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FEATURE ARTICLE

Artificial Intelligence in Healthcare: an Opportunity for Health System Analysis and Normative Discussion



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On the cover



rtificial intelligence undoubtedly revolutionized medicine with its increasing ability to analyze vast datasets and accelerate disease detection. However, the importance of humanity in healthcare remains paramount, and there is unsurprisingly some hesitancy at the thought of technology replacing human roles in the healthcare field. While AI provides efficiency and precision, the compassionate, empathetic touch of human caregivers is irreplaceable. In the ever-evolving field of medicine, striking the right balance between AIdriven advancements and human care will ensure comprehensive patient well-being and a brighter future for healthcare. This cover art reflects the idea that both artificial intelligence and the unique capabilities of humans can work in concert to help improve the future of medicine without one ever fully replacing the other.

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The advent of artificial intelligence (AI) has sparked a transformative wave across numerous fields, and one field that stands to benefit significantly from this revolutionary technology is healthcare. AI encompasses a wide range of technologies, such as machine learning, natural language processing, and computer vision, all of which can be harnessed to tackle complex healthcare challenges.¹ AI has the potential to revolutionize the way we diagnose, treat, and manage diseases, leading to improved patient outcomes, enhanced efficiency, and reduced healthcare costs. As AI advances, it offers unprecedented opportunities for medical professionals, researchers, and patients. In this editorial, we delve into the profound impact of AI in healthcare, emphasizing its potential advantages, addressing concerns, and exploring the essential steps required to harness this technology to its full potential.

AI exhibits exceptional proficiency in the realm of diagnosis. AI-powered applications can analyze, identify patterns, and generate actionable insights from vast amounts of medical data-including patient history, symptoms, lab results, and medical imaging-to assist healthcare professionals in the early detection and more accurate diagnosis of diseases.¹ The integration of AI with medical imaging has proven particularly transformative. Advanced imaging techniques, such as MRI and CT scans, generate massive amounts of data that can overwhelm human radiologists.² AI algorithms, however, excel at image recognition and analysis, enabling radiologists to detect abnormalities with greater accuracy and efficiency. This not only reduces diagnosis time but also minimizes the risk of misdiagnosis. Furthermore, AI algorithms can aid in the early detection of diseases by identifying subtle patterns that may elude human observers, thus improving survival rates and patient outcomes.3 For instance, AI has been shown to detect diabetic retinopathy from retinal images with high sensitivity and specificity, highlighting their potential for early detection and intervention.⁴ An AI-based system has also been tested for detecting lung cancer from chest computed tomography images, and the result shows that it exceeds the diagnostic abilities of human experts and would improve the precision and effectiveness of lung cancer screening.⁵

In addition to diagnosis, AI has significant potential in treatment regimes. Specifically, the integration of AI in healthcare has ushered in the era of precision medicine, where treatment decisions are tailored to the individual patient. AI-powered systems can analyze vast databases of patient records, clinical trials, and scientific literature to identify potential drug targets and develop personalized treatment plans.⁶ AI algorithms can also allow healthcare providers to analyze patient-specific data, including genetic information, medical history, and lifestyle factors, to deliver tailored treatment recommendations. For example, deep learning algorithms have been used to predict drug responses based on genetic and clinical data, enabling personalized treatments.⁷ The use of AI in precision oncology also highlights how AI-driven analysis can optimize treatment decisions by identifying patient-specific biomarkers and predicting treatment response.⁸ By leveraging AI's ability to process

Correspondence to Helen Hsiao (helen712@student.ubc.ca) and analyze complex biological data, researchers can expedite the drug discovery process, significantly reducing costs and increasing the chances of finding effective treatments.^{9,10} Similarly, AI models can predict patient responses to immunotherapy, facilitating targeted and effective cancer treatment strategies.¹¹ Such advancements pave the way for improved patient outcomes and enhanced healthcare delivery.

