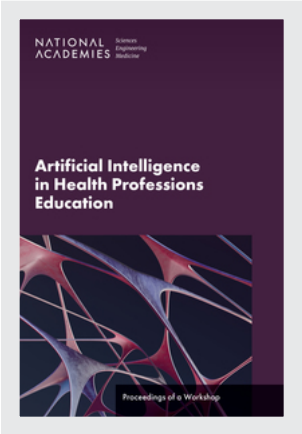

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Artificial Intelligence in Health Professions Education

Patricia A. Cuff and
Erin Hammers Forstag, *Rapporteurs*

Global Forum on Innovation in
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Health and Medicine Division

Proceedings of a Workshop

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We thank the following individuals for their review of this proceedings:

BONNIE MILLER, Vanderbilt University Medical Center
PATRICIA SENGSTACK, Vanderbilt University School of Nursing

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the content of the proceedings, nor did they see the final draft before its release. The review of this proceedings was overseen by **NED CALONGE,** University of Colorado School of Medicine. He was responsible for making certain that an independent examination of this proceedings was carried out in accordance with standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the rapporteurs and the National Academies.

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Acronyms and Abbreviations

AI	artificial intelligence
ChatGPT	Chat Generative Pre-Trained Transformer
DATA-MD	data-augmented, technology-assisted medical decision making
FDA	U.S. Food and Drug Administration
IT	information technology
MIDP	Medical Innovators Development Program
ML	machine learning

1

Introduction[1]

The Global Forum on Innovation in Health Professional Education held a multi-day workshop series on Artificial Intelligence in Health Professions Education. The workshop was held both virtually and in-person and took place over 4 non-consecutive days. The first session, held on March 3, 2023, served to provide a background on artificial intelligence (AI) and its role in health professions education and practice. The second session, held on March 15, 2023, explored the social, cultural, policy, legal, and regulatory considerations of integrating AI into health care, and the third session, held on March 16, 2023, examined the competencies health professionals need to effectively and comfortably use AI in practice. Finally, a closing session was held on April 26, 2023, devoted to discussing steps for integrating AI into health professions education using real-world examples. This workshop proceedings generally follows the order in which the sessions occurred.

The full workshop agenda is provided in Appendix B, and a list of reading materials from the workshop is provided in Appendix D. Biographies of the speakers can be found in Appendix C, while a listing of the members of the Global Forum on Innovation in Health Professional Education, which hosted the workshop, are in Appendix A. The workshop was planned by

[1] The planning committee's role was limited to planning the workshop, and the Proceedings of a Workshop has been prepared by the workshop rapporteurs as a factual summary of what occurred at the workshop. Statements, recommendations, and opinions expressed are those of individual presenters and participants and are not necessarily endorsed or verified by the National Academies of Sciences, Engineering, and Medicine, and they should not be construed as reflecting any group consensus.

BOX 1-1
Statement of Task

A planning committee of the National Academies of Sciences, Engineering, and Medicine will organize and conduct a public workshop to explore opportunities, issues, and concerns with preparing health professionals to maximize the potential of artificial intelligence (AI) to improve the process of health professions education. Invited presentations and discussions will involve global audiences in understanding the duality that health professions educators must consider, which is the need for training in AI and the role of AI in training. Invited speakers may present research and relevant issues related to topics such as:

- Applying AI for accelerating effective interprofessional education and collaborative practice;
- Exploring challenges and opportunities in developing, validating, implementing, and monitoring the use of AI and machine learning algorithms in health professions education;
- Understanding potential risks and benefits of AI for improving the educational process (e.g., bias, equity, and burden);
- Investigating the barriers and facilitators to integrating AI into clinical education; and
- Engaging relevant stakeholders for responsible AI implementation from foundational health professional education to continuing education development.

The planning committee will select and invite speakers and discussants and moderate the discussions at the workshop. Following the workshop, a proceedings of the presentations and discussions will be prepared by a designated rapporteur in accordance with institutional guidelines.

a committee of experts (Appendix C) in accordance with the Statement of Task (Box 1-1). A glossary of terms can be found in Appendix E.

THE ROLE OF AI ACROSS HEALTH PROFESSIONS

The workshop series began with a pre-workshop virtual session held on March 3, 2023. Carole Tucker, the associate dean of research at the University of Texas Medical Branch, welcomed participants to the session, saying that there were two goals of this session: first, to better understand what AI is and, second, to explore why it is necessary for health professionals and educators to recognize the potential role of AI. Saying that the first would be addressed by the keynote speaker, Tucker addressed the second by saying that AI is "already here and it is here to stay." Given that AI is already

embedded in everyday life, it is important for those in the health professions to understand how AI is being used and may be used within and outside of health care, which in turn will have benefits for both health professions education and practice. Tucker then highlighted an aspect of the day's session featuring speakers describing their experiences with AI in health care. She explained that the intent behind sharing practice-based experiences was to stimulate thinking and discussion among educators about what is needed in health professions education to prepare learners so that they are ready to use AI when they shift from classroom learning to the clinical learning environment. These practice-based presentations were elaborated on by formal comments offered by two students. The invited students, who were enrolled in medical and nursing schools, shared their perspectives on AI in health professions education. Reflections from both the learners—Mollie Hobensack, a Ph.D. candidate at the Columbia University School of Nursing, and Areeba Abid, an M.D./Ph.D. candidate at the Emory University School of Medicine—are summarized in boxes following each presentation (see Boxes 1-2, 1-3, 1-4, and 1-5). Virtual and in-person participants listened to the presentations and discussions exploring read-ahead materials that were embedded in the workshop agenda found in Appendix B. Tucker introduced the keynote speaker, Cornelius James, clinical assistant professor at the University of Michigan Medical School, who underscored the speed at which the field of AI is changing, before walking the audience through a hypothetical scenario involving AI.

A Hypothetical AI Scenario

James began with a brief hypothetical scenario. He asked workshop participants to imagine they are caring for a 73-year-old man named Mr. Harris, with a recent diagnosis of Alzheimer's disease. Mr. Harris presents to the office for a routine check-up and is accompanied by his son Adam. Adam expresses concern about his father's risk of falling, but Mr. Harris insists that a recent fall was merely due to old shoes or walking too fast. After some discussion, Mr. Harris agrees to activate an AI-based application that uses sensors embedded in a smartwatch to assess the risk of falling. Over the course of a month, the monitoring reveals multiple loss of balance events, and the algorithm identifies Mr. Harris as high risk for falling. James asked workshop participants to consider how their care of Mr. Harris might be affected by this information.

Applications such as this are possible due to the ubiquity and growth of big data and AI, James said. Devices such as smartphones, cars, appliances, and watches produce large amounts of data, and computers are capable of quickly processing and interpreting these data. For example, email providers use machine learning (ML) methods to categorize spam mail, and

streaming services use viewing history to provide recommendations about shows that may be of interest. AI is an umbrella term that means the use of computers to perform tasks that typically require objective reasoning and understanding, James said. There are multiple domains within AI, including natural language processing (e.g., Alexa, ChatGPT [Chat Generative Pre-Trained Transformer]), and computer vision. Another major domain of AI is ML, defined as the "use of statistical and mathematical modeling techniques that use a variety of approaches to automatically learn and improve the prediction of a target state without explicit programming" (Matheny et al., 2019). A technique within ML is called deep learning, in which artificial neural networks are used to solve complex clinical problems. Deep learning models, James said, have many layers of information and connections of artificial neurons that are drawn between features at each level of the model. While these tools can be useful in making sense of complex information, there are concerns about not being able to know exactly what led to a model's prediction—in other words, not being able to see inside the "black box." This is a particular concern, James said, when deep learning is used to make decisions about the care of patients, as clinicians often want to know the reasons for a recommendation.

There has been a "data explosion" in health care in recent years and, along with it, a proliferation of AI and ML intended for use in a health care setting. The amount of health-related data will only continue to increase, James said, especially as more patients adopt wearable devices. With the amount of data increasing exponentially, the number of facts affecting patient care decisions will exceed human cognitive capacity. AI applications offer an approach for managing these data and helping patients and providers make decisions. While the U.S. Food and Drug Administration has approved more than 500 AI-based health care devices and algorithms, the use of AI in health care has lagged behind other fields.

James identified a number of challenges to the implementation of AI in health care:

- The potential for bias and perpetuation of inequalities and disparities;
- Issues around governance and regulation;
- The trust of providers and patients;
- Transparency and data sharing;
- Dataset quality and availability;
- Integration of AI into the infrastructure, process, and workflow of health care; and
- Calibration drift.

These challenges, James said, can be grouped into four overarching categories related to the adoption of technology by health care providers

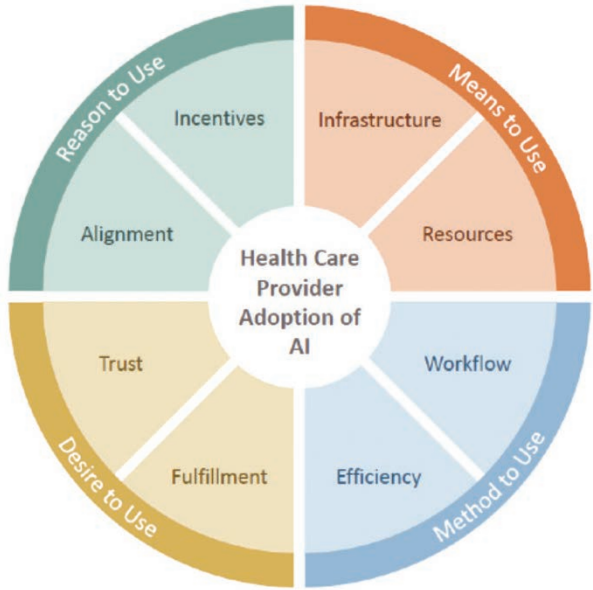

FIGURE 1-1 Health care provider adoption of AI.
SOURCE: Presented by Cornelius James, March 3, 2023 (Adler-Milstein et al., 2022).

(Figure 1-1): challenges related to the reasons a provider would choose to use AI, to the means a provider has to use AI, to the method used for AI, and to the desire to use AI.

Impact on Health Professions Education

The deluge of data and the use of AI in health care has and will continue to affect health professions education, James said. The traditional model for educating health care professionals has been the biomedical model, but the proliferation of AI-based technologies calls for a shift to a "biotechnomedical" model of education. This new model, he said, would go beyond the human biological system of simply understanding normal and abnormal function. A biotechnomedical model could use data-generated AI for proposing interventions in human disease and, as such, could expand the potential impacts of intelligent technologies in the prevention, diagnosis, and treatment of disease. Currently, AI has a minimal presence in medical education curriculum, and it is primarily found in non-mandatory offerings such as electives, workshops, and certificate programs. James argued that this is insufficient for preparing health care professionals to effectively

engage with AI; he expects that AI will become firmly integrated or embedded into curricula over the next few years.

The three pillars of medical education are clinical science, basic science, and health system science; James predicted that within 10 years AI will become a foundation for these pillars, and it will transform the way educators and clinicians teach, assess, and apply information in these domains (Figure 1-2). This will require rethinking and reconsidering which tasks will be delegated to clinicians and what tasks will be delegated to AI. AI is a "fundamental tool of medicine," James said, and clinicians of the future will need to have the ability to interact, engage, and work with this tool.

James told workshop participants about his work to develop curricula to teach learners across the continuum of medical education about AI. The mission of the Data Augmented, Technology Assisted Medical Decision Making (DATA-MD) team is "to develop, implement, and disseminate innovative health care AI/ML curricula that serve as a foundation for medical educators to develop curricula specific to their own institutions and/or specialties." The team includes people from a variety of perspectives and backgrounds, including clinicians, data scientists, lawyers, researchers, medical educators, and administrators. They are developing an online curriculum and are working with the Center for Academic Innovation at the University of Michigan to ensure its launch in August 2023. The curriculum contains four modules:

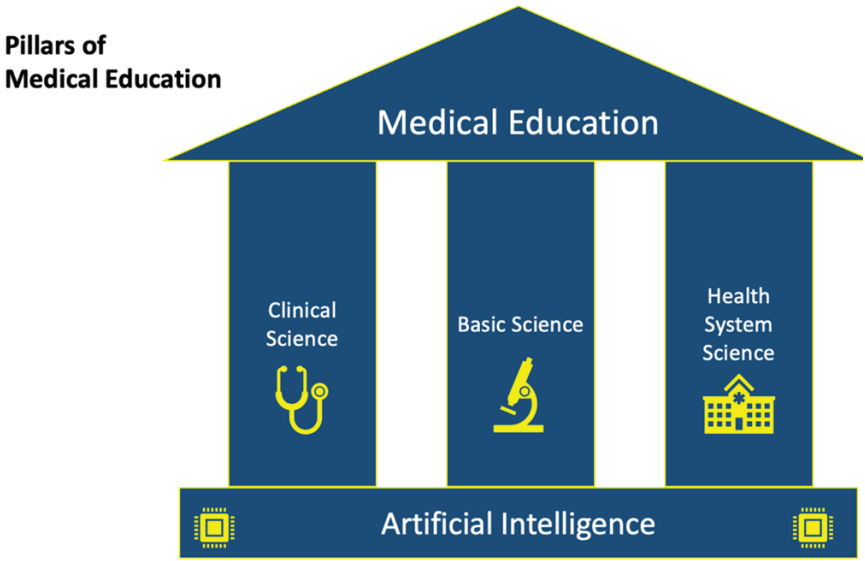

FIGURE 1-2 Pillars of medical education.
SOURCE: Presented by Cornelius James, March 3, 2023 (Fred and Gonzalo, 2018).

- Introduction to AI/ML in Healthcare
- Foundational Biostats and Epidemiology in AI/ML for Health Professionals
- Using AI/ML to Augment Diagnostic Decisions
- Ethical and Legal Use of AI/ML in the Diagnostic Process

Another web-based curriculum, which takes a closer look at the issues surrounding AI/ML, will launch in late 2023. It contains seven modules:

- Intro to AI
- Methodologies
- Diagnosis
- Treatment and Prognosis
- Law, Ethics, Regulation
- AI in the Health System
- Precision Medicine

Both curricula will be evaluated for effectiveness in teaching learners, James said.

James closed by saying that AI has the potential to transform the delivery of health care, but AI/ML instruction in health professions education is lacking. There is a need to consider how to incorporate this content into curricula, and health professionals must be vocal stakeholders in the development, deployment, and education when it comes to use of AI- and ML-based technologies in health care.

BOX 1-2
Learner Perspectives*

- There is major growth in technologies aimed at helping people at home (e.g., fall detection), but there is a lag in AI initiatives focused on post-acute care. Stakeholders are encouraged to be forward thinking in generating AI policies and education tailored to the post-acute care setting. (Hobensack)
- As the use of AI-driven, direct-to-consumer products (e.g., wearable sensors) continues to grow, health professions students need education on how to incorporate these data into clinical practice. (Abid)

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AI in the Data-to-Knowledge Transformation

Tucker said that she takes an information science approach to AI. Through this lens, data are transformed into information through a variety of processes. Out of the information comes knowledge, and out of knowledge comes wisdom (Figure 1-3). AI can provide information and thus knowledge by finding patterns in data, Tucker said. There has been an explosion of data and also of sources of data, from payers to governments to wearable devices. However, data by themselves are just data, she said. What is needed is information and knowledge, which require finding patterns in the data and being able to contextualize and understand these patterns.

