ChatGPT and Other AI Tools for Medicine and Medical Education

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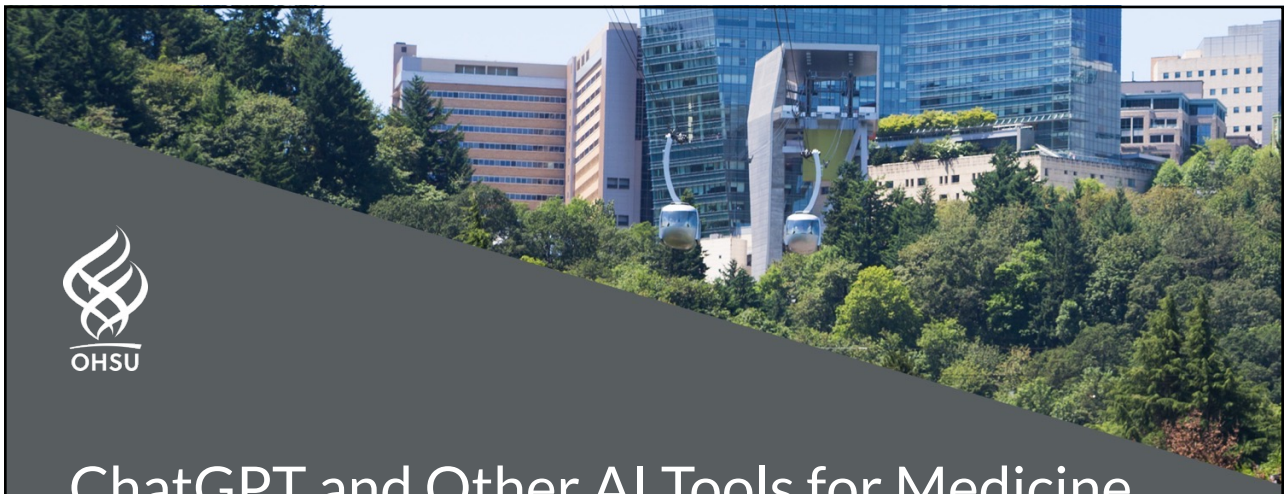

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Overview

1. Brief introduction of AI tools that medical students (health professions learners) can use including ChatGPT
2. Applying ChatGPT and other AI tools to learning in medical education/health professions education
3. Academic misconduct and other risks of ChatGPT and AI tools
4. Future directions for ChatGPT and other AI tools

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1. Introduction – artificial intelligence (AI)

- AI – "information systems and algorithms capable of performing tasks associated with human intelligence" (Rajpurkar, 2022; Sahni, 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 – "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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AI is not new – first era in mid-20th century

- Earliest paper related to AI and biomedical informatics attributed to Ledley and Lusted (1959) aiming to model physician reasoning through symbolic logic and probability
- Warner (1961) developed mathematical model for diagnosing congenital heart disease
- In 1960s-1970s, emergence of "expert systems" – computer programs aiming to mimic human expertise (historical overview – Lea, 2023)
  - Rule-based systems – PhD dissertation of Shortliffe (1975) and subsequent work (Clancey, 1984)
  - Disease profiles and scoring algorithms – INTERNIST-1 (Miller, 1982) and DxPlain (Barnett, 1987)
- Limited by approach of manual construction and maintenance of knowledge
  - Not scalable or sustainable
  - Led to "AI winter" between 1990-2010
  - Main remnant is clinical decision support (CDS) for electronic health records (EHRs) that emerged in 1990s for electronic health records (Greenes, 2023)

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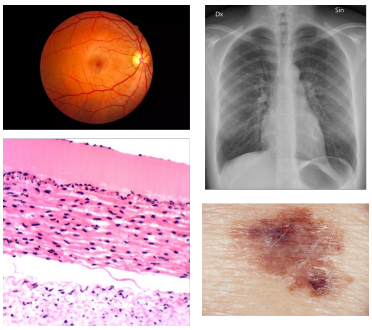
Re-emergence of AI in 21st century

