AI Horizons Institute: AI In Healthcare Workgroup

Introduction

Artificial Intelligence (AI) has the potential to transform the landscape of healthcare, offering unprecedented opportunities to enhance patient care, streamline operations, advance education and foster innovation in clinical and translational research. Although the use of data science and artificial intelligence is not new to UR, generative AI represents a sea change, opening new opportunities to collect and use data more effectively, to develop and implement novel tools, and address longstanding challenges to effective patient care.

This whitepaper aims to explore the current usage, opportunities, and challenges of AI, particularly generative AI, across three key pillars of our institution: clinical care, healthcare education, and clinical and translational research.

Data in Healthcare

Healthcare produces and uses an enormous amount of data; by some estimates, 30% of the data produced in the world each year is healthcare data (Thomason, 2023). That data is generated by and about patients and their care as part of the day-to-day operations of healthcare institutions, and it is stored in electronic health records (EHRs), picture archiving and communication systems (PACS) and other locations. It is frequently managed locally, and healthcare institutions have made significant and growing investments into IT infrastructure and staff to support the collection, archiving, maintenance and use of this data.

In addition to being very high-volume, healthcare data is complex, contextual, and often messy. It includes multi-media content like images and video, as well as structured data stored in relational databases and unstructured text. Data is generated by clinicians during the course of their encounters with patients; by administrative staff as they work through scheduling, billing, coding, referral and other workflows; from medical devices in the hospital, in clinics and from wearables and remote monitoring devices; and received from external sources like health information exchanges, insurers, and third-party vendors. That data is all used across a vast number of use cases, including direct patient care, clinical and operational quality improvement, innovation, research and more.

But the collection of all that data comes at a significant cost. Aside from the substantial technological infrastructure investment and maintenance required, much of the burden of capturing clinical data falls heavily onto the clinicians providing care. Clinicians spend an inordinate amount of time on documentation, often at the expense of their own well-being. Studies have suggested that clinicians can spend up to two hours on EHR activities for every hour of direct patient care (Arndt et al., 2017). This administrative burden not only leads to burnout but also detracts from the quality of care delivered.

This is where generative AI has the potential to transform healthcare. Generative AI is a type of artificial intelligence that can create new content, like text, music, images, or other data. While generative AI tools like ChatGPT and DALL-E have garnered much attention for their human-like chat responses and ability to mimic creativity, an underappreciated aspect of generative AI is its strength in processing unstructured data. It can sift through vast amounts of text, identify critical data points, and extract meaningful information that might otherwise be overlooked. This capability is especially powerful in the context of healthcare, where important details are often buried in narrative notes scattered throughout a patient's chart, and where clinicians must spend time manually trawling through that chart in order to put together a complete picture of a patient's health.

AI In UR Clinical Care

Current State

AI is already part of the daily work of many UR Medicine clinicians. A variety of predictive models are available and implemented in Epic, our EHR system, including models for readmission risk and no-show probability. In some cases, UR Medicine has implemented predictive modeling tools from vendors, such as Bayesian Health's sepsis predictive model. Radiology is one of the most extensive users of AI in their workflows. UR Medicine's radiology department represents the world's largest use of AI in pre-reading and triaging CT scans, with a monthly volume of 20-30K images processed. Based on this outstanding accomplishment, our radiology department has gained a national reputation as a thought leader and pioneer of large-scale both implementation and evaluation of AI tools in the clinical practice of medical imaging.

AI in radiology is particularly significant because it merges sophisticated computational power with one of the most data-intensive areas of healthcare. Medical imaging, involving modalities like CT scans, MRIs, and X-rays, generates vast quantities of high-dimensional data, requiring expert analysis to identify critical diagnostic features. Unlike text data, which generative AI tools like ChatGPT primarily handle by recognizing and generating language patterns, medical imaging requires a deep understanding of spatial relationships, textures, and patterns within complex, multimodal datasets. This complexity presents unique challenges, including the need for extensive training datasets, precise annotations, and robust validation frameworks to ensure clinical safety and efficacy. However, the opportunities are equally profound. AI can enhance early diagnosis, assist in image interpretation, reduce clinician workload, and even uncover insights in imaging data that might elude human perception. The application of AI in medical imaging is transformative, but its success hinges on addressing these challenges while leveraging its ability to augment human expertise in a domain critical to patient outcomes.