Beyond its diagnostic and research capabilities, AI-driven applications have the potential to transform patient care by optimizing workflows, reducing errors, and enabling remote monitoring. Chatbots and virtual assistants powered by AI algorithms can provide 24/7 personalized support to patients, offering guidance and assistance with medication management and symptom tracking.¹²⁻¹⁶ AI can also optimize treatment plans by continuously monitoring patient responses and adjusting therapies accordingly, leading to better outcomes and reduced healthcare expenditures. AI-powered remote monitoring systems can also continuously track vital signs and health indicators, utilizing AI algorithms to analyze patient-generated health data from wearables and home monitoring devices. This enables early detection of potential issues, continuous monitoring of health trends, and reduces the need for hospital and clinic visits, enhancing patient care. By alerting healthcare providers to deviations from baseline values, AI-driven systems facilitate early interventions and prevent adverse events, enabling remote care and interventions.17

While the potential benefits of AI in healthcare are immense, it is crucial to address concerns and challenges associated with its implementation. One significant concern is the ethical use of AI and patient privacy. In the literature, health applications of AI revealed four prevalent ethical themes. These encompassed data privacy and security, bias, trust in AI, and accountability and responsibility.^{18,19}

Using patient data for AI-driven applications raised significant privacy and security issues.²⁰ Concerns were highlighted about the potential misuse of data without individuals' knowledge and the risk of data breaches. An illustrative example involved a 2016 hacking incident in Mumbai where 35,000 patient medical records, including sensitive information, were leaked, while many patients remained unaware.¹⁸ The ambiguity surrounding subsequent data use and widespread surveillance by AI systems through personal devices introduced the risk of reidentifying patient data, leading to potential hacks and unauthorized sharing for profit. Additionally, concerns arose due to proprietary software in smart devices, limiting scrutiny and accountability. These concerns had wide-ranging implications, potentially leading to discrimination against specific population sub-groups when leaked to employers and insurance companies.¹⁸ To address these concerns, several recommendations have been made. Researchers should collect only essential data, and consent procedures must involve individuals transparently about data collection's purpose and potential impacts. Interactive informed consent procedures, with features like social annotations and visual aids, can achieve this. The concept of consent should be adaptable to different contexts, and some suggest adding a data expiration date as an option for patients.²⁰

Another concern is the potential bias embedded in AI algorithms.¹⁸ Bias emerged as a prominent ethical concern in the literature, encompassing both the potential biases embedded within algorithms and

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the data used to train them. The worry centered around human fallibility, as algorithm developers may inadvertently include their own societal biases, leading to outputs favoring specific population groups. Biased datasets perpetuate systemic inequities based on race, gender identity, and demographics, hampering AI's diagnostic and treatment capabilities. Nonetheless, some see AI as a tool to mitigate biases in healthcare systems by reducing human errors and cognitive biases in treatment decisions. Addressing bias requires building AI systems aligned with ethical healthcare standards and adopting a multidisciplinary, participatory approach to AI design and implementation. AI's disruptive potential can reshape the bilateral physician-patient relationship by involving various actors, challenging the traditional medical ethics of "shared decision-making." The shift towards a trilateral "physician-computerpatient" relationship raises concerns about the "third wheel" effect, where the physician's role may be diminished. Preserving the physician's professional integrity as the final decision-maker and avoiding excessive reliance on AI is vital. Negative prejudices about AI's superiority among physicians highlight the need to maintain trust between patients and doctors.²¹ Hence, the integration of AI into healthcare requires effective collaboration between AI developers, healthcare professionals, and regulatory bodies.¹⁸ Clear guidelines, standards, and regulations should be established to govern the development, deployment, and evaluation of AI systems in healthcare. Ensuring AI algorithms' transparency, explainability, and accountability is essential to foster trust among healthcare professionals and patients.²²