Although there are fears surrounding big data and AI, big data and AI are neither the problem nor the answer, Tucker said. She explained how the information and knowledge generated by AI build on prior data, with all their limitations and biases. For example, she said, large health care datasets are generally focused on aspects of health care that are disease promoting (e.g., data from electronic health records). It may be challenging to use these data to look for salutogenic aspects of health. New sources of data, such as wearable sensors, may provide information on a more balanced notion of health, Tucker said.

The transformation of data into information and knowledge requires theoretical framings to make sense of the data. AI is not neutral but is

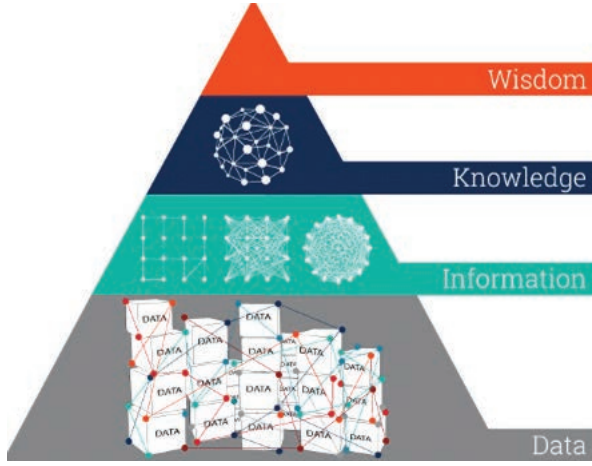

FIGURE 1-3 The data-to-wisdom transformation.
SOURCE: Presented by Carole Tucker, March 3, 2023; graphic created by Ontotext. 2022. "What is the Data, Information, Knowledge, Wisdom (DIKW) Pyramid?" https://www.ontotext.com/knowledgehub/fundamentals/dikw-pyramid.

BOX 1-3
Learner Perspectives*

- Each individual brings a unique perspective on the value and utility of AI technology; one way to incorporate these perspectives into health professions education is through interprofessional development opportunities that use case studies to encourage conversation about AI in health care. (Hobensack)
- Students are excited about AI and ML and want these topics to be integrated into health professions curriculum. (Abid)

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driven by theoretical frameworks and analytical techniques; for example, is the AI designed to look for connections and similarities, or to look for statistical differences? It is important to know what is in the "black box" to understand how the data are being transformed into information, Tucker said. It has been said that generative AI is not simply a technology or tool but reflects the developer and the developer's motivation. Tucker commented that health professions learners and practitioners need to be not just passive learners about AI but active participants in guiding the use of AI within policies and systems.

Tucker shared additional resources for those interested in learning more:

- Bridge to AI (https://bridge2ai.org/)
- Big Data to Knowledge (https://www.nlm.nih.gov/ep/BD2KGrants.html)
- American Medical Informatics Association (https://amia.org/)

Interoperability for Effective AI

Interoperability must be considered as the first step for an inclusive, holistic approach in improving patient safety, care quality, and care delivery outcomes while reducing clinician burden and waste, said Kelly Aldrich, an informatics nurse specialist at Vanderbilt University. The definition of interoperability depends on the lens the person is looking through, she said. The Center for Medical Interoperability (2021) defines it as "the ability of

information to be shared and used seamlessly across medical devices and systems to improve health and care coordination." The 21st Century Cures Act describes interoperability as "health IT [information technology] that enables the secure exchange of electronic health information with, and use of electronic health information from, other health IT without special effort on the part of the user; [and] allows for complete access, exchange, and use of all electronically accessible health information for authorized use under applicable State or Federal law" (ONC and HHS, 2020). Aldrich said that, in comparison, clinicians would be likely to define interoperability as a "plug and play" system for health care; Aldrich compared this system to LEGOs, in which any piece or set can be combined with other LEGOs, and "they just work" (Center for Medical Interoperability, 2021).

Like Tucker, Aldrich said that in order to be useful, data must be transformed into information, knowledge, and then wisdom. This means that AI, according to Lehne et al. (2019), is only useful if it can be converted into meaningful information, which "requires high-quality datasets, seamless communication across IT systems, and standard data formats that can be processed by humans and machines" (p. 1). Where and how are data obtained to create wisdom and to improve the patient's outcomes and our impact on care and coordination? Doing so requires a model; Aldrich spoke about the Interoperability Maturity Model created by the Center for Medical Interoperability (2021) (Figure 1-4). To have interoperability, she emphasized the "need to make our way completely around the spoke." Building a system with interoperability, Aldrich said, means considering the following:

- How connected, secure, and resilient is your health system's infrastructure?
- Is the information your system needs to exchange properly formatted to meet your needs?
- Do the places that send and receive your data speak the same language?
- Is the information sequenced to meet your needs?
- Do your information exchanges enable safety and optimal decisions?

Clinicians want to see data organized and presented in a way that allows them to make decisions to best care for their patients, Aldrich said. She compared this scenario to a fighter pilot cockpit, filled with screens that display easy-to-read, timely data and buttons that allow the pilot to take action. What educators and clinicians have instead, she said, is a system with multiple screens and systems that do not all feed into the same infrastructure and do not allow the clinician easy access to the data for decision making. Many of the medical devices and systems used for patients contain

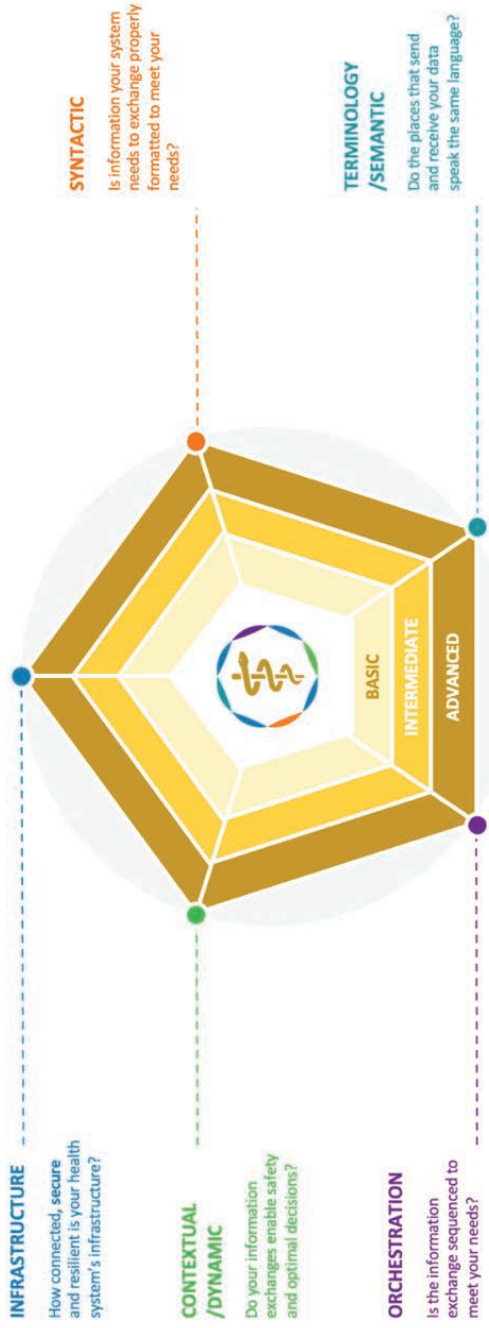

FIGURE 1-4 Interoperability Maturity Model.
SOURCE: Presented by Kelly Aldrich, March 3, 2023 (Center for Medical Interoperability, 2021).

proprietary data and cannot "speak" to one another. The systems may be collecting useful data, but if the data are not entered into the patient's record, they cannot be used to improve care. There are concerns with system vulnerabilities and lack of transparency; for example, there would be no way to know if a system had been hacked in a way that affected patient care. "Our patients and care teams deserve better," she said. A lack of comprehensive interoperability and data liquidity can compromise patient safety, undermine care quality and outcomes, contribute to clinician fatigue, and waste billions of dollars each year.

Clinical interoperability cannot be an afterthought, Aldrich said; it needs to be a leading requirement in the adoption of health IT solutions. Well-functioning health systems are able to appropriately, seamlessly, and interchangeably share and use information. The safety and quality problems associated with a lack of interoperability are a *systems* issue, not a failure of the workforce. Clinicians are tired and need help using data to coordinate care. Aldrich quoted the report *Crossing the Quality Chasm* (IOM, 2001), which reads as follows:

> *Health care has safety and quality problems because it relies on outmoded systems of work. Poor designs set the workforce up to fail, regardless of how hard they try. If we want safer, higher-quality care, we will need to have redesigned systems of care, including the use of information technology to support clinical and administrative processes.* (p. 4)

In integrating AI into health care, Aldrich said, educators and clinicians should look to other fields and industries for ideas. For example, other industries use digital twins (virtual copies of physical objects) to map a system and identify positive and negative impacts; health care could do the same with the care system. Aldrich compared the air traffic control system—in which technologies present clear information to controllers in order to coordinate flights—to the patient care system, in which clinicians still routinely use white boards and markers and magnets to coordinate the care of patients.

At the Vanderbilt University School of Nursing, educators are working to "prescribe technology," Aldrich said. For example, students use immersive virtual reality for empathy training and augmented simulation for clinical skills training. Students get experience using ambient intelligence, which uses sensors and AI to enable caregivers to provide quality care efficiently. For example, an ambient intelligence system can use data to predict if a patient is likely to get out of bed and fall before a caregiver can reach the patient.

BOX 1-4
Learner Perspectives*

- Introducing the issue of interoperability to health professions students early in their education will allow them to begin to notice the ways in which a lack of interoperability affects clinical practice, thereby better preparing them to acknowledge and address interoperability challenges as clinicians. (Hobensack)
- Solving some of the big challenges in health care will not necessarily require complicated technologies; getting devices to communicate with each other could go a long way in improving patient care and reducing burdens on clinicians. (Abid)

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Chatbots for Mental Health: AI in Clinical Practice

Chatbots are a software application used to conduct conversations via text or text-to-speech, said Eduardo Bunge, the associate chair of the psychology department at Palo Alto University. For example, it is now possible to chat via text with an online assistant or via voice with a personal Amazon Echo or Google Assistant. Lately, chatbots are being built with a digital persona—that is, a "person" that can be seen or heard, or both. In the field of mental health, traditional in-person talk therapy is being supplemented with different types of chatbots.

Broadly speaking, there are two types of chatbots currently available: rule-based and AI-based (and they can be combined). Rule-based chatbots are programmed to respond a specific way to keywords or questions; they cannot generate their own answers or respond to queries that are not programmed. This can be useful, Bunge said, when there is a good match between what the user needs and what the chatbot is programmed to do (e.g., discuss respiratory problems). When a query or response is outside of the chatbot's programmed scope, the chatbot usually responds with a generic response or apology. This type of chatbot is not particularly hard to create, even for those who are not tech-savvy. The other type of chatbot is AI-based and uses natural language processing and ML. These types of chatbots, which include Amazon's Alexa and ChatGPT, can generate their own responses and use natural language in responding. These technologies are more sophisticated and require a level of technological expertise.

There are numerous chatbot products on the market in the mental health space, Bunge said, and they are mostly rule-based chatbots. These include Woebot, Youper, Replika, Wysa, and TalkToPoppy. These types of chatbots have shown promise; for example, a meta-analysis found a moderate effect of these interventions for delivering psychotherapy to adults with depressive and anxiety symptoms (Lim et al., 2022). Bunge cautioned that the analysis looked at only a handful of studies and patient follow-up was short-term. Several other papers have reported that patients establish therapeutic bonds with chatbots, including Darcy et al. (2021), Dosovitsky and Bunge (2021), and Beatty et al. (2022).

Technologies involving chatbots and AI yield a lot of power as well as a lot of responsibility, Bunge said. Everyone in health care needs to be aware of these tools and their potential benefits, including reducing work burden, improving outcomes, and expediting processes. These benefits could be applied to both the practice of health care and the education of future health professionals. Bunge suggested that health professions students could even develop their own chatbots to better understand the technology; for example, they could make a simple rule-based chatbot to deliver psychoeducation about depression or other disorders. The promise of chatbots lies in the fact that they can mimic conversations that humans have with other humans, Bunge said. Respondents tend to anthropomorphize chatbots, which leads to a higher engagement level than with other digital interventions. Through this process, people create bonds and have more natural interactions, which leads to longer and better engagement, he added.

BOX 1-5
Learner Perspectives*

- Chatbots hold potential to support the mental health of students and clinicians, particularly as the burden of responsibilities placed on clinicians increases. (Hobensack)
- One area in which chatbots could reduce the burden on clinicians is in patient communication; it takes time to respond to messages sent through patient portals, and clinicians are not always reimbursed appropriately for this time. Using AI to communicate with patients would require further research on how patients feel about talking to AI and whether it affects trust in their provider. (Abid)

*This list is the rapporteurs' summary of points made by the individual speakers identified, and the statements have not been endorsed or verified by the National Academies of Sciences, Engineering, and Medicine. They are not intended to reflect a consensus among workshop participants

DISCUSSION

Following the presentations and learner reflections, a panel discussion was held in which members of the planning committee (Appendix C) asked speakers questions while also sharing personal perspectives and feedback.

Relationship between Clinicians and AI

Kimberly Lomis, the vice president of undergraduate medical education innovations for the American Medical Association, moderated the discussion and asked panelists about the relational aspects of integrating AI into the clinical setting—that is, what do clinicians need to bring to the table in order to best interact with AI and achieve the optimal relationship? James responded that AI has been described as a "teammate." A successful team has established goals, clearly defined roles, mutual trust, communication, and measurable outcomes—all of which would be important in the relationship between AI and clinicians. Another phrase that has been used for AI is "augmented intelligence." This term emphasizes the fact that each member of the care team, from patients to clinicians to AI, brings his or her own expertise and skills and augments the expertise and skills of other members. For example, James said, AI could take certain tasks off the clinician's plate, which would then allow the clinician to focus on fostering and strengthening the patient–clinician relationship. By transferring some tasks to AI, clinicians can "be a bit more human in their interactions with their patients." Bunge added that people can sometimes see AI as a threat to their jobs; he suggested that AI should instead be seen as an ally that can help people do their jobs better. However, for clinicians to view AI in this way, they need to be exposed to it early and often. Students need to have experiences working with AI technologies to build a trust in AI and to know what roles and tasks are appropriate for AI.

Promising Applications for Language-Generative AI

Carl Sheperis, dean at Texas A&M University–San Antonio, said there has been an incredible evolution of language-generative AI recently (e.g., ChatGPT) and asked panelists to share their opinion about the most promising future developments in this area for health care. Aldrich said that when looking for promising AI applications, it is critical to keep focused on the problem being solved. Patient safety and quality of care have been issues for decades, and clinicians are facing moral injury as they manage care without interoperability and without technologies that can help them coordinate care. Technology can be used to build a digital twin of the current system and map out how to close the gap between the current system

and the ideal system, Aldrich said. By focusing on the problems that need to be solved, technologies can be developed and implemented to address those specific problems. Most importantly, Sheperis said, is keeping the patient at the center and identifying opportunities to use technology to improve the patient experience and care.