Our radiologists have worked with Epic to improve their tools for imaging follow-up, contributing heavily to Epic's forthcoming generative AI feature to assist in identifying incidental lung nodule findings in images and follow-up recommendations. Similar AI imaging tools are used in our dermatology services lines to assist generalists in diagnosing and care planning of common dermatological conditions. For more complex conditions, the AI assists with recommending

triaging to the right level of specialty care. As new generative AI features have begun to be introduced by Epic and other vendors, UR Medicine's clinical informaticists are evaluating those tools and prioritizing implementation of the ones that have the potential to most positively impact patient care and provider well-being. Their top priorities for implementation are tools that reduce administrative burden, especially around documentation and information retrieval: ambient documentation, chart summarization, end-of-shift documentation, etc. The UR Health Lab, which serves as UR Medicine's innovation incubator is also working to identify where there are gaps in what commercial tools has to offer and develop solutions to supplement or substitute for vendor solutions.

Opportunities

As noted above, some of the best opportunities for generative AI in the clinical space are those that will streamline operations to reduce the administrative burden for clinicians and other staff while improving patient experience. Ambient documentation tools can reduce the amount of time providers spend on notes, as well as enabling them to spend more of their time during visits interacting directly with patients, rather than the computer and the EHR. Chart summarization and pre-charting tools can highlight and summarize important information from the EHR, making it quicker and easier for the provider to follow the patient's journey since they were last seen, and allowing the provider to focus more on synthesizing that information and understanding the patient's needs instead of spending time to track down consult notes, lab results, imaging reports, etc. from their record. Reducing the cognitive burden that data entry and information retrieval in the EHR impose on clinicians will let them focus on the most important parts of their work: applying their expertise to understand and connect with patients, identify their problems and help them solve them. Nurses in particular deal with many manual workflows that may be able to be automated by using generative AI. In clinical settings, nurses are responsible for documenting thousands of data elements in the EHR: one study found that nurses manually enter more than 600 items over the course of a 12-hour inpatient shift (Gesner, et al., 2022). That data is used not just in clinical care, but it also central to quality assessment and auditing.

Quality reporting and analysis is a key activity for the health system and a core part of how our health system continues to improve and evolve. Effective quality analysis depends on getting good data from the EHR about how patients are cared for and what their outcomes are but extracting that data can be challenging. One example of this is extraction of data for submission to registries. Registries are standardized datasets on cohorts of patients, typically assembled by departments or service lines and shared with regional or national organizations which aggregate and analyze the data across multiple institutions, then report out on comparative outcomes. Understanding how UR Medicine's outcomes compare those of our peers allows us to highlight areas where we excel and where we may have room for improvement. Across UR Medicine, quality improvement nurses spend hours of their time (potentially up to their entire FTE) searching through charts and gathering the data that is required by registries, much of which is embedded in unstructured text notes. There have historically been efforts to fully automate registry data extraction but with limited success. The UR Health Lab is currently leading a project to explore the application of generative AI to this problem, specifically using an LLM to identify and abstract information from note text. Results from our first pilot registry in vascular surgery are promising: across 320 validation cases, the tool is 93%

accurate and completes cases in about 45 sections at a cost of about $.50 per case, compared to a half hour of a nurse's time to complete a case manually.

AI can also potentially be used to address disparities in care. Rural patients in particular face substantial barriers to care, some of which is rooted in the lack of specialty providers practicing in rural areas. AI offers some opportunities to extend the skillset of primary care providers and give them ways to offer patients more advanced care. For example, UR Medicine has partnered with Butterfly, a point-of-care ultrasound provider, to deploy Butterfly's handheld ultrasound probes across primary care. Butterfly's probes have built-in support for users who are not experts in using ultrasound. Their AI-assisted tools guide users toward capturing higher-quality images as well as automatically capture key measurements and highlight specific anatomy. As a result, primary care providers or home care providers can make diagnoses that they would previously have needed to send a patient to a specialist or to the ED for, offering better care with lower barriers.

Accelerated adoption, expansion, and co-development of novel diagnostic and therapeutic AI tools in public-private partnerships offer exciting opportunities for UR Medicine's current flagship domain of real-world AI application in clinical practice, namely radiology: Besides automatic identification of emergent patient conditions that require immediate clinical attention, image-based generative AI will make radiologists better and faster at what they do in many ways: Visionary clinical applications include, but are not limited to, opportunistic screening for ancillary findings on radiology studies that were not the focus of the original imaging requisition, but may help our patients obtain adequate diagnosis and treatment for otherwise undetected health conditions; predictive analytics will optimize patient care based on image-based prognostic markers, thus improving outcomes for overall health and well-being in our community, while simultaneously alleviating healthcare disparities. Finally, by improving radiologists' efficiency and effectiveness at their core business, namely image interpretation, AI tools will play a pivotal role for the economic strength of our institution, by simultaneously "saving lives" and "saving money", thus providing sustainable return on investment and continued growth.