- "Predictive AI" driven by advances in machine learning, increasing availability of data, and more powerful computers and networks (Topol, 2019; Rajpurkar, 2022)
  - Deep learning in imaging advanced 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 EHR data (Rajkomar, 2018)
- Generating clinical notes from patient and physician verbal interaction (Rajkomar, 2019)
- Protein folding from amino acid sequences (Jumper, 2021)
- Next-generation sequencing (NGS) data on >36K tumors able to predict cancer of unknown primary with high confidence for 41% of tumors, leading to improved survival for those patients (Moon, 2023)
- ML 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)

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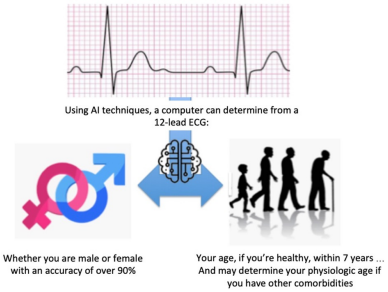
Also success in "seeing" where humans cannot (Topol, 2023)

- 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)
  - Diagnosis and risk stratification in occlusive myocardial infarction (Al-Zaiti, 2023)
  - Chronic kidney disease (Holmstrom, 2023)
  - Left ventricular systolic dysfunction from ECG images (Sangha, 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)



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And now, "generative AI"

- Introduction of ChatGPT in November, 2022 brought new type of AI into focus: generative AI
  - Initially based on GPT-3.5 model; added larger GPT-4 soon after
- Based on large language models (LLMs) processed by deep neural networks using large amounts of training data and tuned for specific tasks
  - Trained on massive amounts of text and other content, e.g., large Web crawls, books, Wikipedia, and more for ChatGPT (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 for specific tasks (Chung, 2022)
  - Activated by (and importance of) prompting (Liu, 2023)

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Results of ChatGPT and other LLMs

- Medical board exams
  - USMLE "arms race," starting with (Kung, 2023)
    - Claimed best – https://www.openevidence.com/blog/openevidence-ai-first-ai-score-above-90-percent-on-the-usmle
    - Even on "soft skills" (e.g., communication skills, ethics, empathy, and professionalism) questions (Brin, 2023)
  - Passing level on some board exams (clinical informatics – Kumah-Crystal, 2023; radiology – Bhayana, 2023) but not others (neonatology – Beam, 2023)
- Answering questions
  - Vary by subject domain and type, but sometimes wrong and/or incomplete (e.g., Antaki, 2023; Chen, 2023)
- Solving clinical cases
  - Comparable to but not better than expert humans (e.g., Levine, 2023; Kanjee, 2023; Rao, 2023; Benoit, 2023; Goodman, 2023)
- Communicating with patients
  - Answer questions in public forums and write letters with comparable or better empathy (Sarraju, 2023; Ali, 2023, Ayers, 2023)

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2. Applying ChatGPT and other AI tools

- It's already here
- ChatGPT in medical education
- Tools for predictive AI

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Generative AI in education – it's already here

- "My class required AI. Here's what I've learned so far." (Mollick, 2023)
- "I'm a student. You have no idea how much we're using ChatGPT. No professor or software could ever pick up on it." (Terry, 2023)
- "The end of the take-home essay? How ChatGPT changed my plans for the fall." (Robin, 2023)
- "Here's my AI policy for students: I don't have one." (Zimmerman, 2023)
- "ChatGPT has transformed the problem of grade inflation from a minor corruption to an enterprise-destroying blight." (Clune, 2023)

Benefits of ChatGPT for faculty

Tasks for students (Mollick, 2022)

- Improving transfer of knowledge
  - Apply concept(s) to new situations
  - Critique output as right or wrong
- Teaching how to evaluate
  - Assess and improve output
- Break illusion of explanatory depth
  - Explain steps of a concept