Despite the challenges and concerns surrounding the integration of AI into healthcare, several actionable steps can be taken to unlock the vast potential of AI in the field of medicine: Investments in research and development are crucial to drive innovation and advance AI technologies specifically tailored for healthcare applications. Governments, private entities, and academic institutions should collaborate to create funding opportunities, research grants, and incentives to encourage the development of AI solutions in healthcare.²³ The integration of AI in medical education and training programs is essential. Healthcare professionals need to be equipped with the necessary skills to effectively use AI technologies, interpret AI-generated insights, and integrate them into clinical practice. Continuous education programs, workshops, and training initiatives should be implemented to foster AI literacy among medical professionals.²⁴⁻²⁶ Robust regulatory frameworks should be established to guide AI's ethical and responsible use in healthcare. Regulatory bodies should work closely with AI developers, healthcare providers, and patient advocacy groups to develop guidelines and standards that promote patient safety, data privacy, and fairness. Regular audits and assessments should be conducted to ensure compliance and address emerging ethical concerns.²⁷ Exploring different AI governance models in healthcare could address current regulatory challenges. The World Health Organization's recent guidance emphasizes policies aligned with ethical principles. Various approaches have been proposed, like Guan's global ethical framework, but logistical challenges in global audits and monitoring persist. Achieving global solidarity and collaboration in regulatory aspects is needed.^{21,28} Furthermore, fostering collaboration and partnerships between AI developers, healthcare institutions, and researchers is crucial. Open platforms that facilitate data sharing and collaboration can enable the development of more accurate and comprehensive AI models. Encouraging interdisciplinary research and fostering a culture of collaboration can lead to breakthrough innovations and accelerate the translation of AI research into clinical practice.23,29

In "AI in Healthcare", the UBC Medical Journal focuses attention on the ongoing work being conducted by healthcare leaders to target our system's most critical challenges. This issue's feature article is written by Benny Pokharel, BMSc and Dr. Sian Hsiang-Te Tsuei, MD, PhD, a family physician specializing in global health systems research, who examines the role of AI in healthcare from a health systems lens.

Integrating AI into healthcare presents many opportunities to enhance diagnosis, treatment, and patient care. By harnessing AI's capabilities, healthcare professionals can provide more personalized and efficient care, leading to better healthcare outcomes. However, ethical considerations and regulatory challenges must be addressed to ensure responsible and equitable implementation of AI in healthcare. As we embrace the future of AI in healthcare, it is imperative to prioritize patient well-being, establish robust ethical guidelines, and adapt regulatory frameworks accordingly. Through ongoing research, interdisciplinary collaboration, and responsible implementation, AI has the potential to revolutionize healthcare, making it a more efficient, precise, and patient-centric field.

Conflict of interest

The authors have declared no conflict of interest.

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Artificial intelligence in healthcare: An opportunity for health system analysis and normative discussion

Sian Hsiang-Te Tsuei^{1,2}, MHSc, MD, PhD, CCFP, Benny Pokharel³, BMSc Citation: UBCMJ. 2023: 15.1 (6-8)

Introduction

The artificial intelligence (AI) market has expanded quickly across the globe in recent years. The annual number of articles on PubMed that has a keyword "artificial intelligence" increased exponentially, rising from about 1,000 articles to 38,000 articles per year between 2000 and 2023.¹ The overall market size is expected to grow by 21.6% to 37.3% annually from 2023 to 2030,² but this may be an underestimate. In March this year, the amount consumers spent on AI-powered apps rose by 4184% compared to the same month last year; the number of AI chatbot in app stores spiked by 1480% compared to 2022.³ Since the computing power supporting AI development has been doubling every 1.5 years since 2003,⁴ the performance of future AI systems should improve even further, fueling further market expansion.

AI applications in the healthcare industry have also become increasingly capable, though not without limitations. AI systems support tasks ranging from foundational discoveries such as drug development to clinical support such as image interpretation and therapeutic recommendations. The main drawback has been the practical need for a large quantity of high-quality data. Experts also speculate that AI systems may never fully acquire empathy because of their digital nature.^{5,6}

The introduction of advanced chatbots this year challenged these assumptions. Despite being merely trained on large quantities of human interactions, rather than specific medical data, ChatGPT 4.0 boasts achieving over 90% accuracy on the USMLE exam.⁷ The human-like, customized conversations with the users also earned it a higher empathy score and perceived quality on average compared to the human physicians.⁸ As the ChatGPT developers acknowledge, patients may conceivably seek medical advice from AI systems.⁷ The individualized exchange can help the conversation seem like a clinical consultation rather than a web-based search.