One of the most exciting opportunities in AI, and especially generative AI, is the possibility of using it to create better, more sophisticated diagnostic tools. Precision medicine uses extensive data about a specific patient to finely tailor prevention, diagnosis and treatment recommendations to that patient's particular history, biology and needs. But it can be challenging to manage and analyze all the data that is required. Generative AI, however, is well-suited to handling high-dimensional data, and the application of these models to precision medicine has the potential to open the door to more effective and personalized healthcare solutions. Additionally, generative AI can help simulate potential treatment outcomes, enabling healthcare providers to make more informed decisions.

Challenges

UR Medicine, like most healthcare organizations, is in the proof-of-concept stage with generative AI within clinical service lines. The challenges of implementing generative AI in clinical care are multifaceted and require careful consideration. One of the most important issues is the challenge of problem selection. The sheer number of opportunities around generative AI in the health system is a double-edged sword. On one hand, there is immense potential to improve clinical care and

operations. On the other, this abundance of opportunities necessitates a strategic approach to problem selection. It is crucial to prioritize problems that are clinically meaningful and impactful, but also solutions that are technically feasible and cost-effective. Resources for development, implementation and maintenance of AI tools are limited, and clinicians' time and attention are already stretched to the breaking point, which means that the health system must be very selective about its approach in this space.

Once the problem to be addressed is clarified and selected, it can then be a challenge to identify whether developing a customized solution in-house or purchasing a turn-key solution from a vendor will be most effective to solve the problem. Over the last several years there has been a proliferation of third-party AI vendors in the healthcare market while EHR vendors have made commitments to incorporate their own AI tools into their platforms. For large academic health systems like UR Medicine, which have in-house data science expertise, it has never been easier to build our AI tools. However, the rapid speed in which AI technology is evolving has further added to the challenge health systems face in making decisions on when to wait and partner with our EHR vendor to deploy AI functionality within their platform versus when to buy a third-party AI tool and tailoring that tool to our specific needs versus when to build our own AI solution in-house.

A compounding factor is the complexity of UR Medicine itself. The health system is large, complex, and distributed, which can make it difficult to discern which problems and AI tools will be genuinely impactful across the entire system. Different departments or clinics may have varying needs and priorities, and in some cases, there might already be existing solutions or ongoing projects aimed at addressing similar issues. Additionally, budget concerns add another dimension to the challenge. It is often unclear when a specific generative AI tool should be funded out of a departmental budget versus central IT. The return on investment is not necessarily evenly or locally distributed: if a department implements a tool that results in downstream efficiencies, it raises the question of who gets credit for those improvements and how the benefits are allocated. Redundancy and lack of coordination can lead to inefficiencies and wasted resources. Therefore, it is imperative to establish robust communication channels and collaborative frameworks that allow for the sharing of knowledge, progress, and best practices.

An equally critical challenge is the acceptance of AI tools by users and clinicians. For generative AI tools to be effective, they must be embraced by those who will be using it daily. Clinicians need to understand AI sufficiently to feel informed and safe using it. This requires comprehensive education and training programs that demystify AI and clearly communicate its capabilities and limitations. Workshops, seminars, and hands-on training sessions can help clinicians become more comfortable with these technologies. Additionally, involving clinicians in the development and implementation process can foster a sense of ownership and trust. Establishing transparent metrics for AI performance and ensuring that these tools are rigorously validated in clinical settings can also help alleviate concerns. By addressing these challenges head-on, UR Medicine can create an environment where generative AI is not only integrated into the healthcare system but also actively supported and utilized by its users.

