Artificial Intelligence: Implications for Health Professions Education

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Artificial Intelligence: Implications for Health Professions Education

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Objectives

- After this talk, you will be able to
  - Define the terminology and major types of AI
  - Discuss key issues for AI in health professions education
  - Describe competencies in AI for health professions learners
  - Have pathway for further learning from (annotated) bibliography

2

If you cannot stay the whole hour, here is tl;dr version of talk

- All health professionals must be competent in the uses and limitations of AI technology they are likely to apply in their clinical practice or other work
- All educators of future health professionals must understand the benefits and challenges for AI technologies in education

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Definitions and terminology related to 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
- Other terms
  - Data science – science of learning from data (Donoho, 2017)
  - Data analytics – use of data and statistical analysis to build explanatory and predictive models and drive decisions and actions (Davenport, 2017)
  - Big Data – data characterized by large volume, velocity, variety and variability (Chang, 2019)

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History of AI – 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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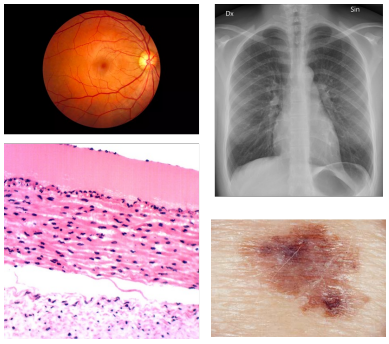
Re-emergence of AI in 21st century

- "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 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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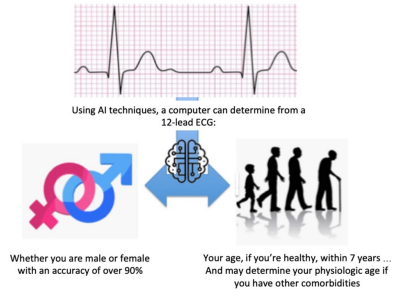
Predictive AI not limited to imaging

- Adverse events in hospitalizations from 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)

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)



And now, "generative AI"

- Introduction of ChatGPT in November, 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
  - 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 for specific tasks (Chung, 2022)
  - Activated by (and importance of) prompting (Liu, 2023)

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; Goodman, 2023)
- Solving clinical cases
  - Comparable to but not better than expert humans (e.g., Levine, 2023; Kanjee, 2023; Rao, 2023; Benoit, 2023; Lekovich, 2023)

Results of ChatGPT and other LLMs (cont.)

- Communicating with patients
  - Answer questions in public forums (Sarraju, 2023; Ayers, 2023)
  - Write letters with comparable or better empathy (Ali, 2023, Ayers, 2023)
  - Generating surgical consent forms better than surgeons (Decker, 2023)
- Use of predictive AI (closing the AI loop)
  - 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)

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But there are downsides to generative AI

- 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)
- Automated GPT detectors do not work well (Sadasivan, 2023; Odri, 2023)
  - 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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Will AI help or hinder healthcare?

- 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)
  - Suboptimal methodologies leading to 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)
  - (Plug in your health profession)
- 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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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 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)
- New AI-competency frameworks (Russell, 2023; Liaw, 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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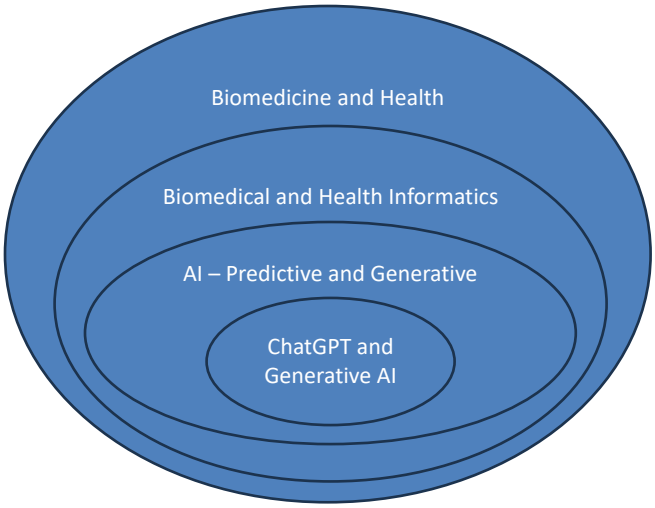
Where does AI fit in health professions education?