Restoring Joy

AI and other technologies have the potential to restore joy to the health care profession, said Lisa Howley, senior director of strategic initiatives and partnerships at the Association of American Medical Colleges. She shared a quote from Robert Wachter (2017): "The combination of intelligent algorithms and automatic data entry will allow each health care professional to practice far closer to the top of her license. As less time is wasted on documenting the care, doctors and nurses will have more direct contact with patients and families, restoring much of the joy in practice that has been eroding, like a coral reef, with each new wave of nonclinical demands" (p. 260). She asked panelists for their thoughts on how AI could be used to free up time for clinicians to spend more time at the bedside with the patient, engaging in more meaningful and joyful activities. James responded that when the electronic health record was first developed, there were significant promises that it would improve clinicians' lives and practice. However, these promises have largely not been fulfilled, in part because clinicians were not involved in the development or deployment of the technologies. In moving forward with AI, it will be important to learn lessons from these prior experiences and to keep in mind the workflow of the clinician and what would actually be helpful. For example, there are AI technologies in development that will help clinicians with documentation and billing, so the clinician can engage more effectively with patients. Tucker noted that the electronic health record was developed without a close look at how technology could improve the process; instead, it "basically took a paper [record] and put it in a computer."

2

Considerations in the Adoption of AI in Health Professions Education

The second session of the workshop series was held on March 15, 2023. Kimberly Lomis, the vice president of undergraduate medical education innovations for the American Medical Association, served as moderator for the session. In contemplating a smoother implementation of artificial intelligence (AI) training across health professions, she said, it is important to explore the social, cultural, policy, legal, and regulatory considerations of AI in health practice and education. This session was designed to explore these topics, with a focus on discussing the combination of computational abilities and human abilities that can best serve patients.

SCHOLARSHIP IN THE AGE OF AI

Alison Whelan, the chief academic officer at the Association for American Medical Colleges, was asked to fill in for a speaker who had to cancel suddenly. She opened her remarks by saying that when thinking about AI in health professions education, there are two different aspects to consider. First, students need to be educated to be competent in their practice and be prepared to use AI-based technologies in this role. Second, AI can be used to enhance the educational experience of students while they are in school. Whelan provided examples of ways in which AI can be used to improve education:

- Personalized education that can adapt to the learning style and pace of individual students and provide personalized content and feedback;

- Simulation experiences that provide a safe and controlled environment to gain practical experience, learn skills, and get feedback;
- Predictive analytics that can identify areas of weakness and areas of growth;
- Remote learning tools that help students access and be immersed in their education, no matter where they are; and
- Research in programmatic analysis and patient outcomes.

While AI holds promise in these areas, she said, it also presents ethical, moral, and legal challenges. Whelan then revealed that the examples she just shared were created by ChatGPT (Chat Generative Pre-Trained Transformer), albeit with minor edits. She asked the audience if she had an obligation to disclose this information and whether her obligation might differ depending on whom she was talking to (e.g., patients, students). The way that students and scholars have gathered information to prepare a speech or a paper has changed dramatically in the past several decades, Whelan said. She spoke about how, years ago, she used card catalogues to find sources and accessed books or journals directly in the library or through interlibrary loans. Soon she had collected file cabinets full of articles and would pull them out as she needed information. Now she has an electronic standing bibliography full of articles that were found via an internet search. Search results and resources such as subscription-based, clinical decision-making resources can make it easy to find evidence, but what, she asked, is the obligation of scholars to check beyond the "black box" to look at the evidence and think critically about what is and is not represented? There are many black boxes in medicine, from magnetic resonance imaging machines to lab tests; clinicians understand the inputs and outputs but may not be aware of the algorithms that are used to transform inputs into outputs, she added.

Whelan closed with a series of questions to the audience. In health care, she said, there has always been an implicit belief that health professionals are subject matter experts and that this expertise gives them the responsibility of making decisions about patient care. With the advent of AI, will health professionals retain this role, or will their role shift? Tools such as smartwatches provide data; will health professionals have the expertise necessary to understand these data and help patients make informed decisions?

ECONOMIC AND DECISION SCIENCE PERSPECTIVES ON CLINICAL AI

Building on Whelan's questions about the future role for clinicians in the context of AI, speaker Nathaniel Hendrix, a researcher and data scientist at the American Board of Family Medicine, discussed the role

that AI may play in health care moving forward and what this means for clinicians. The cost of health care has increased at a much faster rate over the past 20 years than the costs of other goods and services, he noted. One theory of why, he said, is that other parts of the economy are better able to take advantage of new technologies to improve productivity and that improved productivity can lead to slower growth in prices. In health care, there are many barriers to adopting new technologies, and it can be difficult to increase productivity. Hendrix shared an analogy made by economists William Baumol and William Bowen (1965), who noted that the number of musicians to perform a certain symphony has not decreased over time (i.e., there has been no increase in productivity), and the wages of these musicians have gone up. This increase in cost has been absorbed, in part, by turning some of the services of musicians into goods; that is, musical performances have been put on streaming services and made available for purchase. Health care is similar—it takes a certain amount of time and labor to perform tasks, so reducing costs may require taking some health care services and turning them into goods. This transformation, Hendrix said, may require using AI systems to perform some of the traditional tasks of clinicians.

Hendrix proceeded to discuss different ways that AI can interact with clinicians (Figure 2-1):

- AI as decision support,
- AI as independent interpretation,
- The clinician as part of an ensemble,
- AI as triage, and
- Unattended AI.

Hendrix gave several examples of how these different ways of AI usage would look in the clinical setting. An AI system could be used to make a recommendation or to offer an opinion to the clinician. If the AI system and clinician disagree, the decision could be referred to a third party. AI could also be used to identify weaknesses in clinical decision making by humans and to counteract these weaknesses. AI could be used to make triage decisions for very high-risk or low-risk patients; in times of uncertainty, the system could defer to a human clinician.

One of the major benefits of AI, Hendrix said, is that it makes it possible to have no limit on the number of factors used to estimate risk. Studies have shown that clinicians tend to inaccurately model risk; for example, Mullainathan and Obermeyer (2022) found that physicians gave too much weight to age and certain symptoms when assessing the risk of heart attack. Furthermore, many clinicians show "left-hand bias," where the first digit of a patient's age affects their assessment of risk and appropriate care; as

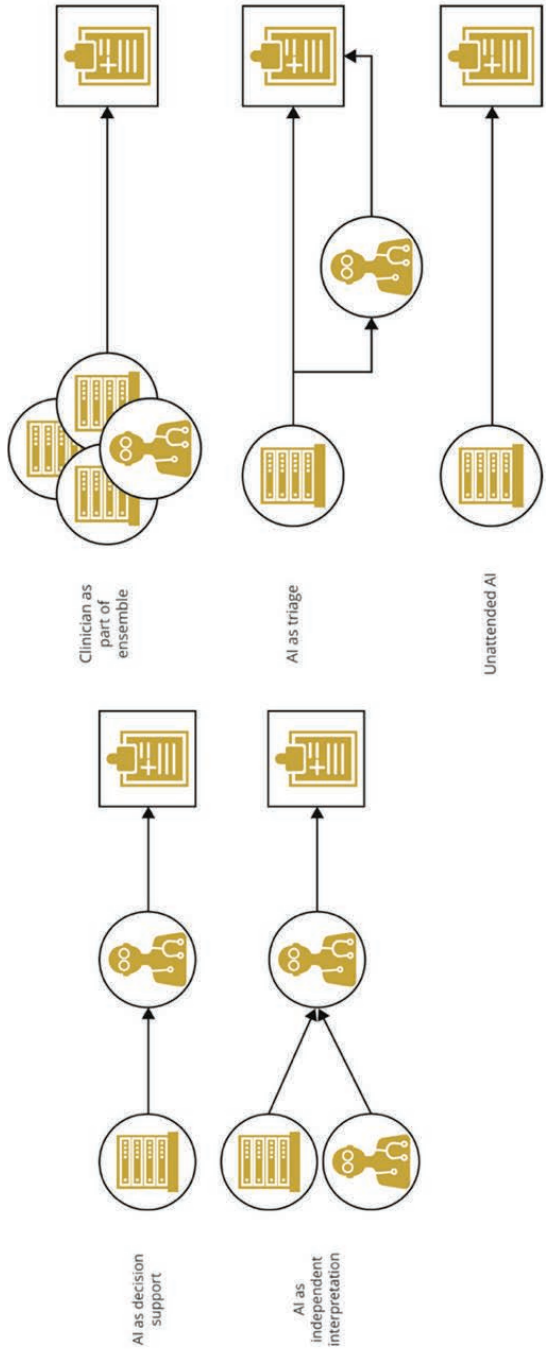

FIGURE 2-1 Ways that AI can interact with clinicians.
SOURCE: Presented by Nathaniel Hendrix, March 16, 2023 (Hendrix et al., 2022).

a result, a 39-year-old and 40-year-old would be assessed differently, even though they are almost exactly the same age. To counteract these types of biases, Hendrix said, AI could consider multiple factors and give a numerical prediction, and a threshold would be set at which a certain action would be taken (e.g., screening). The appropriate threshold would vary depending on the characteristics of the condition (Figure 2-2). For a condition in which the benefits of detection outweigh the risks of false positives, the threshold would be low in order to improve the chances of detecting all true positives. For a condition in which the risks of false positives are high, the threshold would be set higher so that fewer people would be tested. It may be appropriate to set thresholds on both sides and have a human clinician make decisions when the risk assessment is in the grey area. Physicians, patients, ethicists, payers, and other stakeholders should play an active role in setting these thresholds and revisiting them as technology advances, Hendrix said.

Decisions about how to use AI should take into account not only the clinical circumstances but also the algorithm's accuracy. However, knowing an algorithm's accuracy is generally not enough information to determine whether it is worth using. Hendrix gave two examples to illustrate this. In the first, an algorithm is very accurate; it catches a few more cases than the clinician, but it is largely duplicating the work of the clinician. In the second, the algorithm catches fewer cases than the clinician and misses many of the cases that the clinician identifies, but nearly all the cases that it identifies are ones that would have been missed by the clinician. AI recommendations may be most useful when they contradict a clinician, Hendrix said, which creates a challenge for how to communicate an AI recommendation. As clinicians get more experience getting information from AI—particularly assessments that contradict their own—they may be able to use this feedback to calibrate their own predictions better. It is exciting to think of the ways in which AI can be used to help clinicians continually learn and adapt, Hendrix said.

The effective use of AI by health care professionals requires discernment, and an individual's ability to distinguish accurate from inaccurate AI-provided advice may vary. Furthermore, clinicians vary in what they want from AI and how they want to interact with it. Hendrix's research on primary care providers and radiologists found that primary care providers are overwhelmingly concerned with sensitivity and are focused on the evidence base for the algorithm. Around 75 percent are willing to allow AI to make decisions about very low-risk cases without radiologist supervision. Radiologists, on the other hand, have a greater concern for limiting false positives while boosting detection and are more focused on how AI integrates into the workflow. The starkest difference was that none of the radiologists were willing to let AI make decisions without supervision.

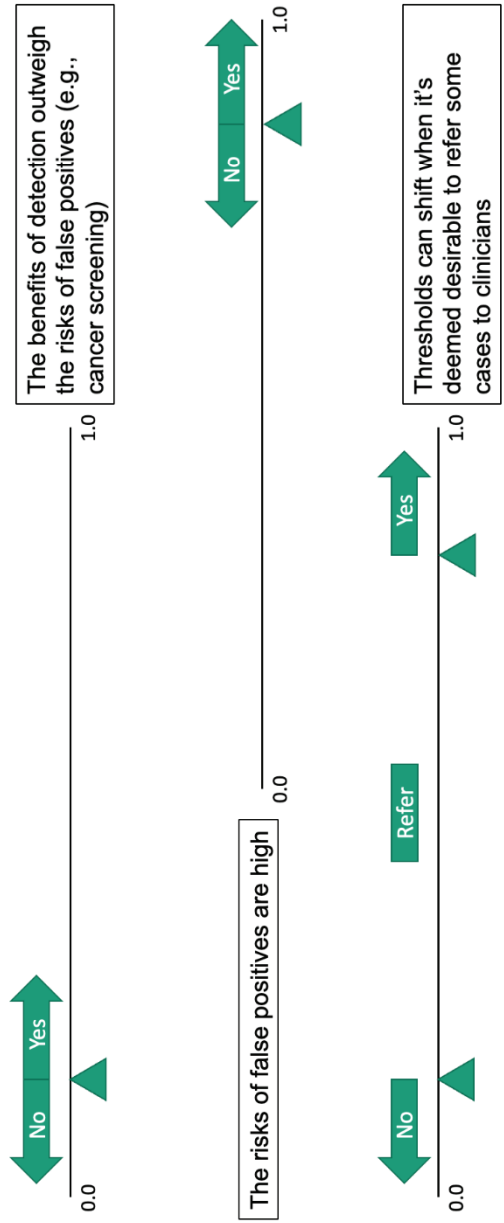

FIGURE 2-2 Turning probabilities into decisions.
SOURCE: Presented by Nathaniel Hendrix, March 16, 2023.

Patients also vary in their comfort level with AI. A Pew Research Center survey (Tyson et al., 2023) found that 60 percent of Americans would be uncomfortable with their health care provider relying on AI, although this varied by such characteristics as gender, race, age, and familiarity with AI (Figure 2-3). The same survey found that a majority of Americans (65 percent) want AI to be used in skin cancer screening and that a large majority (79 percent) do not want to use an AI chatbot to support their mental health (Tyson et al., 2023). Hendrix said he believes that to make sure AI can be a force to improve equity, clinicians will need to be skilled in talking to their patients about the benefits and risks of using AI.

From an economic perspective, the hope is not that AI will replace clinicians, Hendrix said, but instead that the technology will help make health care more affordable and more accessible. However, integrating AI into the health care system would require clinicians to adopt a different skillset. The qualities most important for clinicians in the age of AI, he said, would be the following:

- The ability to communicate and connect with patients,
- Empathy,
- A team-oriented approach to decision making,
- Technical skills and numeracy skills to understand AI recommendations,
- The ability to understand how AI works and how to communicate about it with patients, and
- The ability to integrate AI information into one's work.

EDUCATION AND AI: CREATING A HEALTHY SCIENTIFIC ECOSYSTEM

Uncertainty is pervasive in medicine, said Alex John London, the director of the Center for Ethics and Policy at Carnegie Mellon University, and how this uncertainty is dealt with is an ethical issue. Advancing the moral mission of medicine entails a duty to learn how to reduce medical uncertainty and to reduce unwarranted variation in practice. There is an ethical duty to make health systems more effective (improving patient outcomes), efficient (good stewardship of scarce resources), and equitable (treating all as moral equals), London added.

Medicine relies on a division of labor and expertise, he continued. Experts produce information on which others—both experts and non-experts—rely. The reliability and accuracy of this information affects the ability of each of these stakeholders to discharge their moral obligations. London said that consumers of information must trust the information producers; such trust is critical to the willingness to rely on information and act on information. While trust builds up the scientific ecosystem, hype and fear can degrade it.