In this context, it will be critical to develop robust methods to quantitatively evaluate the usefulness of AI tools in clinical practice. Here, application-specific evaluation metrics need to be carefully chosen, ranging from classical measures of accuracy or turnaround time to economic

criteria, such as return on investment or total cost of ownership. These quantitative metrics have to be systematically applied during all phases of the AI product/service life cycle, ranging from pre-deployment decision, the clinical implementation phase, to post-deployment surveillance for detecting unwanted AI model performance degradation. Again, our radiology department has played a pivotal role in these domains, making our institution a thought leader for clinical AI evaluation, by having invented and practically implemented award-winning novel methods for large-scale multi-institutional AI-based data acquisition and performance evaluation, including Artificial Intelligence Prospective Randomized Observer Blinding Evaluation (AI-PROBE), AI-based Quality Assurance by Restricted Investigation of Unequal Scores (AQUARIUS), which combines generative language-based AI modeling and image-based AI analysis, and Multi-Institutional Data Harvesting (MIDH) through re-purposing of imaging AI orchestrator software for temporal tracking of healthcare challenges in more than a dozen major healthcare systems throughout the United States, such as during the early outbreak of the Covid-19 pandemic, or the recent global shortage of iodinated contrast agent availability. In this context, we have expanded the scope of analyzed data volumes by several orders of magnitude above the current state of the art – analyzing more than 300,000 CT scans from 13 leading healthcare institutions across the country. It will be critical to further develop and expand these outstanding accomplishments to successfully grow our institution's national recognition and leadership in imaging AI development and evaluation among its peers throughout the United States.

Finally, risk concerns and organizational readiness remain the foremost challenge for health systems in implementing and scaling AI tools. This is especially true with generative AI tools due to the untested nature of the technology in healthcare and uncertainty around regulations. It will be imperative for UR to develop clear governance and risk mitigation strategies to tackle a broad range of issues including privacy and security, ethics and bias, to clinical outcomes to ensure regulatory compliance and excellence in quality care. The ability to validate AI models pre-deployment and the ability to routinely monitor/audit these models after deployment in the healthcare will be required for safe use in clinical care. As with any new technology, UR Medicine will need to prioritize first in use cases with the lowest risk, and shortest path to our investment return (i.e. patient outcome impact, financial return/cost saving, clinician/patient satisfaction, etc.).

AI in UR Healthcare Education

As AI is rapidly transforming healthcare from a care delivery perspective, it is also reshaping teaching, learning, and educational practices in healthcare education. AI incorporated into education can serve as an intelligent tool to facilitate the decision-making process more effectively. The UR School of Medicine & Dentistry (SMD), the School of Nursing (SON), and UR Medicine are already exploring how AI can create new opportunities for advanced teaching and learning experiences to improve outcomes.

In collaboration with the UR Health Lab, the UR Georgen Institute for Data Science (GIDS) will be launching one of the first accredited Master's Degree in Healthcare Data Science/AI programs in the country. Complementing GIDS's current undergraduate and graduate data science programs, this new online degree program is intended for professionals from various backgrounds including those already working in the healthcare domain in technical or clinical roles and looking to gain

relevant skills in data analytics and data science/AI applied to the healthcare industry. The curriculum includes programming, statistics, data management, visualization, clinical informatics, applied machine learning, deep learning, and storytelling.

The UR Health Lab has also developed and implemented a Digital Health Innovation Residency track available to medical residents and practicing nurses. This education initiative offers opportunities for clinicians to learn about the basics of AI and potential applications within care delivery. The practicum component of the program provides students interested in doing a deeper dive into AI the opportunity to be paired with UR experts within a faculty-mentored project. In partnership with UR Medicine's Department of Health Humanities and Bioethics, the UR Health Lab has also developed an AI Ethics in Healthcare brief curriculum and consultation program. This program provides education/consultation supports for the responsible and ethical use of AI in healthcare to all UR faculty and students. With the support of the UR Health Lab, the UR Medicine Information Systems Division (ISD) and Clinical Informatics, have also developed an Analytics Academy to serve as the go-to source for targeted education for UR Medicine faculty and staff around the analysis of data to answer pressing questions within the health system.

Several other initiatives have focused on using AI to transform the way we educate students and trainees. The UR SMD has developed an AI in Education Taskforce aimed to guide the incorporation of innovation and AI into its educational curriculums. The purpose of this taskforce is to assess AI opportunities and screen new AI tools that would be used by learners and educators. While the SON, has started to explore how AI can be integrated into their curriculums under the school's Redefining Our Classroom Initiative (iROC) initiative. The iROC initiative already leverages cloud-based simulation technology and virtual reality (VR) headsets, which help nursing students to develop and sharpen their patient engagement skills. The iROC's technology infrastructure has significant AI integration opportunities, with interactive manikins, academic electronic health records, hospital equipment, VR headsets and state-of-the-art A/V, to better prepare new nurses faster and in a more personalized way when compared traditional educational settings.