If the AI systems begin dispensing medical advice—even with sufficient disclaimers (as Box 1 shows)—this could nevertheless verge on medical malpractice. The algorithms are not validated by medical professionals via licensing exams, but it nevertheless provides guidance on potential therapies. It is also unclear if the training approaches are sufficiently unbiased, reliable, and accurate across patient contexts.⁹

To minimize the potential harms from AI systems, conceptualizing appropriate health system responses to the AI shock is therefore imperative and urgent. Two questions are particularly crucial. First, how is AI affecting health systems? A realistic appreciation for the answers to this question would set the stage for thoughtful responses to the second question: how should the health systems adapt to the AI shock?

Describing how AI is affecting health systems

Our team is developing a longitudinal, up-to-date, systematic analysis of health systems' adaptation to the AI shock. We will draw on the comparative case study approach to capture different countries' policy approaches in adapting to AI technology. The international scope of the analysis captures a diverse set of policy orientations for varying contexts while the longitudinal scope captures health systems' evolution, which can highlight points of structural inertia and opportunities. Both advantages can generate context-specific and nuanced recommendations for national and international leaders.

The analysis will leverage the world-renowned control knob framework,¹⁰ which remains one of the most theoretically rigorous and practically useful frameworks for policy analysis and development. The framework conceptualizes health systems as a set of policies (control knobs) that lead to specific outcomes of interest. The policies include financing, the method and level of financing towards AI development and use; payment, the method and level healthcare organizations and providers are paid; organization, the policies that affect healthcare sector, organization, and provider-level divisions; regulation, the rules, guidelines, and norms governing healthcare industry; and persuasion, the range of coercive to promotional practices that affect health behaviour inclinations. These control knobs then affect key intermediate outcomes (i.e., the access to, quality of, and efficiency of healthcare services) and target outcomes (i.e., health outcomes, public satisfaction, and financial risk protection).

How should AI be used in the clinical realm

Notwithstanding the ongoing regulatory efforts from the Office of the Privacy Commissioners¹¹ and Health Canada,¹² two of the most relevant upcoming regulations still offer room for clinician contribution.

The Canadian Artificial Intelligence and Data Act (AIDA) offers the most comprehensive regulatory framework around general AI products.^{13,14} At the time of writing, the AIDA has passed the second reading and is under deliberation within the parliamentary committee.¹⁵ However, how the AIDA will operationalize its regulations over medically related AI systems is yet unclear. First, the AIDA applies to high-impact AI systems, which should show "evidence of risks of harm to health" and be "critical to health and safety".¹³ However, the practical boundaries of these criteria await further clarifications. Second, the framework recommends administrative monetary penalties for problematic AI use in healthcare, but the extent and indications of such penalties remain unclear.

The Canadian Food and Drug Act is also relevant. At the time of writing, AI developers can submit for approval of their AI systems along with the expected functions, but this fails to regulate AI systems that can evolve post-authorization.¹⁶ Health Canada is expected to release additional regulations for such adaptive AI systems in Schedule G, which captures complex therapeutic products that the original FDA did not anticipate. However, such issuance has not yet happened.

In addition to the national regulations, the international

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community also needs to unify their regulatory approaches. Otherwise, users and industry actors can simply bypass national restrictions via the internet. Canada is already engaging in such international dialogues on AI regulation,¹³ but this effort may nevertheless be challenging due to various nations' ethical preferences and norms.

The lack of regulatory clarity offers a unique opportunity to shape how AI should be incorporated into medical practice. We are considering developing a multi-stakeholder group to engage with this area. Medical practitioners and trainees have an especially important role given their unique institutional, ethical, and practical knowledge around medicine.

Engagement efforts could explore at least the following directions: What characteristics and evidence should the AI systems demonstrate to be considered trustworthy?¹⁷ In what phase of clinical encounter should AI systems be consulted (e.g., triaging patient flow, taking history, generating differential diagnoses, and / or providing therapeutic recommendations)? To what extent should providers and patients rely on AI systems' recommendations? How should malpractice be handled for physicians who consult AI systems?