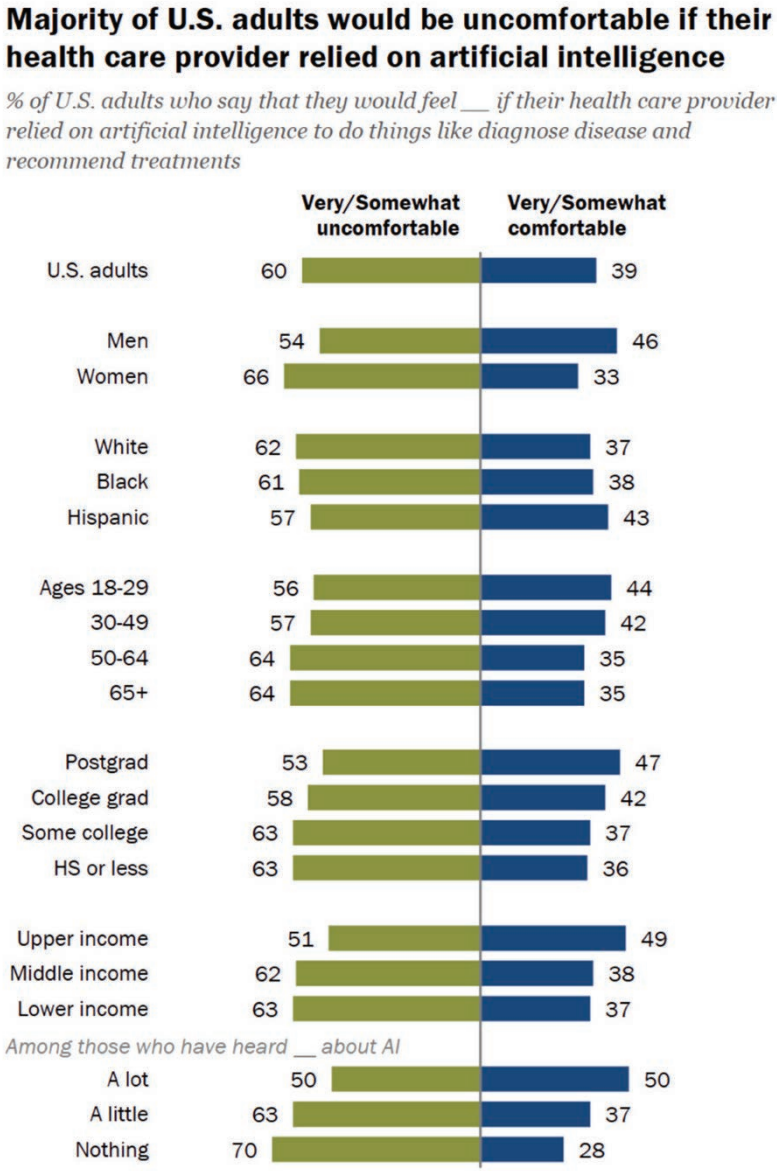

FIGURE 2-3 Comfort with artificial intelligence in health care, Pew Research Center. SOURCE: Presented by Nathaniel Hendrix, March 16, 2023 (Tyson et al., 2023).

London emphasized that when an ecosystem is inflated by hype or divided by fear, it can become challenging to develop systems capable of performing tasks that will make health systems more effective, efficient, or equitable. Hype and fear can make it difficult to deploy systems or to review and revise systems after deployment. In such a scenario, London said, three potential risks exist: underuse of an effective system, overuse of an ineffective system, and misuse of a system that is only effective for a different task.

London said that the scientific ecosystem, in the context of AI and medicine, is "really unhealthy at the moment." Efforts to communicate and educate stakeholders about AI often "wind up perpetuating outsized expectations." For example, a paper by Obermeyer et al. (2019) compared expert systems to an "ideal medical student" and machine learning (ML) to a "doctor progressing through residency." The paper implied that AI could simply take in information and then apply it in new situations. A better way of thinking about AI, London said, is to think of it as a "family of technical techniques" for learning, in the same way that the toolkit for radiological imaging includes different types of imaging and technologies. There are different ML techniques, each is suited for a different type of task, and each has its own strengths and limitations. It is important to educate and train stakeholders to understand these differences and uses and to get away from the idea that clinicians will be "displaced by a kind of synthetic human in a box."

An unhealthy scientific ecosystem creates challenges across the life cycle of AI development and deployment, London said, specifying that one of the key challenges with AI in medicine is ensuring that the capability of the system matches a task that is clinically appropriate and that will meet a need of patients or health systems. London offered two examples of AI-based technologies with capabilities that did not end up being useful in a clinical or research setting. First was the IBM Watson system, which was initially designed to answer questions on the game show *Jeopardy.* There were outsized expectations of Watson, and one of its developers cautioned that Watson was engineered to predict correct answers for trivia; it was not "an all-purpose answer box ready to take on the commercial world." MD Anderson Cancer Center partnered with IBM Watson to create an advisory tool for oncologists, London said, but the project was scrapped in 2016 after $62 million had been spent. Recently, Watson Health was "sold for parts," with a private equity firm buying some pieces for more than $1 billion. London emphasized that this was not a "mom and pop" enterprise that failed due to a lack of resources; there were 7,000 employees involved in Watson Health at its peak. It was described by the media as a "total failure that they needed to just cut their losses and move on." This is an example, he said, of a major corporation trying to make AI work in medicine that failed in part because of a mismatch between the capabilities of

the system and the task it was assigned. London's second example was more recent—Meta created a system to synthesize scientific literature in 2022. The program, dubbed "Galactica," lasted around 3 days after its release, partly because it wrote racist language and partly because it fabricated evidence and citations. This is another example of a mismatch between the capabilities of a system and the job it was given.

Even if an AI system's capabilities are well-matched with its tasks, London said, the data in the system must also be fit-for-purpose. Many health care data are collected for purposes other than research; for example, electronic medical record data reflect billing, administrative, and clinical purposes. Researchers may need data that are more granular, more frequent, or have broader variables. There is a need, he said, for better awareness of the value and limitations of the data relative to the data that are needed. With this awareness in hand, stakeholders can evaluate the prospects for implementing AI in particular spaces.

The development, testing, and deployment of new AI technologies are similar to that of any other innovation, London said. Just as most drugs in development do not end up working, most new AI systems will likely not end up working. However, the system for validating AI systems is relatively immature in comparison to the robust drug approval system. There are few prospective clinical trials of AI interventions, and the performance measures used to validate systems are often not clearly linked to meaningful clinical outcomes. A study of AI-based medical devices approved by the U.S. Food and Drug Administration found that none of the high-risk devices were evaluated by prospective studies and that a majority of approved devices did not include publicly reported multi-site assessment in the evaluation (i.e., the evidence base for the device was derived from a single institution) (Wu et al., 2021).

In closing, London shared four discussion takeaways on the current landscape and potential of AI-based technologies:

- There is a duty to learn and to make health systems more effective, efficient, and equitable.
- Health professionals are struggling to calibrate expectations in a scientific ecosystem inflated with hype and fear.
- AI/ML can be seen as one tool in a larger toolkit for learning.
- Greater fluency with AI/ML is a first step to improving the health of our scientific ecosystem.

London concluded that there is room for improvement in our evaluation of AI-based technologies and that this improvement would require a broader education among stakeholders about the strengths and limitations of AI systems.

DISCUSSION

Following the presentations, Lomis moderated a question-and-answer session among the panelists.

Shifting Role of Clinicians and Bias in Data

As AI moves into the clinical space, Lomis said, the role of the clinician will shift from a "steward of knowledge" toward a curator or translator of knowledge. This shift has already occurred to some extent with the explosion of information available to patients, she added. Whelan agreed that the integration of AI is not an entirely new phenomenon but instead a step on the continuum of how knowledge is accessed and used. AI can be a tool for managing knowledge and helping to improve the care of all patients. The issue, she cautioned, is whether the data that feed into AI systems are inclusive of the entire patient population. Lomis responded that this was unlikely and that there is bias already underlying existing datasets. Lomis cautioned that AI may run the risk of amplifying that bias. Whelan added that since algorithms are created by people, they often reflect the biases of their creators; having diverse teams generate algorithms may be one way to mitigate such risks, assuming that different groups are represented on the team. London underscored how the incompleteness of representation in datasets reflects the unequal access to health care, which is a difficult problem to overcome. At the same time, there is a push to use AI to achieve a more equitable health system, but AI systems are built on inequitable data. It is a "chicken and egg problem," he said. In addition to inequitable access, London said, even some of the sensors used to collect data are systematically biased. For example, peripheral oxygen detectors work better on lighter skin (Mantri and Jokerst, 2022). Bias "goes very, very deep in medicine," he said. London asked participants, "If clinicians do not even have the technologies to accurately collect data on different patient populations, can AI systems ever be unbiased?"

Managing Uncertainty

The most successful clinicians are those who have been taught how to deal with variability and tolerate uncertainty, Carole Tucker, associate dean of research at the University of Texas Medical Branch, said. AI may add to the uncertainty that clinicians must deal with, for example, when an AI recommendation contradicts the assessment of the clinician. Hendrix said there is a deep-seated desire to be certain, particularly when making decisions that affect people's health, and that part of the role of clinicians is to manage expectations and communicate clearly with patients about their level of certainty. He added that rather than acting as authoritative experts,

clinicians need to share the process of decision making and do the best they can with the information they have. Hendrix further commented that one role for clinicians will be detecting when AI systems are working well and when they are not; this requires good clinical judgment. However, if AI systems are taking on some of the clinical decision making, this reduces the opportunities for clinicians to develop their clinical judgment. One solution, he said, might be to take AI "off autopilot" in order to create intentional opportunities for developing and retaining clinical judgment. Sanjay Desai, the chief academic officer at the American Medical Association, made an analogy to driving, saying that he would not trust his teenage children in a self-driving car because they have not yet developed the judgment for when they should take over the wheel. However, once the technology improves, the self-driving car would likely be far safer than a car piloted by a human driver. Likewise, the technologies in health care are still immature, Desai said, encouraging clinicians and AI to work together rather than letting one take the lead.

Competencies of Future Health Professionals

Lomis noted that the suggested competencies for future health care professionals who will be working with AI are different from the more historical competencies considered important for health care practice; for example, speakers identified numeracy skills, comfort with data, and ability to accept input from other sources. At the same time, speakers talked about how AI may free up clinicians so they can focus on the interpersonal side of health care. Lomis commented that good data skills and good interpersonal skills aren't typically seen in the same person, and she wondered whether this has an implication for recruitment of learners. Whelan responded that the most important attributes for learners are a growth mindset and the ability to work together in a team of people who have different competencies, interests, and skills. The team of health care professionals will expand, she said, and include people who have not traditionally been part of the team (e.g., engineers). Whelan added that health care professionals will need to learn what other professionals bring to the table, be comfortable working with others, and be able to speak the same language. This will require giving students and practitioners many opportunities for interprofessional education and for interfacing with other team members and technologies.

Rethinking Structures and Processes

Can AI be plugged into our existing system, Lomis asked, or is there a need to rethink structures and processes? Hendrix answered with a

metaphor: "You can't take a Rolls Royce engine and put it in a Toyota and expect the Toyota to drive better." In other words, Hendrix explained, simply providing better information to clinicians without making it interpretable or actionable is likely to be a burden rather than a benefit. Clear workflows need to be developed for the integration of AI; when new technologies are introduced, it will be important to consider how they will affect decision making and taking action and who specifically will be affected.

3

Embedding AI within Health Professions Education

Workshop chair Carole Tucker, the associate dean of research at the University of Texas Medical Branch, briefly recapped previous sessions of the workshop and the discussions held on the role of artificial intelligence (AI) in health care education and practice with social, cultural, economic, and policy considerations. The second session, she said, would examine the practical side of integrating AI into health professions education, relevant competencies, and how health professionals can develop these competencies.

EMERGING COMPETENCY MODELS

Bonnie Miller, a former senior associate dean for health sciences education at the Vanderbilt University School of Medicine and the executive vice president for educational affairs at the Vanderbilt University Medical Center, spoke about her experiences working on a multidisciplinary team, identifying and describing the competencies that are necessary for health care professionals to use AI tools (Russell et al., 2023). She began with a definition of AI: "computer science techniques that mimic human intelligence, including algorithms that leverage machine learning, deep learning, natural language processing, and neural networks." The most frequent uses for AI in health care, she said, include risk stratification and scores, image interpretation, and health record summarization.

Their process of identifying competencies began with a scoping review, looking at papers that described the implementation of AI-based tools in clinical settings. While there were many papers that described the

implementation process, far fewer discussed the training that clinicians received before using a tool. Miller and her colleagues reviewed the literature, summarized the evidence, and conducted interviews and questionnaires. An initial list of competencies was developed, and the list was refined based on feedback from subject matter experts. These experts, Miller said, were from a wide variety of professions, including informatics, medical education, public health, nursing, machine learning, surgery, ethics, pharmacy, social sciences, and computer science. Several themes related to the integration of AI into clinical practice emerged from this process:

- The need for foundational knowledge;
- Ethical, legal, regulatory, social, economic, and political issues;
- Clinician roles and responsibilities and the nature of the clinical encounter;
- The impact on team dynamics and workflow;
- Concerns about bias and representativeness of datasets; and
- Continuing professional development.

Miller shared a few details about these themes. All of the experts said there was a need for foundational knowledge about data, statistics, and the appropriate use of different types of tools. Many also mentioned the need for consideration of ethical issues in the use of AI, with two subthemes emerging. First, clinicians cannot abdicate their professional responsibility to their patients by saying "the AI made me do it." Second, there were strong concerns about the potential for amplifying pre-existing inequities because of underlying bias in the datasets as well as lack of representation in the groups making decisions about what tools should be used and how. Experts also pointed to the potential for AI to free up clinician time to focus on the patient relationship, but Miller emphasized that this will not automatically happen; it is important to think about *how* to make it happen. Furthermore, it is critical to consider how AI tools will be accommodated in the workflow and to be proactive and deliberate about this process.

Based on these themes, Miller and her colleagues developed six competency domains with 25 sub-competencies. She offered a brief description of each domain that is published in the article by Russell et al. (2023):

- **Basic knowledge of AI:** *Explain what AI is and describe its health care applications.*
- **Social and ethical implications of AI:** *Explain how social, economic, and political systems influence AI-based tools and how these relationships affect 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 the implementation of AI-based tools.*
- **Practice-based learning and improvement regarding AI-based tools:** *Participate in continuing professional development and practice-based learning activities related to use of AI tools in health care.*

Although all of these competencies are important, Miller said, a competent clinician also needs to function within a capable system. The capability of an organization depends on the competencies of individuals as well as on the organization's resources and infrastructure and the routines that are in place (Figure 3-1). Clinician competencies are critical, she said, but clinicians must be supported by capable organizations and social, regulatory, and legal systems.

In concluding, Miller offered her thoughts on how health professions education and practice can move forward with integrating AI in a thoughtful and efficient way. First, she said, health care teams will want to include experts in AI. While not every team member will have to be an AI expert, it would be desirable to bring mathematicians, data scientists, and others into the team. Second, this is a rapidly changing field, and not all changes are visible. Miller added that there is an obligation for transparency, communication about uncertainty, and regular monitoring to ensure that clinicians and patients understand the tools that are being developed and their appropriate use. Third, there will be changes in other sectors that will influence public opinion and expectations. For example, there are many opinions and fears about technologies such as self-driving cars and ChatGPT (Chat Generative Pre-Trained Transformer), but as these technologies improve and become more integrated into daily life, people may expect similar changes in health care. Finally, Miller shared that AI poses a risk of widening existing disparities, due to biased data, biased algorithms, and the varying ability of different institutions to access and use new technologies. It is important to think carefully about how these resources can be equitably distributed, she said. Miller quoted a *New York Times* article, in which the writer said that people working on AI tools "are creating a power they do not understand at a pace they often cannot believe" (Klein, 2023). An entire system may be totally disrupted

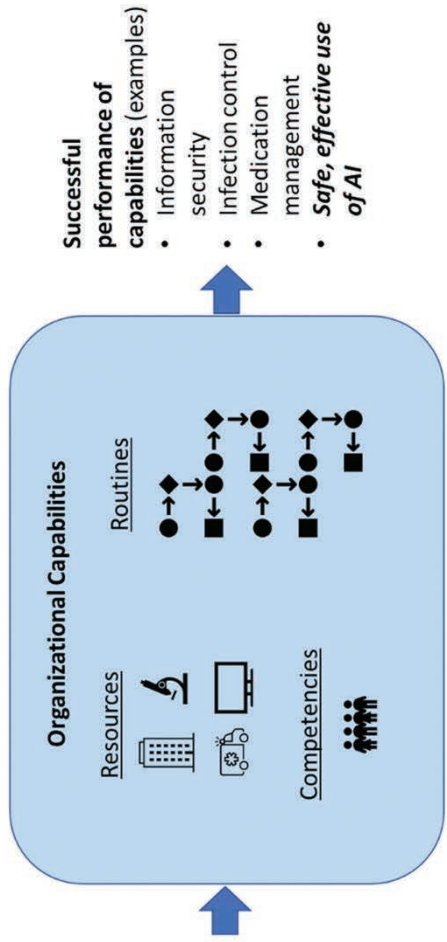

FIGURE 3-1 Organizational capabilities.
SOURCE: Presented by Bonnie Miller, March 16, 2023 (Novak et al., 2023).

by these technologies, and educators and clinicians alike need to expect the unpredictable, Miller concluded.