Benefits for faculty (Mollick, 2023)

- Providing multiple examples and explanations
- Uncovering and addressing student misconceptions
- Frequent low-stakes testing
- Assessing student learning
- Distributed practice of important ideas over time

ChatGPT will change education, not destroy it (Heaven, 2023)

- Assessment already broken: “if ChatGPT makes it easy to cheat on an assignment, teachers should throw out the assignment rather than ban the chatbot”
- Change focus: use ChatGPT to generate an argument and then annotate it according to how effective argument was for a specific audience; then turn in rewrite based on their criticism
- Overcome misinformation and bias: ask students to use ChatGPT to generate text on a topic and then point out flaws
- Interact with ChatGPT to debate and generate counterarguments

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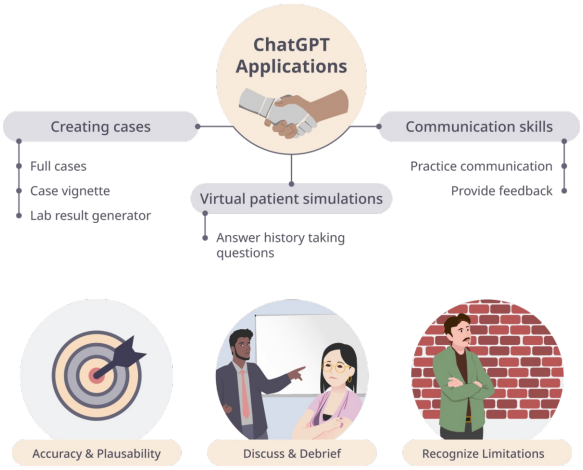
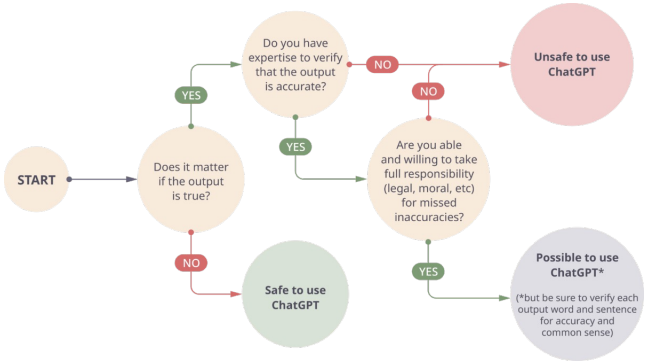
ChatGPT in medical education (Ratliff, 2023)





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Prompt engineering in medical education (Heston, 2023)

Best practices

- Structure with context, general request, how the generative AI is to act, and output format
- Utilize iterative prompts
- Avoid vague, misleading, and inappropriate prompts
- Mathematical, logical, and academic citation prompts can be challenging

Uses and concerns

- Use for
  - Summarizing material
  - Generating frequently asked questions (FAQs)
  - Creating test questions
- What constitutes cheating?
  - Use of generative AI instead of thinking and synthesizing?
  - Use to improve grammar or readability?
  - Best approach to incorporate rather than prohibit?

Other uses of ChatGPT

- Developing patient handouts in rural dermatology (Baker, 2023)
- Creating medical art (Huston, 2023)
- Using ChatGPT in medical practice (Bair, 2023)
  - Create checklists for common presentations
  - Plugins to access management guidelines and literature pertaining to patient-specific issues
    - BrowserPilot allows access to live websites in real-time
    - ScholarAI allows search for peer-reviewed articles on PubMed and other research databases
  - Generating templates for common clinical scenarios

Let's not forget about tools for predictive AI

- Data sets – no single repository (e.g., PubMed) but easy to find by searching (why you need that competency), e.g.,
  - Linked to papers using data sets
  - Kaggle challenges
    - https://www.kaggle.com/datasets?search=biomedical
  - Papers With Code
    - https://paperswithcode.com/datasets?mod=medical
- Tools – age-old question: Should physicians be programmers?
  - Programming tools in Python and R
  - No-code (visual) programming tools (Hirzel, 2023)