Opportunities

Traditionally, healthcare education has aimed to impart a thorough understanding of clinical practices, diagnostic processes, and treatment techniques to students. The American Medical Association (2024) recommends that for AI to be effectively integrated into care delivery, it is essential to continue advancing AI technologies and ensure that future clinicians are equipped with the skills and expertise to use these tools effectively in clinical practice. AI can impact learning by improving the learning process (playing the role of assessing learner needs, simulating personalized learning, by providing better and more effective study tools, etc.), and by addressing the demands on educators in healthcare (improving the educators time efficiency while reducing cognitive load, improving lesson/curriculum design, etc.). Moreover, the World Federation for Medical Education (WFME), the international accrediting body of health professions education, has provided a guideline on the use of AI in healthcare education, showing the opportunities for healthcare students and professionals to use AI for training in basic and continuing professional development (Leon-Borquez, 2024). Therefore, there is room to expand AI use in healthcare education in the near future.

Personalized Learning

AI tools have the potential to adapt and tailor educational content to meet the learner's needs. AI can determine the learner's knowledge level and provide personalized lesson content to help guide the learner to mastery based on their progress and learning style in healthcare education (Glauberman et al., 2023). An AI learning platform can appropriately space and sequence learning events based on an individual's knowledge gaps while providing specific remedial measures if progress is not being made. For example, when teaching in diagnostic disciplines like radiology, pathology, or microbiology a content-based image retrieval AI tool can present the learner with images similar to a reference image for diagnostic purposes but provide remedial educational content if the learner makes a misdiagnosis. Expanding on this, reinforcement learning from AI feedback (RLAIF) has been shown to enhance the capability of AI educational platforms to dynamically adjust educational strategies based on real-time student feedback. This approach refines AI responses to better align with the learning needs and pace of individual students, fostering a deeply personalized learning experience (Dou et al., 2024).

Intelligent Tutoring Systems

AI systems can analyze vast amounts of data regarding a learner's past performance, preferences, and learning style to identify learning gaps to create a learning experience that fills those gaps (Narayanan et al., 2023). Large language models can emulate a human tutor by interpreting the learner's questions and answers, and appropriately responding to the learner based on course content to provide real-time feedback, including simulations and exercises (Dave & Patel, 2023). Moreover, these models adapt to the unique linguistic and conceptual challenges posed by students, providing targeted assistance that evolves with the learner's educational journey (Xiong et al., 2023). Intelligent AI tutors have the potential to help learners understand complex clinical concepts outside of the classroom.

Virtual Patient Avatars and Chatbots

The SMD and SON have incorporated virtual patient simulations into their education curriculum. AI can improve the evaluation of traditional learner-patient simulations for clinical procedures by comparing the steps with preloaded video data and give feedback about the learner's ability to complete those procedure steps. AI also has the potential to further enhance these simulations by creating more dynamic interactions that mimic closer to "real life" patient and clinician scenarios (Hamilton, 2024). For instance, AI avatars and chatbots can take on the role of a virtual patient exhibiting realistic symptoms that will respond to the clinical learner's interventions. In these generated simulations the learner interacts with the AI as if they would interact with a human patient to acquire clinical data, suggest differential diagnoses, recommend clinical interventions, and follow up based on the response of the virtual patient to those interventions (Garcia-Torres et al., 2024). Studies highlight that AI can be specifically tailored for multicultural and multilingual contexts, potentially enhancing virtual simulations in diverse educational settings by integrating culturally specific scenarios and medical conditions (Yang et al., 2023; Wang et al., 2023). AI can be used to assess learner interpretation skills by developing different presentations based on typical and atypical findings of various diseases. Incorporating gamification using AI into these virtual patient scenarios can further customize and personalize the learning experience by adjusting the complexity of the interaction by formulating different sets of case scenarios based on

the learner's performance to the previous scenarios (Narayanan, et al., 2023). Gamification can also enhance learner engagement and collaborative efforts with other students.

Educator Administrative Efficiency

AI can support educators around decision-making in areas involving curriculum development and the drafting of exams/quiz questions, homework, or case studies. It can assist educators around the evaluation and overall management of course work. AI can reduce the time required to analyze different curricula by evaluating multidimensional issues and show a connection between the elements in curriculum assessment to help identify gaps or even develop predictive analytics for at-risk learners (Narayanan, et al., 2023). Similar to the clinical domain, some of the best opportunities for generative AI in the healthcare education are those that will streamline operations to reduce the administrative burden for the educators. AI-powered systems can efficiently manage the records related to education including learner attendance and leave records, scheduling of homework/quizzes/exams, faculty training/development, learner performance management, and learner engagement. The analysis of education financial spend, forecasting the expenses within budget proposals and allocation of educator resources to have the best learner outcomes could also be supported by AI systems (Narayanan, et al., 2023).