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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)
- "Homework as we know it is over." (Mollick, 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)
- "Assigning AI" (Mollick, 2023 – https://www.oneusefulthing.org/)

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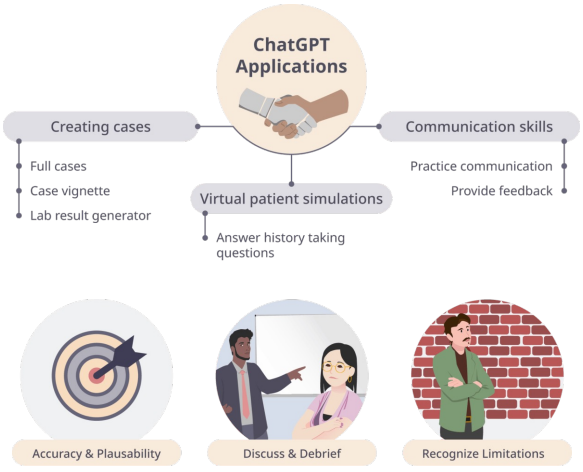
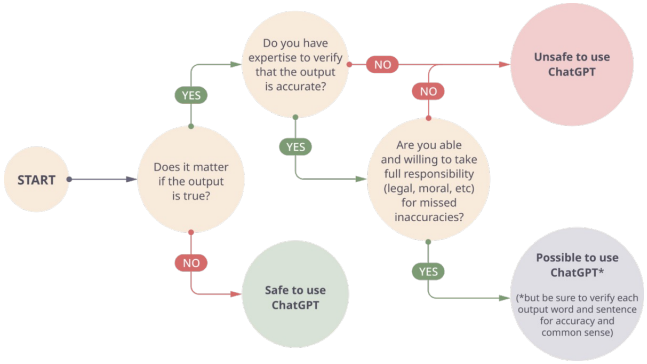
Some advocated that ChatGPT will change education, not destroy it (Heaven, 2023)

- 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

ChatGPT in medical education (Ratliff, 2023)





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

Prompt engineering

- Best practices (Heston, 2023)
  - 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
  - Clarify what constitutes "cheating"
- Tutorial (Meskó, 2023)
- Adding "according to sources" to ChatGPT prompts improves quoting of pre-trained data (Weller, 2023)
- "Cheat sheets"
  - https://www.aifire.co/c/ai-learning-resources

Uses and risks of "assigning AI" (Mollick, 2023)

AI USE	ROLE	PEDAGOGICAL BENEFIT	PEDAGOGICAL RISK
MENTOR	Providing feedback	Frequent feedback improves learning outcomes, even if all advice is not taken.	Not critically examining feedback, which may contain errors.
TUTOR	Direct instruction	Personalized direct instruction is very effective.	Uneven knowledge base of AI. Serious confabulation risks.
COACH	Prompt metacognition	Opportunities for reflection and regulation, which improve learning outcomes.	Tone or style of coaching may not match student. Risks of incorrect advice.
TEAMMATE	Increase team performance	Provide alternate viewpoints, help learning teams function better.	Confabulation and errors. "Personality" conflicts with other team members.
STUDENT	Receive explanations	Teaching others is a powerful learning technique.	Confabulation and argumentation may derail the benefits of teaching.
SIMULATOR	Deliberate practice	Practicing and applying knowledge aids transfer.	Inappropriate fidelity.
TOOL	Accomplish tasks	Helps students accomplish more within the same time frame.	Outsourcing thinking, rather than work.

Risks:

- Confabulation
- Bias – from training content
- Privacy – policies not always clear
- Instructional – student over-reliance

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Other uses of ChatGPT

- Using ChatGPT in medical practice, e.g.,
  - Developing patient handouts in rural dermatology (Baker, 2023)
  - Create checklists for common presentations and generate templates for common clinical scenarios (Bair, 2023)
- Assist with aspects of scholarly publishing (Zhou, 2023)
- Plugins enhance functionality
  - BrowserPilot – access live Web sites
  - ScholarAI – search PubMed and other research databases
  - SmartSlides – generate (short) Powerpoint presentations

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Other uses of LLMs

- Creating medical art (Huston, 2023)
- Adding generative AI to search, e.g.,
  - Bing – with version of GPT-4
  - Google – with Bard/PaLM
- As someone whose research area includes information retrieval (Hersh, 2020), do not yet find generative AI ready to replace most types of searching, especially
  - Comprehensive literature review
  - Known-item searching

My (small) use of ChatGPT in informatics teaching so far (due next month)

- You need to have a conversation with ChatGPT, not just ask it a single question.
- There are some good recent papers on methods for prompting ChatGPT (Heston, 2023; Meskó, 2023).
- You conversation with ChatGPT should ask it about some aspect of informatics that interests you or is important to your job. You can further ask it about things you want to learn more about or point out things it says that are incorrect or are missing and should be there.
- You should include your own post-conversation analysis summarizing what ChatGPT told you, where it added new knowledge for you, what you believe it said that was not correct (i.e., confabulating), and what was missing. If you asked it to provide references, you should identify any that were incorrect.
- All of your conversation should be recorded in a Word document and then submitted as outlined in the syllabus. You can do this by copy and paste from ChatGPT to get your conversation into the Word document, and then add your post-conversation analysis after that. Your document should be the same 2-3 pages as required for the original assignment.