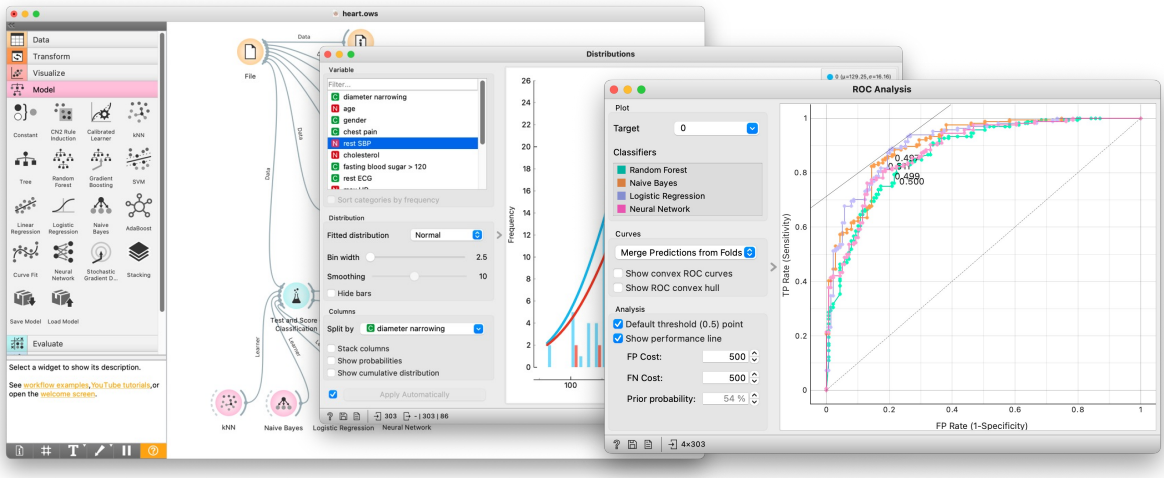
No-code programming – Orange data mining

- "No-code" model development – visual programming package
  - https://orangedatamining.com/
  - https://orangedatamining.com/download/
- Written in Python and extensible
- Excellent series of introductory YouTube videos
  - https://www.youtube.com/@OrangeDataMining
- NoCode Data Science (Bob Hoyt and David Patrishkoff)
  - https://www.nocodedatascience.net/

Functionality in Orange

- Comes with small data sets but you can add your own
- Tools for data exploration, visualization, and modeling, including
  - Predictive models
    - Classification
    - Regression
  - Image classification
  - Text mining

Visual programming, exploration, and modeling in Orange



What is impact of AI in medicine to date?

- Real-world use and evidence base still modest – systematic reviews of clinical trials of predictive AI systems (Zhou, 2021; Plana, 2022; Han, 2023) show
  - Small numbers of trials – especially relative to predictive model papers)
  - Mediocre methodologies including risk of bias
  - Mix of positive/negative results
- "AI won't replace radiologists, but radiologists who use AI will replace radiologists who don't," (Langlotz, 2019)
- Must address bias in data and algorithms
  - AI may compromise care if not used properly (DeCamp, 2023)
  - Must be implemented in responsible (Dorr, 2023) and fair (Chen, 2023) ways

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3. Academic misconduct and other risks of ChatGPT

- Downsides to ChatGPT and other LLMs
- Balancing benefits and risks

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Downsides to ChatGPT and other LLMs

- Equally compelling disinformation – humans cannot distinguish between true and false tweets generated by GPT-3 and written by real Twitter users (Spitale, 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
- 8 dermatology questions asked of 4 LLMs recapitulated "harmful, race-based medicine" (Omiye, 2023)
- Performs worse than humans in abstraction and analogy problems (Moskvichev, 2023)
- GPT detectors more likely to classify non-native English writing as AI-generated (Liang, 2023)