Challenges

Although AI offers many promising opportunities within healthcare education, there are several challenges that will need to be addressed before there is universal adoption in education institutes like the UR. A specific challenge in integrating AI into healthcare education is determining the appropriate level of AI literacy required for learners across many different levels (students, trainees, professionals, etc.) to engage effectively and ethically with these technologies. As AI becomes increasingly integrated into clinical practice, it will be crucial for healthcare education programs to equip learners with a foundational understanding of AI principles, capabilities, and limitations. This includes knowledge of how AI models are trained, how they make decisions, and the potential biases. Without this understanding, healthcare professionals may struggle to critically assess AI-generated insights, potentially leading to over-reliance on AI systems or misuse of AI tools in clinical settings. Differentiated levels of learners will require training that is tailored to their needs, while maintaining consistency with UR-wide guidance/principles.

Moreover, a systematic review reports that the current most challenging aspect of AI use in healthcare education is ethical dilemma and issues (Sun et al., 2023). Ethical considerations around AI, such as issues of consent, data privacy, and bias, necessitate that learners are not only technically informed but also ethically aware. Learners must be able to navigate the complex moral landscape that AI introduces, ensuring that their use of technology aligns with ethical standards. This requires an educational approach that integrates AI literacy into the broader healthcare curriculums in our clinical training programs, balancing the technical knowledge of our STEM programs with ethical reasoning. However, achieving this balance poses a challenge, as our SMD and SON curricula are already dense with essential clinical content. Our educators must find ways to incorporate AI education without overwhelming learners or detracting from core clinical care training. This necessitates thoughtful curriculum design and possibly interdisciplinary collaboration to develop effective education strategies.

As the role of the educator continues to evolve, educators will face the challenge of maintaining professional development and identity. The acceptance and trust of AI by both educators and learners will be crucial as there may be resistance due to fear of job displacement or skepticism about AI's reliability in delivering educational content (Narayanan et al., 2023). For example, introducing AI use in healthcare may generate a sense of self-threat and professional identity challenges for medical students and residents, resulting in resistance and avoidance to utilize AI (Jussupow et al., 2022). But as AI technologies become more prevalent, educators must adapt to new education paradigms that incorporate AI-driven tools and resources which could lead to a redefinition of the educator's identity. This shift will require educators to continually update their skills and knowledge to stay abreast of technological advancements, which can be a daunting prospect, particularly for those who may not be technologically inclined or who have established careers based on traditional educational methods. Professional development should focus not only on technical proficiency with AI but also on pedagogical strategies that leverage AI's strengths while maintaining the human elements of empathy, judgment, and ethical reasoning that are crucial in healthcare education. The UR will need to support our educators through this transition by providing the resources, training, and a supportive community of practice. It will also require a clear governance process for vetting and approving new AI tools/technologies for our faculty, staff, and students to use.

AI in UR Clinical and Translational Research

UR has been looking towards AI to drive forward translational clinical research for many years. UR has specific expertise in optics, image processing and computer vision. Researchers across SMD, Hajim School of Engineering, and GIDS have been leading studies to improve clinical care by applying AI to medical imaging. Major areas of investigation include automated analysis of ultrasound to segment of areas of interest leading to the development of new generation of diagnostic tools for musculoskeletal and cardiac etiologies while deriving new insights to better understand the underlying disease process. Researchers in our Department of Radiology have also been applying AI on MRI images for human brain mapping, mammography for breast cancer diagnosis, image segmentation in Multiple Sclerosis and Alzheimer's Dementia to multi-modality fusion, biomedical time-series analysis, and quantitative bio-imaging.

UR is at the forefront of integrating AI into diverse areas of research with projects across disciplines highlighting the potential of these tools and approaches. Within the Wilmot Cancer Institute, UR researchers have been applying AI to support genomics research. The UR Medicine Departments of Psychiatry and Neurology have partnered with GIDS to study the use of AI avatars to enhance communication skills or improve those of persons with developmental disorders with impaired communication skills, such as autism. The UR Center for Health + Technology, has clinical trials underway evaluating the use of AI supported digital tools to monitor the progression of several neurodegenerative and movement disorders, while the Department of Cardiology has studied the use of AI within video monitoring digital tools to capture patient biometrics. The SON has researchers using predictive AI models to evaluate clinical assessments made during pregnancy, and heart failure. These initiatives underscore UR Medicine’s ability to harness the power of AI to solve problems across a wide range of clinical settings.

