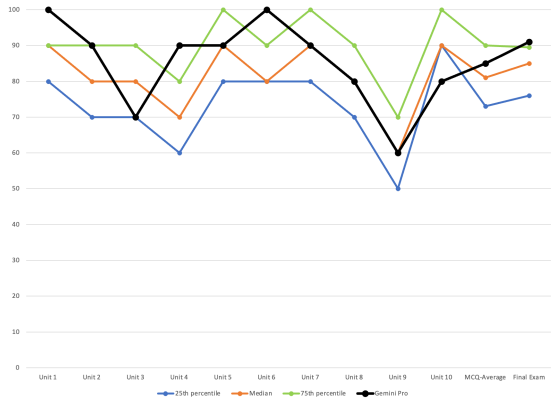
Translational AI: how do we "show the evidence?"

- 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 RCT showed positive outcomes
  - Many RCTs showed aspects of "risk of bias"

Impact on education: generative AI is a challenge

- (Hersh, 2024)
- Well-known, highly subscribed introductory course taught at graduate, continuing education, and medical student levels
- 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



Challenges for educators in many disciplines

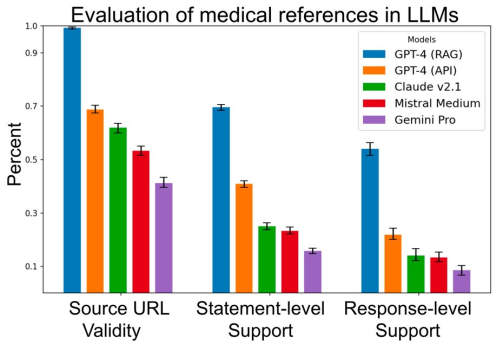
- May be causing “homework apocalypse” (Mollick, 2023) but also provides opportunity to improve teaching and learning (Mollick, 2024)
- Impact in many disciplines beyond medicine, including
  - Computer science (Denny, 2024)
  - Data science (Hong, 2024)
  - Law (Choi, 2023)

Search still matters (Hersh, 2024)

- Generative AI systems such as ChatGPT are cool and fun 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

Search in era of generative AI

- How well do LLMs cite their sources?
- Best LLM with RAG (GPT-4 in CoPilot) achieved about 70% statement-level support and <50% for others (Wu, 2024)
- Research being pursued in Text Retrieval Conference (TREC) Biomedical Generative Retrieval (BioGen) Track
  - https://dmice.ohsu.edu/trec-biogen/



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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

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Questions?

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