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ChatGPT benefits and risks in education (Sok, 2023)

Benefits

- Creating learning assessment
- Enhancing pedagogical practice
- Offering virtual personal tutoring
- Creating an outline
- Brainstorming ideas

Risks

- Academic integrity issues
- Unfair learning assessment
- Inaccurate information
- Over-reliance on AI

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Recommendations for medical faculty and institutions (Boscardin, 2023)

Educators

- Increase AI knowledge
- Understand the current landscape of AI use in medical education
- Review strategies for successful AI integration into education
- Become stewards of ethical use of AI

Institutions

- Review and revise school policies (and create new policies as needed) regarding use of generative AI
- Support faculty development about AI and provide resources for teaching
- Offer information-checking tools for originality and plagiarism to faculty

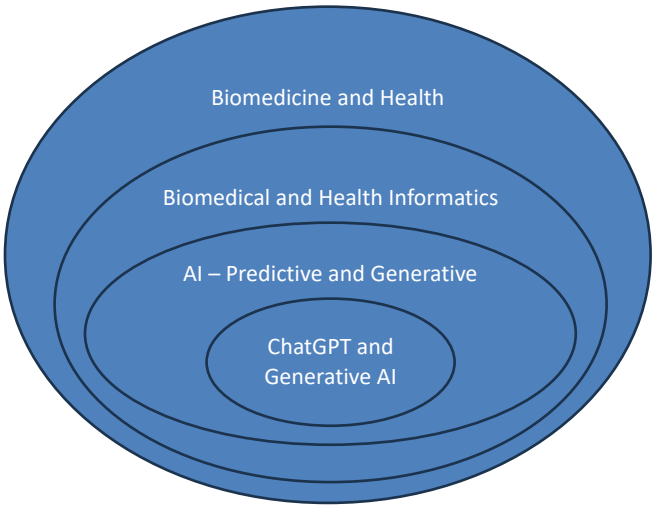
Strategies for responsible use of ChatGPT in education (Halaweh, 2023)

- Explicit policy in course syllabi or assessments
- Student reflection
- Audit trail of queries
- Use AI detector tools
- Swap student and instructor roles in use

4. Future directions for ChatGPT and other AI tools

- Where do ChatGPT and other AI tools fit in medical education?
- What competencies should medical students have in AI and larger biomedical and health informatics?
- How can we prepare students for practice in a future of Big Data, algorithms, and AI?

Where do ChatGPT and other AI tools fit in medicine?



AI and health professions education

- Mostly physician-based but applies to all health professions
- Before generative AI there was recognition of need for competencies in clinical informatics for medical education (Hersh, 2014; Hersh 2020; Hersh, 2023)
- Others noted
  - AI should be taught as a "fundamental toolset" (Ötleş, 2022)
  - 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)
- New AI-competency frameworks
  - Use of AI-based tools by healthcare professionals (Russell, 2023; Liaw, 2023; Seth, 2023)
  - We must prepare physicians for the "clinical algorithm era" (Goodman, 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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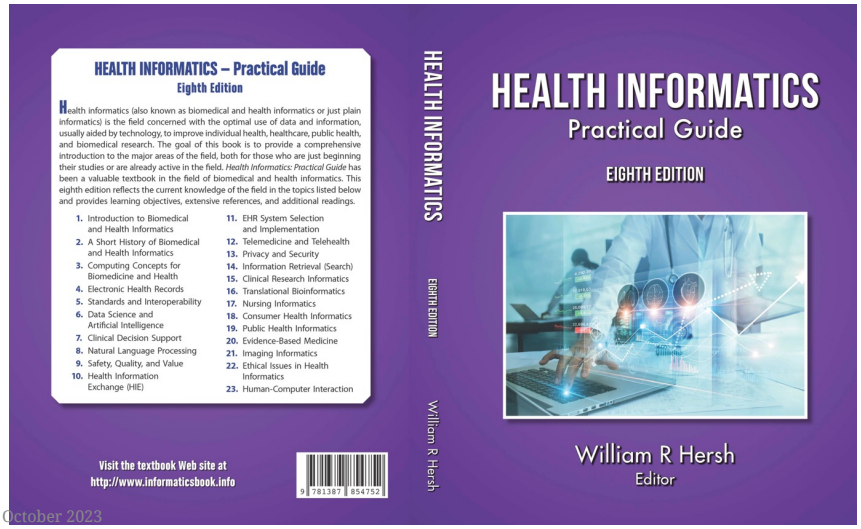
There are many additional topics to master in health/clinical informatics (Hersh, 2022)