A key enabler of that work is the UR Clinical and Translational Science Institute (CTSI), the research engine that helps researchers connect, learn, and get what they need to improve and speed the development of interventions to improve health outcomes for all people. The CTSI's Informatics and Analytics branch provides support for researchers across the University interested in translating AI research into clinical practice. The CTSI is currently working with researchers in SMD, bioethics, and GIDS around the application of safe, equitable, and responsible AI in healthcare.

Opportunities

Despite there being thousands of published studies on AI models, there have been limited controlled clinical trials on real-world clinical interventions that used AI models. To show their continued safety and effectiveness, AI systems should also be carefully evaluated using clinical translational research to better understand how well AI will benefit patients and their care. UR researchers will continue to evaluate how AI models can accurately predict development of disease, diagnosis of disease, and beneficial treatments. One of the most promising opportunities of the use of generative AI in translational research for the UR is in drug discovery and development. Generative AI can be used to design novel compounds by analyzing vast datasets of chemical properties and biological activities. By simulating how new drugs interact with biological systems, researchers can identify promising candidates faster and more efficiently than traditional methods.

In our clinical trial research, there is an opportunity for generative AI to optimize trial design by predicting patient responses to treatments, thereby enhancing the selection of appropriate candidates and reducing trial durations. This capability is particularly valuable in precision medicine research being done in our UR Rochester Genomics Center, where individualized treatment plans could be developed based on a patient's genetic makeup. There is also an opportunity for generative AI to enhance our current research in medical imaging. By creating synthetic but realistic medical images, generative AI can assist in training diagnostic algorithms and improving their accuracy especially in situations where there is a lack of labeled data. One of the biggest opportunities for UR is to become leaders on studying how to optimally implement AI in safely in clinical practice given the full integration of our health system within the university structure. Driving towards personalized healthcare, AI has the potential to analyze patient data to predict disease progression and treatment outcomes, enabling healthcare providers to tailor interventions more precisely. However, to do this successfully healthcare will need further research on pre-deployment validation of AI tools, as well as post-deployment monitoring of these tools for continued safety and trust. This approach will not only improve patient outcomes but also contribute to the efficiency and cost-effectiveness of UR Medicine.

Challenges

It is of the utmost importance that AI research in healthcare operates under rigorous governance frameworks to uphold ethical standards and prioritize the protection of patients and research subjects. There are several significant challenges to developing these frameworks and the institutional support to implement them. There are a wide variety of uses and approaches to AI in research, from the development of new models to the application of existing models and

foundation models to novel problems, to the use of AI solutions to capture, process and analyze research data. Governance must address concerns including data privacy, informed consent, bias, and transparency across the spectrum of AI in clinical and translational research and developing appropriate guidelines will require a multidisciplinary approach involving ethicists, legal experts, researchers, and healthcare professionals.

This challenge is further complicated by how quickly AI evolves, particularly in the availability of new models and tools and opportunities for their application in research settings. The rapid pace of AI development may outstrip the ability of UR's existing governance structures to adapt, leading to potential gaps in oversight and regulation. This continuously changing environment will necessitate a proactive approach to governance, including ongoing monitoring and adaptation of guidelines to ensure they remain relevant and effective.

Developing the necessary infrastructure to support clinical and translational AI research presents its own set of challenges. UR will need continued investment in advanced computational resources, including CIRC's high-performance computing systems and secure data storage solutions, to handle the vast amounts of data generated and processed by AI technologies. Additionally, building on the work of the CTSI, there is a need to maintain and enhance robust data management practices that ensure data integrity, security, and compliance with regulatory requirements such as HIPAA. Balancing these infrastructure demands with limited budgets and resource availability requires strategic planning and prioritization to ensure that clinical and translational research that incorporates, applies or develops AI technologies can thrive while maintaining our broader educational and healthcare missions.

Enabling interdisciplinary collaboration and developing comprehensive training and education programs are critical components in advancing AI research in healthcare. By fostering an environment where researchers, clinicians, data scientists, and IT professionals can collaborate effectively, we can drive innovation to enhance the impact AI research will have on healthcare. It is essential to continue the development of training programs that equip current and future researchers with the necessary skills to effectively leverage AI, including technical education in machine learning, along with an understanding of ethical considerations and regulatory requirements specific to healthcare. By prioritizing interdisciplinary collaboration and education, UR will be able to not only advance the application of AI in healthcare but also prepare a workforce capable of navigating the complex challenges and opportunities in this rapidly evolving domain.