DISCUSSION

Incorporating AI into a Packed Curriculum

Kimberly Lomis, the vice president of undergraduate medical education innovations for the American Medical Association, began by asking Miller how health educators can "possibly incorporate AI into already over-packed programs." Miller responded that ideas about what should be covered by health professions education have evolved over the years, and curricula have evolved as well. For example, issues of health equity and the social determinants of health were not widely covered 10 years ago. There may be a need to rethink some of the prerequisites for programs (e.g., emphasizing statistics over calculus) and a need to integrate foundational knowledge about AI into introductory courses. Miller said that faculty competency to teach new content domains "always lags behind the need," so experts from other fields (e.g., informatics, computer science) may need to be brought in for course work and clinical experiences.

Anticipating Issues

AI is moving quickly, a workshop participant emphasized, and it might be beneficial to get ahead of the social, legal, regulatory, and other issues before AI is fully integrated into health care. Miller agreed and said the U.S. Food and Drug Administration (FDA) is beginning to regulate some AI-based devices, but some systems may not be subject to FDA regulation; some AI might even be embedded in tools in which it is possible to "not even know that they're there." Some have called for "model facts" (Sendak et al., 2020), which would be similar to a nutritional label. The label might include information about the dataset the model was trained on, the question the model was engineered to answer, and the model's specificity and sensitivity—the likelihood of accurate predictions. An additional approach would be a statement that is equivalent to an environmental impact statement. Before employing a technology in a specific environment, stakeholders would be encouraged to anticipate the impacts and unintended consequences and, after the technology was implemented, to monitor for these effects. For example, stakeholders would consider who will be displaced, how workflows would be disrupted, and what populations might be benefited or harmed. These are questions, Miller said, that need to be studied before the technologies are implemented.

Student Competencies

Melissa E. Trego, an associate professor at the Pennsylvania College of Optometry, described herself as an educator of young learners, and, as such, she said she is not concerned about whether they will embrace these new technologies or be comfortable using them. She is more concerned that students might not be comfortable enough communicating and connecting with patients face-to-face. Miller responded by acknowledging this as a valid concern, not just among young people but among people of all ages. There may be a need to be more deliberate about teaching people skills, she said, and implementing practices such as device-free breaks.

Another competency that will be essential, Kim Dunleavy, associate clinical professor at the University of Florida, said, is critical thinking skills. Some students are used to "push button" technology that simply gives the answer, so how can health professions education help students develop the ability to think critically about how to use information from different sources? Miller responded that students need opportunities to use and interact with technologies and that such opportunities are teachable moments. For example, students could generate text from ChatGPT and then be asked to critique the text and identify evidence that supports or disagrees with what the AI tool created. Tucker added that when ChatGPT initially came out, she thought it would be bad for students and their ability to think critically. However, she now sees that it could be helpful for students as they learn to analyze the value and veracity of information, as, ideally, critical thinking skills would be taught long before health professions education.

AI as a Tool

Framing AI as a clinical tool is a useful way to look at it, Alison Whelan, the chief academic officer at the Association for American Medical Colleges, said. She drew an analogy between AI and genetics technology. Years ago, when Whelan taught genetics to first-year medical students, she would introduce whole-genome sequencing and discuss how it could affect care. The students learned the content, but the information soon became irrelevant to them because it didn't exist in the clinical space. She had similar experiences when teaching practicing physicians about the promise of genetics. However, once a new genetic test came out—for example, a hereditary risk test or genetic profiling of tumors—everyone wanted to know how it worked and how they could use it. This need-to-know moment is the "teachable moment," she said. Whelan encouraged stakeholders to capitalize on opportunities to discuss AI in the context of new tools and interesting case studies. While starting with a discussion of a specific AI tool rather

than the foundational knowledge around AI may seem "backwards," she said, it is more likely to be relevant and understandable to students. Whelan concluded that if educators move too far ahead teaching the concepts of AI without a concrete example, students will likely give a "blank stare" because it doesn't resonate with them.

4

Exploring the Competencies

DISCUSSIONS

During the third session of the workshop series, participants broke into groups to explore the competency domains and sub-competencies that Bonnie Miller, a former senior associate dean for health sciences education at the Vanderbilt University School of Medicine and the executive vice president for educational affairs at the Vanderbilt University Medical Center, had previously presented. Participants in each group discussed whether the competencies resonated with their own professional or educational practice and considered how the competencies might be integrated into health professions educational programs or curricula. Breakout groups also identified challenges and opportunities to incorporating these competencies. One virtual breakout group featured a panel of students, co-moderated by Mollie Hobensack, a nursing doctoral student at the Columbia University School of Nursing, and Cornelius James, clinical assistant professor at the University of Michigan Medical School, sharing their experiences and perspectives.

General Thoughts on AI

Hobensack began the conversation by asking a general question: "When you hear the word AI [artificial intelligence], what comes to mind? Are you excited about it? Are you nervous?" Erkin Ötleş, an M.D./Ph.D. student at the University of Michigan, replied, "All of the above." He elaborated and said that technologies such as AI have the potential to greatly improve

patient care and the work lives of clinicians. However, just making the tool does not guarantee the outcome, and there is a great deal of risk involved. For example, using AI with biased data has the potential to scale harm. He said that people are needed to look at these tools and consider their impact on clinical care and identify unexpected consequences. "The benefits are real, but the risks are big," he said. Noahlana Monzon, a nutrition student at the University of Oklahoma, agreed and said, "AI is exciting because there is so much that can be done with it, but it is also scary because the technology moves so fast and it is difficult to keep up and to understand it."

James asked panelists how comfortable they are being part of the conversation about the risks and benefits of AI and how it could be integrated into health care. Alonzo Turner, a Ph.D. student in counseling and counselor education at Syracuse University and a 2022 National Board for Certified Counselors doctoral minority fellow, replied that today's health professions students have the opportunity to be a conduit for information about AI, whether with fellow students, clients, patients, or the public. As AI becomes more integrated into health care, sharing transparent information that is easy to understand will build trust and will help people understand the role that AI can play in health care. Monzon added that patients often want to know *why* something is happening—a diagnosis, a treatment, a medication. An earlier speaker mentioned that AI can provide a recommendation but has more difficulty with the question *why*. AI will never take the place of people, Monzon said, because an important role of the clinician is to act as an interpreter and a mediator between the patient and the information on which decisions are based. Monzon believes the next generation of health professions practitioners will need to act as a bridge between patients and AI.

AI in the Educational Setting

Carl Sheperis, dean at Texas A&M University, asked the student panelists to comment on the use or misuse of AI in the educational setting itself. For example, many faculty members have concerns about students using AI to cheat. Monzon said that one of her professors is very much in favor of AI and allows students to use any sort of AI to answer questions. While this could be considered "cheating," Monzon said that it gives students the opportunity to incorporate AI into their education, to evaluate the validity of the information that the AI provides, and to think about when and where AI is an appropriate resource. She said that because AI-based technologies like ChatGPT (Chat Generative Pre-Trained Transformer) are so new, it is important that educators be very clear about what is or is not allowed and communicate their expectations in order to relieve potential frustrations when the rules change.

Ötleş responded by asking, "What is the point of writing an essay?" Often, the point is to develop a skill, he stated, and, as an engineering major, Ötleş wrote essays to explain why one design was better than another or why a certain method is optimal. The point of these essays was to construct a persuasive story. If a student can use ChatGPT to construct this story, without introducing errors, he believed this could be a good thing. Ötleş explained that the assistance of AI to generate persuasive arguments could be more efficient and less time-consuming, and could result in a better, more persuasive document; it could also be used as a starting point to help students overcome writer's block. When considering whether and how AI should be part of an educational project, Ötleş said it is critical for students to take a nuanced approach to think about the intention of the project and how AI could benefit or harm that intention rather than simply allowing AI to play a role. James expanded on Ötleş's point by saying that if a student uses ChatGPT to write a persuasive essay, it will ultimately be up to the student to decide whether or not ChatGPT has accomplished that goal. Winston Guo, an M.D. candidate at Weill Cornell Medical College, added that ChatGPT could serve as an excellent substrate with which to start a paper. For example, ChatGPT could present arguments for and against a certain ethical principle; students could then examine these arguments in light of their own understanding and use them to formulate their own line of reasoning. In addition, ChatGPT can be used as a quick survey of a new field of information to build a scaffold of knowledge. While there may be errors, it can offer an overview that could be helpful to get students started. Guo downplayed concerns that AI would prevent students from developing clinical reasoning skills. The structure of medical school exams and clinical experiences force students to grapple with clinical reasoning, he said. Monzon added that if students rely too heavily on ChatGPT or other tools, they will be unlikely to pass their licensure exams.

Deskilling, Reskilling, and Learning New Skills

Given the potential for AI to reshape the roles of clinicians, James asked panelists for their thoughts on deskilling, reskilling, and learning new skills. Will health professions education need to reassess the skills and competencies that are being taught? How will faculty members and practitioners get the skills they need? Monzon replied that one of the interesting things about computer science and AI is that they are subjects people can teach themselves; she said that students could potentially come to class with far more knowledge about AI than the professor. There will be a need to educate faculty to enable them to educate these types of learners. Ötleş told workshop participants about a museum in Michigan called the Henry Ford Museum of American Innovation. The museum contains various old technologies

and innovations such as a tinsmith workshop and steam engines. These are technologies that are not actively used anymore; society as a whole has decided that such skills are not worthwhile to maintain. When technology evolves, there is a natural process of reskilling that occurs, Ötleş said. In medicine, there has been relatively little reskilling in the past 70 years. New technologies have been adopted, but the cognitive processes have remained basically the same. Ötleş said that AI presents an opportunity to rethink the way clinicians take in, interpret, and take action on information. He cautioned the audience not to use AI as the gold standard and to be careful not to lose abilities that are central to medical practice. He made an analogy to piloting a plane: computer systems largely are responsible for flying the plane, but if something malfunctions, human pilots need the skills to take over and land the plane. Turner agreed with this assessment and noted that during the pandemic, many health professionals were thrust into practicing telemedicine. The foundational core competencies of health care remained the same but with new technologies and capabilities.

Interprofessional Teams

James asked panelists to think about what interprofessional teams could look like in the future. For example, will the integration of AI shift the stakeholders on the teams or how teams work together? Monzon said that players who are often missing on a team are computer scientists, programmers, data scientists, and informatics experts. Bringing health care knowledge together with expertise on AI would be very beneficial, she said. Ötleş said that his own work has not been very interprofessional, and it has suffered because of that. For example, he has seen software developed and implemented without the input of the people who were the intended users. Having an interprofessional relationship from the outset makes it much easier and more comfortable reaching out with questions or to gain insight. For example, a team working on AI for the health care setting could reach out to health care workers to find out more information about their workflows and the needs of their patients. Tools are often created from a specific task perspective (e.g., a tool for doctors to use to assess sepsis); Ötleş compared it to finding a "nail for your hammer." With a broader interprofessional team, tools could be created with the broader aim of improving the patient experience and the patient's health. Hobensack agreed that it is critical to include users early in the process of tool development. Clinicians are heavily burdened with responsibilities, and if a tool is created for them but without them, they are likely to see it as just another thing they have to do. James added that developers can have brilliant ideas, but they are not asking the right questions or addressing the right issues. There is a need to bring a diverse group of users and stakeholders to the table to

ensure that the tools being developed address the actual needs of clinicians and patients.

Priorities for Consideration

As a final question, James asked the panelists what changes they would make in their educational program tomorrow if they could. Ötleş responded that he is "staring down the barrel of residency." While he is excited for this process and for becoming clinically adept, he said he wishes there was more time to think—time to think about how AI or machine learning could be incorporated into the workflow or time to experiment with AI tools. If residencies were structured slightly differently, there could be a half day every other week for residents to think and experiment and "mess around a little bit" in the AI technology sandbox. This could also allow residents time to master certain skills or to take opportunities to collaborate interprofessionally with colleagues in other fields.

5

Closing Session

Workshop chair Carole Tucker, the associate dean of research at the University of Texas Medical Branch, began the final session by saying that when considering how artificial intelligence (AI) will be integrated into health care, health educators must grapple with three main issues: training future health professionals in the use of AI, using AI as a tool in health professions education, and identifying an appropriate role for health professionals in the development and deployment of AI systems. Tucker recapped the previous workshop sessions and highlighted discussions from speakers and participants that were related to these three issues, including the following:

- Applying AI for accelerating effective interprofessional education and collaborative practice;
- Exploring challenges and opportunities in developing, validating, implementing, and monitoring the use of AI and machine learning (ML) algorithms in health professions education;
- Understanding potential risks and benefits of AI for improving the educational process (e.g., bias, equity, and burden);
- Investigating the barriers and facilitators to integrating AI into clinical education; and
- Engaging relevant stakeholders for responsible AI implementation from foundational health professional education to continuing education development.

In this closing session, speakers and participants explored what health professions educators can do to incorporate AI into health professions

education. The session began with Kimberly Lomis, the vice president of undergraduate medical education innovations for the American Medical Association, presenting a list of eight proposed steps drawn from her own published work (Lomis et al., 2021):

1. **Educating yourself** and your faculty in basic concepts and controversies related to AI
   - Consider the differing levels of understanding needed for various faculty roles.
2. **Building relationships**, considering these resources:
   - Health system informatics and clinical decision support teams
     - What is the penetration of AI applications in affiliated clinical enterprise?
     - How is training being carried out in the clinical system?
   - University computer science departments
   - Ethicists
   - Faculty and learners with interest in this topic
   - Interprofessional education colleagues
3. Establishing a **local advisory group** to collaborate with the existing curricular oversight process
   - Create learning opportunities about AI for faculty leadership and the institutional community.
   - Openly address skepticism about AI.
   - Consider mechanisms to protect learners as AI is applied to facilitating educational practices, such as assessment.
4. Reviewing the program's existing **competency outcomes** and curriculum
   - Consider how expansion of AI will affect our understanding of existing competency domains, such as medical knowledge, patient care, communication skills, interprofessional collaborative practice, systems-based care, professionalism, and practice-based learning and improvement.
   - Consider new domains of competency needed in computer science and technology.
   - Consider incorporation of AI learning objectives into relevant existing content areas, such as clinical reasoning, metacognition, diagnostic error, cognitive bias, etc.
   - Identify potential opportunities for AI to assist in the administration of the curriculum.
5. Reviewing the existing **assessment** program
   - Move from an emphasis on assessing each learner's possession of knowledge to assessing each learner's ability to access, critically appraise, and apply knowledge. For example, consider

incorporating clinical decision support tools into simulation events.
    - Consider opportunities to assess necessary new competencies and skills.
    - Identify potential roles for AI to assist in the administration of programmatic assessment.
6. Reviewing existing admissions/**selection process**
    - Move from an emphasis on individual knowledge and accomplishment toward evidence of teamwork and situational judgment.
    - Identify potential roles for AI to assist in the review of applicants.
7. Participating in **evaluation** and research regarding the impact of AI in education
8. Engaging in **national and global discussions** to
    - Enhance training in AI;
    - Establish learning objectives and developmentally appropriate progression of training in AI;
    - Use AI in training; and
    - Develop AI capabilities that assist in the delivery of educational programs.