Uses of LLMs for which I am more ambivalent

- Online discussion forums – could be helpful for students with difficulty expressing themselves vs. disincentivizing original thinking
- Quizzes and exams – tend to prefer open-book testing of applying knowledge but preliminary analysis shows ChatGPT capable of passing
- Conclusion – we need discussion and policy

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

Domain	Competency
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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Competencies for use of AI in primary care (Liaw, 2023) – applicable to all health professions use

Domain	Bottom Line	Competency
Foundational knowledge	What is this tool?	Clinicians will explain the fundamentals of AI, how AI-based tools are created and evaluated, the critical regulatory and socio-legal issues of the AI-based tools, and the current and emerging roles of AI in health care.
Critical appraisal	Should I use this tool?	Clinicians will appraise the evidence behind AI-based tools and assess their appropriate uses via validated evaluation frameworks for health care AI.
Medical decision making	When should I use this tool?	Clinicians will identify the appropriate indications for and incorporate the outputs of AI-based tools into medical decision making such that effectiveness, value, equity, fairness, and justice are enhanced.
Technical use	How do I use this tool?	Clinicians will execute the tasks needed to operate AI-based tools in a manner that supports efficiency and builds mastery.
Patient communication	How should I communicate with patients regarding the use of the tool?	Clinicians will communicate what the tool is and why it is being used, answer questions about privacy and confidentiality, and engage in shared decision making, in a manner that preserves or augments the clinician-patient relationship.
Unintended consequences (cross-cutting)	What are the "side effects" of this tool?	Clinicians will anticipate and recognize the potential adverse effects of AI-based tools and take appropriate actions to mitigate or address unintended consequences.

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Teaching AI is more than ChatGPT/LLMs – some examples from DMICE R25 summer internship

- Predictive AI
  - Orange Data Mining
    - https://orangedatamining.com/
  - Open-source "no code" visual programming environment to teach data exploration and visualization, ML modeling, etc.
  - Excellent set of introductory YouTube videos
    - https://www.youtube.com/@OrangeDataMining
- Health Data Equity and Ethics Seminar
  - Student-led presentations and discussion about issues related to data and algorithm bias, fair and responsible use of AI, etc.

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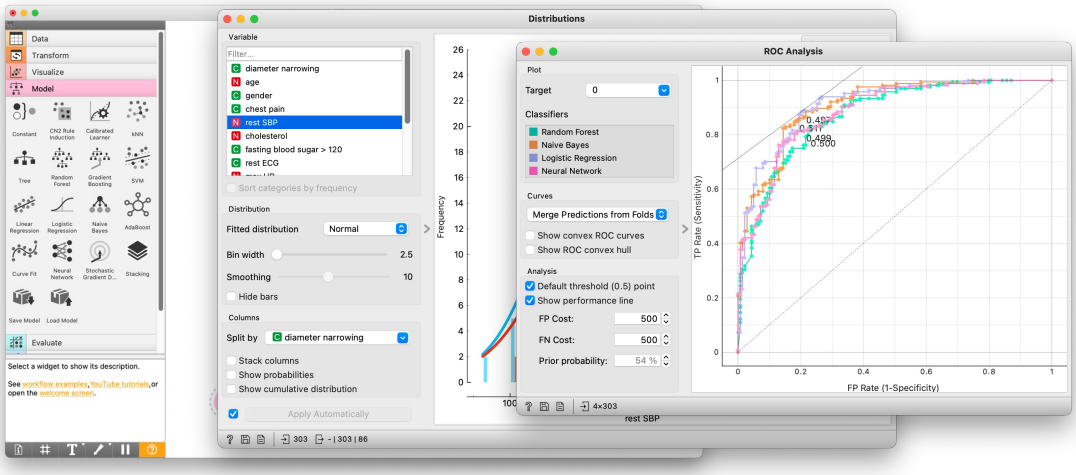
Visual programming, exploration, and modeling in Orange



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
  - Where do we draw line on appropriate use?

Questions?

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