References

American Medical Association (2024, Apr 5). *Augmented intelligence in medicine*. American Medical Association. https://www.ama-assn.org/practice-management/digital/augmented-intelligence-medicine

Arndlt, B.G., Beasley, J.W., Watkinson, M.D., Temte, J.L., Tuan, W.J., Sinsky, C.A., & Gilchrist, V.J. (2017). Tethered to the EHR: Primary care physician workload assessment using EHR event log data and time-motion observations. *Annals of Family Medicine, 15*(5), 419-426. doi: 10.1370/afm.2121

Dave, M., & Patel, N. (2023). Artificial intelligence in healthcare and education. *British Dental Journal, 234*, 761–764. doi: 10.1038/s41415-023-5845-2

Dou, C., Zhang, Y., Jin, Z., Jiao, W., Zhao, H., Zhao, Y., & Tao, Z. (2024). *Exploring LLM-based Data Annotation Strategies for Medical Dialogue Preference Alignment*. arXiv. https://doi.org/10.48550/arxiv.2410.04112

Garcia-Torres, D., Ripoll, M.A.V., Peris, C.F., & Solves, J.J.M. (2024). Enhancing clinical reasoning with virtual patients: A hybrid systematic review combining human reviewers and ChatGPT. *Healthcare, 12*(22), 2241. doi: 10.3390/healthcare12222241

Gesner, E., Dykes, P.C., Zhang, L., & Gazarian, P. (2022). Documentation burden in nursing and its role in clinician burnout syndrome. *Applied Clinical Informatics, 13*(5), 983-990. doi: 10.1055/s-0042-1757157

Glauberman, G., Ito-Fujita, A., Katz, S., & Callahan, J. (2023). Artificial intelligence in nursing education: Opportunities and challenges. *Hawai'i Journal of Health & Social Welfare*, *82*(12), 302–305.

Hamilton A. (2024). Artificial intelligence and healthcare simulation: The shifting landscape of medical education. *Cureus*, *16*(5), e59747. doi: 10.7759/cureus.59747

Jussupow, E., Spohrer, K., & Heinzl, A. (2022). Identity threats as a reason for resistance to artificial intelligence: Survey study with medical students and professionals. *JMIR Formative Research*, *6*(3), e28750. doi: 10.2196/28750

Leon-Borques, R. (2024). Role of artificial intelligence and the WFME standards. World Federation for Medical Education (WFME). https://amcoa.org/wp-content/uploads/2024/08/Training-and-Research-Role-of-Artificial-Intelligence-and-the-WFME-Standards-%E2%80%93-Dr.-Ricardo-Leon-Borquez.pdf

Narayanan, S., Ramakrishnan, R., Durairaj, E., & Das, A. (2023). Artificial intellegence revolutionizing the field of medical education. *Cureus, 28*(15), 1-9. doi: 10.7759/cureus.49604

Sun, L., Yin, C., Xu, Q., & Zhao, W. (2023). Artificial intelligence for healthcare and medical education: A systematic review. *American Journal of Translational Research*, *15*(7), 4820–4828.

Thomason, J. (2023). Data, digital worlds, and the avatarization of health care. *Global Health Journal, 8*. 1-3. doi: 10.1016/j.glohj.2024.02.003

Xiong, H., Wang, S., Zhu, Y., Zhao, Z., Liu, Y., Huang, L., Wang, Q., & Shen, D. (2023). *DoctorGLM: Fine-tuning your Chinese Doctor is not a Herculean Task*. arXiv. https://doi.org/10.48550/arxiv.2304.01097

Yang, S., Zhao, H., Zhu, S., Zhou, G., Xu, H., Jia, Y., & Zan, H. (2023). *Zhongjing: Enhancing the Chinese Medical Capabilities of Large Language Model through Expert Feedback and Real-world Multi-turn Dialogue*. arXiv. https://doi.org/10.48550/arxiv.2308.03549

Wang, H., Liu, C., Xi, N., Qiang, Z., Zhao, S., Qin, B., & Liu, T. (2023). *HuaTuo: Tuning LLaMA Model with Chinese Medical Knowledge*. arXiv. https://doi.org/10.48550/arxiv.2304.06975