This list was used to frame a discussion on potential next steps for incorporating AI into health professions education. Taking one point at a time, panelists were asked to comment on how they were engaging in each step and to discuss their perspectives on and experiences with challenges and lessons learned. Lomis reviewed all eight items but asked panelists to share their thoughts on only the first six, which she said have more immediate applicability to educators currently grappling with how to incorporate AI into their course or curriculum.

Educating Yourself and Your Faculty

Katie Link, a medical student at the Icahn School of Medicine at Mount Sinai, told participants about a student-led effort to initiate an elective course on AI and medicine, designed to create basic AI literacy among medical students and others. The students began by reaching out to the faculty to get their input and perspectives and looking for faculty mentors who could champion the course. They brought in examples from the existing curriculum as well as articles that showed the importance of AI literacy for health professionals, and they demonstrated significant interest from the student body. This effort took place before ChatGPT (Chat Generative Pre-Trained Transformer) and the associated excitement around AI, Link said. There was some content that had already been delivered by faculty members, and students were asking for more content in this area, believing

it to be essential for their future careers. Lomis pointed out the first big step, which is often getting people "educated enough to know" the importance of AI; that is, people must first gain some basic knowledge of AI and its place in the health professions in order to see the value of integrating AI into health professions education.

Bonnie Miller, a former senior associate dean for health sciences education at the Vanderbilt University School of Medicine and the executive vice president for educational affairs at the Vanderbilt University Medical Center, added that "we are at a teachable moment," given all the publicity around ChatGPT. Currently, there are many ad hoc efforts happening around the country. In the future, these efforts could be more coordinated, structured, and systematic, but right now it is a good time to capitalize on the excitement and make things happen.

Cornelius James, clinical assistant professor at the University of Michigan Medical School, spoke about his experiences at University of Michigan. The conversations about AI at the university involved many people in computer science, research, and engineering but few frontline clinicians or medical educators, he said. To address this issue, he and his colleagues developed a series of webinars that culminated with a symposium; the webinars were open to individuals across the country and had a diverse turnout of people from various backgrounds. It was important to get these people in the same room and speaking the same language about this important topic, James said.

Other educational efforts discussed included the following:

- A seminar at Vanderbilt University Medical Center designed for faculty, graduate students, and physicians to look at foundational knowledge about AI and interprofessional practice. (Miller)
- A collaboration with informaticists between the Vanderbilt School of Nursing and the Vanderbilt School of Medicine to create opportunities for faculty and students to learn the basics of AI. (Pam Jeffries, dean at the Vanderbilt University School of Nursing)

Building Relationships

What are the relationships to put in place, Lomis asked, so the right experts are in the room when integrating AI into health professions education? Who are the stakeholders to be included—educators, clinicians, computer science professionals, ethicists? Can early adopters from any field be a resource for new efforts? Miller answered that her research (see Chapter 4) found that competent clinicians need to be supported by capable organizations. Capable organizations are those that have the infrastructure (e.g., committees) set up to evaluate and monitor outcomes and make decisions. Educators need to be represented on these committees in order to consider

the impact these tools could have on the learning environment or on the opportunities that students have to develop knowledge and skills.

Link commented that in their effort to start a course on AI, the student group met with experts within their own institution and in other institutions. These experts were critical for making the case for education on AI and for elaborating on ways that AI is being integrated in the clinical workflow. The students brought in diverse speakers and experts from academia as well as industry to open the group's thinking on broader perspectives related to AI. One industry professional gave a demonstration of an automated documentation tool to students; this gave them a real-world perspective on how these tools work in the clinical setting. In addition, they invited students from across the country and across disciplines to participate in their online courses, which challenged all of the participants with different perspectives.

Judy Gichoya, an assistant professor at the Emory University School of Medicine, spoke about her experiences as the lead for an ML elective at her university. One lesson she learned was the necessity of reaching out to others and getting out of "your comfort zone." In an academic institution, there are most likely many people working on AI in other departments and schools; connecting with these individuals will save time and effort. No one can do this work alone, she said, and working with people in different areas will open pathways to new perspectives and encourage learning from one another. There is no benefit to reinventing the wheel; the benefits are to be found in what educators can teach students and how to inspire learners.

The Data Augmented Technology Assisted Medical Decision-Making team (DATA-MD) at the University of Michigan consists of individuals engaged in medical education, clinical care, research, data science, pharmacy, nursing, precision health, informatics, and other fields, James said. Initially, he thought that all of these "wonderful, brilliant people" were doing him a favor by helping him to develop AI curricula. Soon, however, he realized they are also all learning from one another. For example, he heard a computer scientist ask clinicians for their opinion on a model and an engineer ask about the needs of health professions students. There is mutual benefit to these types of collaborations, James said. And he added that while the workshop was focusing on teaching AI to health professions students, there is also a need to teach computer scientists and engineers about health care, so they can develop models and tools that are relevant and important.

Establishing a Local Advisory Group

The third step on the list of action items, Lomis said, is to establish a local advisory group. Every educational program has a curricular oversight committee, but that group likely does not have a high level of AI-related expertise.

An AI-specific advisory group can coordinate with the existing committee and consider how different pieces fit together. Related to this, Lomis asked panelists how the set of interprofessional competencies fits together with AI competencies—are they completely separate competencies, or do they overlap in some ways? Miller responded that in her research on AI competencies, she and her colleagues began with an established interprofessional competency framework. However, they found that the framework did not fit neatly, so they developed a separate framework that could better communicate their ideas. Lomis remarked on how often seemingly compatible competencies don't work well together and said that it can be helpful to explicitly acknowledge the relationship between the concrete competencies in one domain and how they fit into a broader view of competencies.

Link joined the discussion, saying that the Mount Sinai medical school is in the process of redesigning its curriculum and that a group of students who were involved in the AI course have been invited to share what they have learned. The students are working on identifying elements to potentially incorporate into required curriculum. They are also looking into areas for elective curriculum and the possibility of creating extended advanced coursework for students who are very interested in pursuing a deeper understanding of AI.

Jeffries commented on her own AI efforts at Vanderbilt where she created a small advisory group to look at the role of AI in communications, admissions, and the classroom. While this group is creating general guidelines, Jeffries acknowledged that because technology evolves so rapidly, there needs to be flexibility and a willingness to iterate and redesign. Tucker further remarked that changing curriculum can be a slow process because it is largely driven by the competencies identified by the accreditation board. However, there is space to include "chewable chunks" of information about AI and ML for students who need basic information but who are not going to pursue an elective or advanced course in the topic. Making progress in students' understanding of AI does not necessarily require a monumental effort, she said, but maybe just try to move everyone "forward a little bit . . . in their breadth of understanding." Miller then expanded the discussion by suggesting that patients could be involved in conversations about integrating AI into health professions education and practice and that community members and patient advocates could help educators and clinicians better understand how AI affects patients, diversity, and equity.

Reviewing Existing Competency Outcomes and Curricula

There are many areas in which AI can fit into existing competency frameworks and curricula, Lomis said. For example, coursework about clinical reasoning and clinical decision making can include discussions

about the appropriate role of AI. James offered his perspective as the director of the evidence-based medicine curriculum at his medical school. A decision was made at the University of Michigan to begin getting AI-related content into the curriculum through evidence-based medicine, acknowledging that not everything can be done at once. Next, the school's department of internal medicine residency program received funding to integrate AI-related content into its curriculum. Lomis interjected that it can be very challenging to try to introduce a new course, so weaving AI into areas where there is already a connection is a great way to start.

Miller spoke briefly about how AI can be used in the educational process itself, in particular with precision education and identifying strengths and gaps for individual students. The American Medical Association is a leader in this area, Miller said. AI could be used to mine information from new sources (e.g., progress notes) to find conceptual gaps or experience gaps in a systematic way; students would then be directed to the next level of what they need. Such advanced technology allows educators to focus on individual students' needs, Miller said, and is a great opportunity to use AI to improve education. Technologies such as ChatGPT could be used by educators for tasks such as generating first drafts of clinical scenarios and could make teaching more efficient. There is a need, however, for transparency in the use of these types of tools. Lomis said that one of the hopes for AI in the clinical space is that it could reduce some of the administrative burdens of clinical care; similarly, there could be opportunities to use AI to reduce some of the administrative burdens in academia so educators can focus more on students.

Mollie Hobensack, a Ph.D. candidate at the Columbia School of Nursing, shared her experience working with researchers on a clinical decision support system called CONCERN, which uses AI to analyze nursing data to produce an early warning score that identifies patients at risk for deterioration. An evaluation of the implementation of this system found that one benefit of this system is that nurses are learning about how their documentation can be used and analyzed in AI technology. This tool in particular can support new nurses in building critical thinking skills through reflecting on the drivers of deterioration and how they are captured in the electronic health record. Young health professionals in particular may be interested in and motivated by this type of interaction with AI, she said. Tucker added that documentation is an area in which there is a big opportunity for AI to make a difference and one that "everybody could get a handle on very easily."

Reviewing Existing Assessment Programs

Given the new competencies and skills health professionals may be expected to have, Lomis asked, how can learners be assessed to determine

if they have developed these competencies and skills? Lomis acknowledged that because AI is a relatively new area, assessment may not be a current top priority. Link responded to the question by saying that the course at her medical school is pass/fail and graded by attendance; the only assessment has been on student feedback on the course (e.g., self-reported changes in their understanding of AI). There are plans to develop case-based assessments to possibly set up simulating environments in which learners can use the information in practice. Gichoya said that her course is also pass/fail, but there are three milestones the students can fulfill at the end of the course. One milestone is a dataset exercise, where students choose any dataset and examine it. Another is a focused literature review, and the third is to propose a technical project. Gichoya said she has realized that students, even those with a computer science background, struggle with carrying out the technical side. ChatGPT has only been out for 5 months, and it has already changed the curriculum; educators can strive to create structures that can quickly adapt to new technologies and situations.

Lomis concluded the discussion by saying that assessment is an area in which there is an opportunity to use AI. She proposed a scenario where AI could be used to look at the feedback given to learners and at how to improve the quality of that feedback. Then, based on the AI assessment of the feedback, supervisors could be coached to use language that is actionable and aligned with the targeted competencies.

Reviewing Existing Admissions and Selection Processes

Shifting to the use of AI in admissions and the selection process, Lomis called out two issues related to AI. First, does the integration of AI in health care mean that health professions education programs should be recruiting or accepting different types of students with different backgrounds or interests? Second, how could AI be used to make the admissions process more efficient? Link responded by saying that she is part of her medical school's admissions committee, and, as such, she has learned the value of having a diverse group of people evaluating applicants. For example, an application of a student with a computer science background is best reviewed by someone who is familiar with that educational pathway and can evaluate how the student's experience may be useful in the program.

Miller told workshop participants about the Medical Innovators Development Program (MIDP) at Vanderbilt, which was designed to recruit applicants who already have Ph.D.'s in technology-related fields. Students in the MIDP, as well as other medical students, have the opportunity to identify clinical challenges that could be solved with a technological innovation. Students can work on these innovations as a different type of internship experience in the third or fourth year. This program

has been helpful, she said, in diversifying the group of students who come to medical school as well as in influencing other medical students about potential career paths.

Jeffries described conversations she had with faculty at Vanderbilt University School of Nursing who have been discussing the issue of students using ChatGPT for admissions essays. Lomis offered her opinion that banning the use of ChatGPT is unlikely to work, so there is a need for more nuanced and realistic solutions. Jeffries agreed, adding that schools need to empower students to use tools like ChatGPT in an appropriate way—for example, to use it in creating an outline that cites ChatGPT for its contribution.

Lomis asked if AI will or should influence the type of learner being recruited for health professions education programs. James responded by saying that he believes there is a need for a diverse group of students in the health professions and that not every learner will need to be an expert in AI. He drew an analogy to randomized clinical trials: not every health professional needs the skills to conduct a randomized clinical trial, but every health professional needs to be able to appraise and apply the results of a trial. Similarly with AI, not every health professional will be a programmer. As AI is integrated into practice, health professionals will need team skills for building bridges between the patient, the care team, and AI tools. Through this process, clinicians' time may be freed up to pay more attention to empathy and communication. Lomis built upon James's comment, saying that such a scenario would require health professionals to balance the assessment and appraisal of information with being an interface between the patient/families and tools.

DISCUSSION

To illustrate the use of AI, Carl Sheperis, dean at Texas A&M University, had spent the closing session cutting and pasting comments and questions raised during the workshop into ChatGPT and then asked it to perform a thematic analysis on the inputted data. The ChatGPT noted five primary themes:

- AI involvement and transparency in diagnosis and treatment planning;
- Addressing public mistrust of AI through community education;
- Integration of AI into health care education and competencies;
- Ensuring global participation and equity in AI integration; and
- AI applications in clinical education, mental health, and disaster response and potential disruptions to medical specialties.

Lomis asked the panelists to comment on the second theme of addressing public mistrust of AI, noting that in the current environment of misinformation and disinformation, health professionals will likely need to be able to explain to patients how technologies like AI work. Furthermore, there may be a need to be more deliberate as a field to communicate with the public more generally. Gichoya pointed to the value of ChatGPT for bringing AI to the forefront of the public's attention. ChatGPT was used to write a song that drew from the musical artist Drake, and the public largely responded by saying this crossed a line. There is a tremendous opportunity, Gichoya said, to take advantage of this public attention to educate the public about AI and how it potentially could be used in fields such as health care. One area of concern, she said, is using AI for ambient listening—that is, documenting everything that is said in the clinical setting, whether it needs to be documented or not. Lomis concluded that it will be important to examine how the clinical world will be changed and how to train health professions students to work in this world. "We need to be honest about the upcoming disruption," she said, and have the hard conversations about how clinicians and educators will address and manage those disruptions.

On the question of trust, Miller said that while mistrust of AI is an issue, there is also the issue of misplaced trust in AI. Trust in expertise is diminishing in general, she said, and people who do not trust experts may be more likely to place their trust in what a computer tells them rather than what their health care professionals tell them. The most effective clinicians, she said, may be the ones who are able to acknowledge the information and resources that are out there and use their expertise to help patients make sense of the information and make decisions about their care.

Miller also remarked about her "mixed thoughts" on whether the use of AI in the clinical setting needs to be disclosed to a patient. The current uses of AI are fairly narrow, she said, and it does not seem necessary to explain these to patients. However, as AI progresses institutions will have to consider the need to make statements about their use of AI and think about institutional commitments and policies regarding responsible use. James commented on the more than 300,000 health apps available to consumers, noting that many of them employ AI. Some patients may already be fairly savvy about the use of AI and the tools that exist. Patients also vary in terms of their comfort and trust of AI; some may trust AI over a doctor and others trust the doctor over AI. Being aware of these dynamics, Miller concluded, is how health professions educators and practitioners can be better positioned moving forward and, as such, better ensure that health professions students are prepared and ready to address these issues of trust in their workplaces.

With that, Tucker thanked the planning committee, panelists, moderators, and attendees for their participation and adjourned the workshop.