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Competencies for use of AI-based tools by healthcare professionals (Russell, 2023)

Domains	Details
Basic knowledge of AI	Explain what AI is and describe its healthcare applications
Social and ethical implications of AI	Explain how social, economic, and political systems influence AI-based tools and how these relationships impact justice, equity, and ethics
AI-enhanced clinical encounters	Carry out AI-enhanced clinical encounters that integrate diverse sources of information in creating patient-centered care plans
Evidence-based evaluation of AI-based tools	Evaluate the quality, accuracy, safety, contextual appropriateness, and biases of AI-based tools and their underlying datasets in providing care to patients and populations
Workflow analysis for AI-based tools	Analyze and adapt to changes in teams, roles, responsibilities, and workflows resulting from implementation of AI-based tools
Practice-based learning and improvement regarding AI-based tools	Participate in continuing professional development and practice-based improvement activities related to use of AI tools in healthcare

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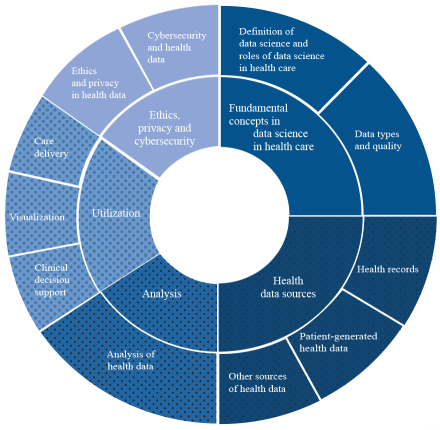
Core competencies in data science for medical education in age of AI in healthcare (Seth, 2023)

- Fundamental concepts in data science in health care
  - Definition of data science and roles of data science in health care
  - Data types and quality
- Health data sources
  - Health records
  - Patient-generated health data
  - Other sources of health data
- Analysis
  - Analysis of health data
- Usage
  - Visualization
  - Care delivery
  - Clinical decision support
- Ethics, privacy, and cybersecurity
  - Ethics and privacy in health data
  - Cybersecurity and health data



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Preparing physicians for the "clinical algorithm era" (Goodman, 2023)

Preclinical medical education

- Teach probability in medical school using intuitive, modern approaches
- Teach probabilistic clinical reasoning
- Assess probability and probabilistic reasoning skills
- Teach core, foundational working knowledge of CDS and EHR implementation, relevant to clinical use
- Practice interpreting CDS output in applied learning

Clinical training

- Reinforce probabilistic training and application
- Build CDS interpretation into curricula
- Reinforce working knowledge of CDS and EHR implementation, relevant to clinical use
- Include working knowledge of CDS in ACGME core competencies

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Conclusions

- Predictive and generative AI will profoundly impact the practice and education of all health professions
  - Day-to-day impact, especially in clinical settings, small so far but likely to grow
  - Need real-world implementation and evaluation for safety and efficacy just like all other clinical interventions
- Clinical and informatics professionals must be able to understand, implement, and critique applications of AI in their work and in healthcare more broadly
- Health professions educators must adapt to generative AI for writing, examination, and other pedagogic tasks

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Questions?

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