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Appendix B

Workshop Agendas

MARCH 3

March 3: Pre-Workshop Virtual Session
[The Why]
Critical Importance and Relevance of AI in HPE

Session Objective: To move toward a shared understanding of artificial intelligence (AI) by exploring the current state in practice across disciplines, which drives the need for training

10:30 a.m. ET **Welcome from Workshop Chair**

The Role of AI Across Health Professions
Moderator: Carole Tucker, Workshop Chair and Associate Dean of Research, School of Health Professions, University of Texas Medical Branch, Galveston

- Cornelius A. James, Clinical Assistant Professor, Departments of Internal Medicine, Pediatrics, and Learning Health Sciences, University of Michigan Medical School

Q&A

- Health Professional Panelists:
  — *Using AI to Make Sense of Complex Datasets* – Moderator's remarks

— *Interoperability for Effective AI* – Kelly Aldrich, Informatics Nurse Specialist, Vanderbilt University
— *AI Conversational Agents for Mental Health* – Eduardo Bunge, Associate Chair, Psychology Department, Palo Alto University

Student Response Panel:

- Mollie Hobensack, BSN, RN, Ph.D. Candidate, Columbia University School of Nursing
- Areeba Abid, M.D./Ph.D. Candidate, Emory University School of Medicine

Planning committee asks questions to the panelists & responders

Audience is encouraged to ask questions/make comments using the chat function

12:00 p.m. ET **Adjourn**

MARCH 15-16

March 15: Opening Hybrid Session [The What] AI Considerations in the Adoption of AI in HPE

Session Objective: To discuss educational content for exploring social, cultural, policy, legal, and regulatory considerations with learners

4:00 p.m. ET **Recommended Reading:**

- *Artificial intelligence in medicine: Overcoming or recapitulating structural challenges to improving patient care?*
- *Assessing the economic value of clinical artificial intelligence: Challenges and opportunities*

Welcome from Workshop Chair

Carole Tucker, Workshop Chair and Associate Dean of Research, School of Health Professions, University of Texas Medical Branch, Galveston

AI Considerations

Explore social, cultural, policy, legal, and regulatory considerations with learners of AI as a tool and as content within health professions education

Moderator: Kimberly Lomis, Vice President, Undergraduate Medical Education Innovations, American Medical Association
- Nathaniel Hendrix, Researcher and Data Scientist, American Board of Family Medicine
- Alex John London, Director, Center for Ethics and Policy, Carnegie Mellon University

Discussion

5:30 p.m. ET **Adjourn**

March 16: Hybrid Workshop Sessions
[The How]
Embedding AI within Health Professions Education

Session Objective: To explore applications of artificial intelligence (AI) within health professions education and AI competencies that cut across all health professions

9:00 a.m. ET **Opening from Workshop Chair**
Carole Tucker, Workshop Chair and Associate Dean of Research, School of Health Professions, University of Texas Medical Branch, Galveston

Providing Education in AI
Required Reading: *Competencies for the use of artificial intelligence–based tools by health care professionals*

Emerging Competency Models for AI in Health Professions
Facilitator: Kimberly Lomis, Vice President, Undergraduate Medical Education Innovations, American Medical Association
- Bonnie Miller, Former Senior Associate Dean for Health Sciences Education at Vanderbilt University School of Medicine and Executive Vice President for Educational Affairs at Vanderbilt University Medical Center

9:30 a.m. ET **Bridging Competencies with Education and Practice**
- Facilitated discussion with audience

10:00 a.m. ET **10-minute break – Move to breakout groups**

Breakout Groups

- **In-person:**
  - — Room 101
  - — Room 102
- **Virtual audience:** Listen to students/trainees** explore AI in health professions education and competencies

**Facilitator: Mollie Hobensack, Ph.D. Candidate, Nursing Informatics, Columbia University

Learner panelists:

- Noahlana Monzon, Coordinated Program for M.A. in Dietetics Nutrition Student, University of Oklahoma
- Dallas Peoples, Ph.D. Candidate in Sociology, Texas Woman's University
- Winston Guo, M.D. Candidate, Weill Cornell Medical College
- Alonzo D. Turner, Ph.D. Student, Counseling and Counselor Education, Syracuse University and 2022 NBCC Doctoral Minority Fellow
- Erkin Ötleş, M.D./Ph.D. Student, University of Michigan

10:10 a.m. ET **Breakout Groups**

- Review the list of six competency domain statements and 25 sub-competencies
- Consider opportunities in existing contexts related to clinical reasoning, evidence-based medicine/practice, documentation, ethics, etc.

Questions to guide the discussion

1. Do these competencies resonate with your profession or educational practice? Why or why not? How might these apply to interprofessional education and collaborative practice?
2. How might we integrate AI outcomes or competencies into current local health professions educational programs or existing curricula? What barriers exist and how might we address them?
3. What might be some challenges and opportunities at your institution to incorporating/adopting the competencies into interprofessional education?

11:10 a.m. ET **Close breakouts – Return to main room**

11:15 a.m. ET **Share ideas**
Facilitator: Kimberly Lomis, Vice President, Undergraduate Medical Education Innovations, American Medical Association
- Share adapted lists and how we can start incorporating key concepts into existing programs (in addition to beginning development of more formal educational interventions)

12:00 p.m. ET **Closing:** Carole Tucker, Workshop Chair and Associate Dean of Research, School of Health Professions, University of Texas Medical Branch, Galveston

Adjourn – Stay tuned for closing session in April

APRIL 26

April 26: Virtual Workshop Session [A Call to Action] Exploring the Future of AI within Health Professions Education

Session Objective: To discuss what health professions educators can do now to incorporate artificial intelligence (AI) into education and training for learners

12:30 p.m. ET **Welcome from the Chair — Carole Tucker, Workshop Planning Committee Chair**
- What the audience has been saying and asking throughout the sessions

12:45 p.m. ET AI in Education: Where do I begin?
Eight Proposed Action Steps based on Box 1 of *Artificial Intelligence for Health Professions Educators*
Moderator: Kimberly Lomis, Vice President, Undergraduate Medical Education Innovations, American Medical Association
Panel Discussants:
- Carole Tucker, Workshop Chair and Associate Dean of Research, School of Health Professions, University of Texas Medical Branch, Galveston

- Cornelius A. James, Clinical Assistant Professor, Departments of Internal Medicine, Pediatrics, and Learning Health Sciences, University of Michigan Medical School
- Mollie Hobensack, Ph.D. Candidate, Nursing Informatics, Columbia University
- Katie Link, Medical Student, Icahn School of Medicine at Mount Sinai
- Carl Sheperis, Dean, Texas A&M University, College of Education and Human Development
- Pamela Jeffries, Dean, Vanderbilt University School of Nursing
- Judy Gichoya, Assistant Professor, Emory University School of Medicine
- Bonnie Miller, Former Senior Associate Dean for Health Sciences Education, Vanderbilt University School of Medicine

1:55 p.m. ET Closing Remarks from the Chair

2:00 p.m. ET **Adjourn**

Appendix C

Workshop Planning Committee and Speaker Biographical Sketches

PLANNING COMMITTEE

Carole Tucker, Ph.D., PT (*Chair*), is the associate dean of research; the Adoue Distinguished Professor in Cognitive Neuroscience; the director of the Center for Recovery, Physical Activity, and Nutrition; and the chair of and a professor in the physical therapy department at the University of Texas Medical Branch, Galveston. Previously, she was an associate professor in the College of Public Health and the College of Engineering at Temple University. Her education and training as both a physical therapist and an electrical engineer provide extensive skills to contribute to research and innovation for individuals with movement impairments. Dr. Tucker has an extensive background in physical therapy clinical practice in pediatrics. Her current research focuses on the development of patient-centered measures, including patient-report outcome measures of health status, in pediatric populations using modern measurement approaches; bioinformatics application in learning health systems; application of pattern recognition and advanced statistical analytical approaches to large datasets; and development and application of biosensors and related technology to improve function and mobility in individuals with disabilities. She is also involved in interprofessional practice opportunities for students both abroad and locally in the Philadelphia metropolitan region serving immigrant communities with limited access to health care. She currently serves on the Functioning and Disability Reference Group, the working group for the World Health Organization's International Classification of Functioning, Health, and Disability, and serves as the American Council of Academic Physical Therapy alternate for the Global

Forum on Innovation in Health Professional Education. She has received funding for her research from the National Institutes of Health, the National Science Foundation, the Department of Defense, and Shriners Hospitals for Children. Dr. Tucker is on the editorial boards of *Pediatric Physical Therapy*, the *Journal of Neuroengineering and Rehabilitation*, and *Physical and Occupational Therapy in Pediatrics*.

Judy Gichoya, M.D., M.S., is an assistant professor in the Department of Radiology and Imaging Sciences at Emory University School of Medicine. Dr. Gichoya is a multidisciplinary researcher, trained as both an informatician and an interventional radiologist. She is a member of the Cancer Prevention and Control Research Program at Winship Cancer Institute. She holds professional memberships with the Radiological Society of North America, American College of Radiology, Society of Interventional Radiology, Society of Imaging Informatics in Medicine, and American Medical Informatics Association. Dr. Gichoya earned her medical degree from Moi University in Kenya. She completed her medical internship at Kiambu District Hospital. She earned a master of science in health informatics from Indiana University–Purdue University in Indianapolis, Indiana. In addition, she completed postdoctoral training in informatics at Regenstrief Institute in Indianapolis, Indiana, and a residency in diagnostic radiology at Indiana University. Prior to arriving at Emory, she completed a fellowship in interventional radiology at Oregon Health Sciences University in Portland, Oregon.

Drawing upon extensive experience with open source communities and contextual knowledge in Africa, Dr. Gichoya hopes to use her skills to build capacity for data science in Africa. Dr. Gichoya's research interests include studying clinical disparities for minimally invasive procedures; validating machine learning models for health in real clinical settings; and exploring explainability, fairness, and a specific focus on how algorithms fail. She has worked on the curation of datasets for the Society for Imaging Informatics in Medicine's hackathon and machine learning committee. She volunteers on the machine learning committees of the American College of Radiology and the Radiological Society of North America to support the artificial intelligence (AI) ecosystem and advance the development and use of AI in medicine.

Mollie Hobensack, M.Phil., B.S.N., RN, is a Ph.D. candidate in nursing informatics at the Columbia University School of Nursing. She is funded by the National Institute of Nursing Research T32 grant, Reducing Health Disparities Through Informatics (T32NR0769) and by the Jonas Scholarship. Prior to beginning her Ph.D. program, she worked clinically as a bedside nurse on a geriatric inpatient unit. She is mentored by Dr. Maxim

Topaz, and her dissertation is focused on incorporating social risk factors extracted using natural language processing in machine learning models to prevent hospitalization in the home health care setting.

Lisa Howley, Ph.D., M.Ed., is an experienced educational psychologist who has spent more than 20 years in the field of medical education supporting learners and faculty, conducting research, and developing curricula. She joined the Association of American Medical Colleges (AAMC) in 2016 to advance medical education and support experiential learning and curricular transformation. Prior to joining the AAMC, she spent 8 years as the associate designated institutional official and assistant vice president of medical education and physician development for the Carolinas HealthCare System in North Carolina. In that role she led a number of medical education initiatives across the professional development continuum, including graduate medical education accreditation and physician leadership development for the large integrated health care system. She concurrently served as an associate professor at the University of North Carolina (UNC) School of Medicine, where she led curriculum and faculty development. She also held a faculty appointment in educational research at UNC–Charlotte where she taught social science research methods and led and collaborated on numerous studies of effective education. From 1996 to 2001 she was a member of the medical education faculty at the University of Virginia School of Medicine, where she designed and led performance-based assessments and simulation-enhanced curricula. She received her bachelor's degree in psychology from the University of Central Florida and both her master of education and Ph.D. in educational psychology from the University of Virginia.

Cornelius A. James, M.D., is a clinical assistant professor in the departments of internal medicine, pediatrics, and learning health sciences at the University of Michigan (U-M). He is a primary care physician, practicing as a general internist and a general pediatrician. Dr. James has served in many educational roles across the continuum of medical education. He also serves on local and national medical education committees. In multiple years Dr. James has been identified as one of the top teachers in the Department of Internal Medicine. In addition, in 2022 he received the preclinical Kaiser Permanente Excellence in Teaching award, the most prestigious teaching award given by the U-M medical school. Dr. James has completed the American Medical Association (AMA) Health Systems Science Scholars program, and he was also one of 10 inaugural 2021 National Academy of Medicine (NAM) Scholars in Diagnostic Excellence. As a NAM scholar, he began working on the data-augmented, technology-assisted medical decision making (DATA-MD) curriculum. The DATA-MD curriculum is

designed to teach health care professionals to use artificial intelligence (AI) and machine learning (ML) in their diagnostic decision making. Dr. James is also leading the DATA-MD team as they develop a web-based AI/ML curriculum for the AMA. He has published articles in *JAMA*, *Annals of Internal Medicine*, *Academic Medicine*, the *Journal of General Internal Medicine*, *Cell Reports*, and more. He is interested in curriculum development and teaching learners to provide evidence-based, data-driven, equitable, patient-centered care. His research interests include clinical reasoning, implementation of AI/ML curricula across the continuum of medical education, and implementation of digital tools into clinical practice.

Pamela Jeffries, RN, is an internationally recognized leader and researcher in nursing and health care education, with a reputation for innovation in teaching strategies, experiential learning, new pedagogies, and the use of technology. She became the ninth dean of Vanderbilt University School of Nursing (VUSN) on July 1, 2021. Dean Jeffries has been principle investigator on federal, state, and organization grants from entities such as the National Institutes of Health, Health Resources and Service Administration, National League for Nursing (NLN), and the National Council of State Boards of Nursing. She is recognized for the development of the NLN Jeffries Simulation Theory, considered the major contribution to simulation scholarship. Prior to being named VUSN dean, she served as the second dean of the George Washington University School of Nursing. In her 6-year tenure, she expanded the infrastructure and processes and standards for the emerging school, leading it through a significant period of growth. Before joining George Washington University, she had a series of progressively more responsible leadership roles at The Johns Hopkins University, where she was a professor of nursing, the associate dean for academic programs, and the vice dean of faculty for the School of Nursing before being appointed vice provost for digital initiatives for the university.

Dean Jeffries is a popular national and international speaker who has also served as a consultant on clinical education, simulations, and other emerging technologies. She has published extensively and is the editor of four books, *Simulations in Nursing Education: From Conceptualization to Evaluation, 3rd ed.*; *The NLN Jeffries Simulation Theory Monograph*; *Developing Simulation Centers Using the Consortium Model*; and *Clinical Simulations in Nursing Education: Advanced Concepts, Trends, and Opportunities*. Dean Jeffries is a fellow of the American Academy of Nursing, fellow of the Society for Simulation in Healthcare Academy, fellow of the Academy of Nurse Educators, inductee into the Sigma Theta Tau International Research Hall of Fame, and recipient of the American Association of Colleges of Nursing Scholarship of Teaching and Learning Excellence Award. She is also a Robert Wood Johnson Foundation Nurse Executive

Fellow. She is active in a variety of professional organizations, including the NLN, the Society for Simulation in Healthcare, and the Global Network for Simulation in Healthcare (GNSH), and she currently serves on the board of directors of the American Academy of Nursing and GNSH.

Kimberly Lomis, M.D., is the vice president for undergraduate medical education innovations at the American Medical Association. In that capacity she guides the Accelerating Change in Medical Education (ACE) consortium of 37 medical schools, affecting approximately 25,000 medical students across the United States. Dr. Lomis is invested in competency-based medical education. She previously served as the associate dean for undergraduate medical education at the Vanderbilt University School of Medicine, where she guided a major revision of the medical school curriculum which included implementation of a comprehensive competency-based assessment program. Dr. Lomis also served as the director of the national pilot of the Association of American Medical Colleges Core Entrustable Professional Activities for Entering Residency. Dr. Lomis trained in general surgery at Vanderbilt University Medical Center from 1992 to 1997 and practiced until 2012. She retains an appointment at Vanderbilt as an adjunct professor of surgery and of medical education and administration.

Dallas Peoples is a program specialist for Transforming Medical Education at the Association of American Medical Colleges (AAMC). She is responsible for assisting in the development, planning, implementation, and tracking of new initiatives and projects in competency-based medical education and interprofessional and collaborative education. Ms. Peoples is also responsible for facilitation of the AAMC's Medical Education Senior Leaders' Anti-Racism Taskforce efforts. Prior to taking this role in June 2022, Ms. Peoples was an education coordinator at the University of Texas Southwestern Medical Center for 4 years. She managed and coordinated undergraduate medical education programs in the Department of Family and Community Medicine for 3 years, and graduate medical education research programs in the Simmons Comprehensive Cancer Center for 1 year. Ms. Peoples earned a bachelor of science in sociology from Texas Woman's University, and a master of science in sociology from Texas A&M University–Commerce, and is currently pursuing a Ph.D. in sociology with a concentration in health and illness at Texas Woman's University. Her research uses a qualitative methodological lens on concerns with health inequities, social determinants, and intersectionality. Her primary areas of focus are medical education, environmental health, and reproductive health. Ms. Peoples also teaches Health and Illness, an undergraduate level course in the Department of Social Sciences amd Historical Studies at Texas Woman's University.

Javaid Sheikh, M.D., is an internationally renowned medical executive and creative thought leader in global academic medicine. Since beginning his tenure as dean of Weill Cornell Medicine-Qatar (WCM-Q) in 2010, Dr. Sheikh has pioneered and implemented innovative biomedical educational and research programs enabling WCM-Q to become widely acknowledged as a leading institution preparing "global physician-scientists" for the 21st century, equipped with the skills, knowledge, and outlook needed to provide exceptional standards of health care while also driving advances in scientific discovery. In addition, Dr. Sheikh led the establishment of a comprehensive research infrastructure at WCM-Q equipped with core laboratories with advanced capabilities in genomics, proteomics, transcriptomics, and metabolomics, making the college a valuable national resource and turning Doha into a regional and global hub for cutting-edge scientific inquiry and international collaboration. To support the ongoing professional development of health care practitioners, Dr. Sheikh established a Division of Continuing Professional Development at WCM-Q which was the first such program in the region to be accredited by the U.S. Accreditation Council for Continuing Medical Education, a very important step in maintaining world-class physician performance and delivery of high-quality medical care. Furthermore, Dr. Sheikh has also led the conceptualization and implementation of comprehensive programs to advance health promotion and disease prevention for the general population of Qatar by cultivating healthy behaviors in school-age children and by designing and conducting population-based, longitudinal studies to assess the efficacy of these interventions. Most recently, Dr. Sheikh has launched a digital health program at WCM-Q, with a curricular component based on data science/machine learning, in collaboration with Carnegie Mellon University-Qatar and Qatar Computing Research Institute.

Dr. Sheikh also co-founded Innovations in Global Health Professions Education (https://www.innohealthed.com), a globally interconnected forum providing an international platform for profiling conceptual and technological innovations in health professions education. He also serves on the Artificial Intelligence in Health Professions Education forum of the National Academy of Medicine in the United States.

Prior to joining WCM-Q, Dr. Sheikh built a distinguished career as a professor of psychiatry and behavioral sciences, associate dean, and chairman of the board at the Palo Alto Institute for Research and Education at Stanford University School of Medicine and affiliated hospitals in California.

Carl Sheperis, Ph.D., M.S., is the dean at Texas A&M San Antonio. Previously Dr. Sheperis was interim president and chief executive officer of the National Board for Certified Counselors, Inc. and Affiliates (NBCC) and

its division, NBCC International. Headquartered in Greensboro, North Carolina, the NBCC is the preeminent certification agency for professional counselors in the United States. It has certified more than 64,000 counselors and provides licensure examinations for all 50 states, the District of Columbia, Puerto Rico, and Guam. Dr. Sheperis completed his undergraduate studies at Kutztown University of Pennsylvania, and earned a master of science in education in 1994 from Duquesne University and his doctorate in mental health counseling in 2001 from the University of Florida. He is a national certified counselor, certified clinical mental health counselor, master addictions counselor, approved clinical supervisor, and licensed professional counselor, as well as a past NBCC board chair. Before joining the NBCC full time in April 2018, he was the program dean for the College of Social Sciences at the University of Phoenix, and earlier served at Lamar University in Beaumont, Texas, where he was chair of the Counseling and Special Populations Department and led the largest state university system counseling program in the United States. Dr. Sheperis has been president of the Association for Assessment and Research in Counseling and an associate editor for the *Journal of Counseling and Development* as well as editor of the *Journal of Counseling Research and Practice*. He also has worked with the American Counseling Association as chair of the Research and Knowledge Committee.

Speakers

Areeba Abid is an M.D. candidate at the Emory University School of Medicine. She received her bachelor's in biomedical engineering from Georgia Tech and worked as a software engineer at Google before medical school. She also worked as an engineer at Abbott, Cardinal Health, and multiple startups. She is excited about innovation in medical technology, particularly machine learning and process improvement. She co-founded MedAI, an organization developing artificial intelligence curricula for medical trainees.

Kelly Aldrich, D.N.P., M.S., RN-BC, FHIMSS, is a board-certified informatics nurse specialist who has served for more than 35 years in clinical, academic, and leadership roles and is recognized as a senior informatics leader, innovator, and advocate for useful, safe, and effective health care transformation. She is an associate professor and the director of informatics innovation for the Vanderbilt School of Nursing, with a secondary appointment in the Department of Biomedical Informatics. Dr. Aldrich spent the first 20 years of her career at the bedside in cardiac and trauma critical care settings. Driven by a passion and dedication to create a seamless patient-centered care environment supported by functional technology, she pursued further academic training in informatics and executive leadership. She is the former chief clinical transformation officer for the Center for Medical

Interoperability, a nonprofit organization led by health systems to simplify and advance data sharing among medical technologies and systems. Prior to that, she served as the invited inaugural chief nursing informatics officer for HCA Healthcare, where she successfully created clinical informatics strategic and tactical roadmaps for implementing meaningful and innovative solutions at scale. She is engaged in research and informatics innovation learning models, which is reflected in publications advocating for the unique nurse identifier and Digital RN citizen model. Other publications include informatics for nursing documentation standards, her model for blending education leadership and technology (BELT) for highly reliable technology systems in innovation, interoperability for better care, the American Nurses Association's (ANA's) Nursing Informatics Scope and Standards of Practice revision, and, most recently, her current work with the Centers for Disease Control and Prevention on health care trust data platforms demonstrating automation of personal protective equipment data in burn and predictive needs for the nation.

With her background in informatics, technology, and innovation and as a fellow with the Healthcare Information and Management Systems Society, Dr. Aldrich proudly represents the nursing perspective on task forces for the Department of Health and Human Services (HHS) and the Office of the National Coordinator for Health Information Technology that are focused on interoperability experience and standards, and she contributes to industry advisory councils including HHS National Cybersecurity Future Gazing, Baxter Healthcare Digital Health, and the ANA Innovation Advisory Committee. Additionally, she owns and manages an informatics consulting company. Dr. Aldrich received her master of science in health care systems leadership and nursing informatics and her doctor of nursing from the University of South Florida.

Eduardo Bunge, Ph.D., M.S., is a professor in the Department of Psychology at Palo Alto University and the director of the master of science in psychology program. He was born and educated in Argentina, earned his undergraduate degree at the University of Buenos Aires, and received his Ph.D. in psychology from the University of Palermo (Argentina). Dr. Bunge currently directs the Children and Adolescents Psychotherapy and Technology Research Lab and is associate director at the International Institute of Internet Interventions for Health at Palo Alto University. He has published five clinical books in three languages (English, Spanish, Portuguese) and more than 40 articles in peer-reviewed journals and chapters. He has been teaching in the master of science program since 2013 and is highly passionate about how technology can contribute to high-quality education and advance the field of mental health.

Winston Guo, M.D. Candidate, is a third-year M.D. student at Weill Cornell Medical College. He previously studied computer science and obtained research experience in labs that use basic, clinical, and computational approaches. He is now interested in the applications of machine learning in clinical spaces (e.g., informing diagnosis and treatment decisions), preventive health, and health care access.

Nathaniel Hendrix, Pharm.D., Ph.D., is a researcher and data scientist with the American Board of Family Medicine and its Center for Professionalism and Value in Health Care. His research focuses on cost-effectiveness analysis, pharmacoepidemiology, and artificial intelligence in primary care. He received his Pharm.D. from the University of Washington (UW) School of Pharmacy and his Ph.D. from UW's Comparative Health Outcomes, Policy, and Economics (CHOICE) Institute, and he completed a postdoc at the Harvard T.H. Chan School of Public Health.

Alex John London, Ph.D., is the Clara L. West Professor of Ethics and Philosophy and director of the Center for Ethics and Policy at Carnegie Mellon University. An elected fellow of the Hastings Center, Dr. London's work focuses on ethical and policy issues surrounding the development and deployment of novel technologies in medicine, biotechnology, and artificial intelligence; on methodological issues in theoretical and practical ethics; and on cross-national issues of justice and fairness. His book *For the Common Good: Philosophical Foundations of Research Ethics* is available in hard copy from Oxford University Press and is available in PDF as an open access title. His papers have appeared in *Mind*, *The Philosopher's Imprint*, *Science*, *JAMA*, *The Lancet*, *BMJ*, *PLOS Medicine*, *Statistics in Medicine*, *The Hastings Center Report*, and numerous other journals and collections. He is also co-editor of *Ethical Issues in Modern Medicine*, one of the most widely used textbooks in medical ethics.

Bonnie Miller, M.D., is a professor of medical education and administration at the Vanderbilt University School of Medicine. She attended Colorado College for her undergraduate education, earning a bachelor of arts in biology in 1976. She received her M.D. degree at the University of Oklahoma, graduating in 1980. She then moved to Nashville for 6 years of postgraduate training in general surgery at Vanderbilt University Affiliated Hospitals. During this time, she spent 18 months doing basic research in surgical nutrition and the metabolic response to injury. After completing her residency, she spent 1 year in Seattle in fellowship in hepato-biliary disease at the Virginia Mason Clinic. Since 1987, Dr. Miller has been back in Nashville.

For 11 years she served as a surgeon in private practice at one of the Vanderbilt-affiliated teaching hospitals, where she worked with residents and students. She then spent 1 year working as a staff surgeon at the Nashville Veterans Affairs Medical Center before assuming the role of associate dean for medical students at Vanderbilt in June 1999. Although she loved the triumphs and trials of student affairs, she was drawn to the challenges facing medical education in the 21st century and moved to her current position in January 2005. Dr. Miller's clinical interests were focused on patients with breast cancer. Her academic interests include the moral development of physicians and the structure and function of curriculum committees.

Noahlana (Lana) Monzon is a first-year student in the Nutritional Sciences M.A./M.S. Program at the University of Oklahoma Health Sciences Center. She has an undergraduate degree in biomedical engineering from the University of Arkansas. Ms. Monzon currently serves as the Unity Clinic nutrition representative liaison and committee member for interprofessional outreach response group. With a passion for improving patient outcomes through technology, communication, and nutrition, Ms. Monzon's master's thesis focuses on the development of a nutrition communication efficacy scale to be used in interprofessional care settings.

Erkin Ötleş is a Medical Scientist Training Program fellow (M.D.-Ph.D. student) at the University of Michigan. His mission is to advance health by harnessing the power of data. He is currently in his final year of combined M.D.-Ph.D. training. His doctoral research focused on creating artificial intelligence (AI) tools for patients, physicians, and health systems. He has led work across the AI lifecycle with projects advancing from model development to validation, technical integration, and workflow implementation. His Ph.D. dissertation research was co-advised by Dr. Brian Denton (industrial and operations engineering) and Dr. Jenna Wiens (computer science and engineering). He is also interested in incorporating education about AI tools into medical curricula. He has a professional background in health information technology development, having worked at Epic and later leading a health care data science team. After completion of his M.D.-Ph.D. training, he plans on pursuing postgraduate medical training (residency).

Alonzo D. Turner is currently a doctoral student pursuing a Ph.D. in counseling and counselor education at Syracuse University. He is a 2022 National Board for Certified Counselors doctoral minority fellow, a national certified counselor, a licensed clinical mental health counselor, and a qualified supervisor with several years of providing counseling services for clients of multicultural backgrounds. His research agenda focuses include

intersectional feminism, Womanist theology, multiculturalism, and examining how the experiences of Black millennials in Black church culture affect their religiosity and spirituality. He is committed to addressing cultural attitudes that perpetuate stigmas regarding mental health services in the Black community. His aim is to use his research to bridge the gap between counselor educators and the Black community. Through his research, he aims to enhance current pedagogic, clinical, and supervisory practices and literature regarding spirituality and religiosity for clients of historically marginalized backgrounds.

Appendix D

Workshop Materials

Suggested readings noted in workshop agendas (see Appendix B):

- Lomis, K., P. Jeffries, A. Palatta, M. Sage, J. Sheikh, C. Sheperis, and A. Whelan. 2021. Artificial intelligence for health professions educators. *NAM Perspectives*. Discussion paper. Washington, DC: National Academy of Medicine. https://nam.edu/artificial-intelligence-for-health-professions-educators/.
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- London, A. J. 2022. Artificial intelligence in medicine: Overcoming or recapitulating structural challenges to improving patient care? *Cell Reports Medicine* 3(5):100622.
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- Centers for Medicare & Medicaid Services. 2022. *Using Z codes: The social determinants of health (SDOH) data journey to better outcomes*. https://www.cms.gov/files/document/zcodes-infographic.pdf.

Appendix E

Glossary of Terms

Artificial intelligence (**AI**) is an umbrella term that means the use of computers to perform tasks that typically require objective reasoning and understanding (Thomason, 2020).

Artificial neural networks are a set of algorithms that mimic the human brain (Kavlakoglu, 2020).

Deep learning is a technique within machine learning in which artificial neural networks are used to solve complex clinical problems (Sarker, 2021).

Interoperability has multiple definitions, including the following:

- The ability of information to be shared and used seamlessly across medical devices and systems to improve health and care coordination (Center for Medical Interoperability, 2021).
- Enablement of the secure exchange of electronic health information with, and use of electronic health information from, other health information technology without special effort on the part of the user; [and] allows for complete access, exchange, and use of all electronically accessible health information for authorized use under applicable state or federal law (ONC and HHS, 2020).

Machine learning (ML) is defined as the "use of statistical and mathematical modeling techniques that use a variety of approaches to automatically

learn and improve the prediction of a target state without explicit programming" (Matheny et al., 2019).

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Sarker, I. H. 2021. Deep learning: A comprehensive overview on techniques, taxonomy, applications and research directions. *SN Computer Science* 2:420. (2021). https://doi.org/10.1007/s42979-021-00815-1.

Thomason, R. 2020. Logic and artificial intelligence. *The Stanford Encyclopedia of Philosophy* Summer. E. N. Zalta (ed.). https://plato.stanford.edu/archives/sum2020/entries/logic-ai/>. (accessed June 23, 2023).