Conclusion

The boom in AI technological development and uptake will undoubtedly continue in the next few years, and it is imperative for the healthcare practitioners, researchers, and policymakers to 1) understand how the health system is adapting to the AI technology and 2) grapple with how such technology should be used for healthcare. Both are yet unclear. Given the large-scale impact this shift will have, the current uncertainty presents an important and urgent opportunity for thoughtful actors to help shape the use of AI in health systems.

Box 1: Example dialogue with ChatGPT 4.0 for medical advice as of April 21, 2023 (ChatGPT response, prompt regarding medical diagnosis, 21 April 2023)

ST: I have a slight cough. Can you help me understand how serious my cough is?

ChatGPT 4.0: I'm not a doctor, but I can try to help you understand some general information about coughs. It's important to remember that you should consult a healthcare professional for an accurate diagnosis and advice tailored to your specific situation.

Coughs are generally classified as acute, subacute, or chronic:

Acute cough: Lasts less than 3 weeks and is often caused by a cold, flu, or other viral infection. It can also be caused by allergies, sinusitis, or exposure to irritants like smoke or dust.

Subacute cough: Lasts between 3 and 8 weeks, and is sometimes a lingering symptom after a respiratory infection.

Chronic cough: Lasts more than 8 weeks and can be caused by a variety of factors, such as chronic respiratory conditions (e.g., asthma, COPD, bronchitis), gastroesophageal reflux disease (GERD), or medications (e.g., ACE inhibitors).

Some signs that your cough may be more serious and warrant a visit to a healthcare professional include:

Shortness of breath or difficulty breathing

Chest pain or discomfort

Coughing up blood or bloody mucus

High fever (greater than 100.4°F or 38°C)

Persistent or worsening cough despite treatment

Wheezing or a whistling sound while breathing

Unintended weight loss

Night sweats

Swollen lymph nodes

If you're experiencing any of these symptoms or are concerned about your cough, it's important to consult with a healthcare professional for proper evaluation and treatment.

ST: I had a little bit of chest discomfort, but it just comes and goes. Can I wait for a few days? It's hard to see a doctor nowadays.

ChatGPT 4.0: I understand that seeing a doctor can be challenging, but I am not a healthcare professional and cannot provide medical advice. If you're experiencing chest discomfort, it's important to consult with a healthcare professional to determine the cause and appropriate course of action.

In the meantime, you can monitor your symptoms and take note of any changes or worsening. It may be helpful to consider the following questions when discussing your symptoms with a healthcare professional:

How long have you had the cough?

How severe is the chest discomfort?

Are there any specific triggers for the discomfort?

Are you experiencing any other symptoms, such as fever, shortness of breath, or coughing up mucus?

Have you recently been exposed to anyone with a respiratory illness or COVID-19?

Do you have any underlying health conditions or take any medications?

You may be able to consult with a healthcare professional through telemedicine or virtual appointments if in-person visits are difficult. Remember, it's essential to seek professional advice for any health concerns.

ST: 1) Only had the cough a couple of days 2) Discomfort's not too bad. 3) When I breathe in, the pain's a bit worse. 4) Not much other symptoms. Maybe just a little shortness of breath. 5) No exposure to anyone with respiratory illness or COVID-19 6) No, I'm pretty good.

ChatGPT 4.0: While I cannot provide medical advice, I can offer general information. A cough that has only been present for a couple of days and is accompanied by mild chest discomfort and shortness of breath could be due to a variety of factors, such as a common cold, allergies, or even muscle strain from the act of coughing itself.

It's important to monitor your symptoms and note any changes or worsening. If your symptoms persist or worsen, it's a good idea to consult a healthcare pro-

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fessional. They can provide a proper evaluation, diagnosis, and treatment recommendations based on your specific situation.

In the meantime, you may be able to find some relief by:

Staying well-hydrated by drinking water, warm tea, or clear broth. Using a humidifier or vaporizer to add moisture to the air.

Avoiding irritants like smoke, dust, and strong odors.

Sucking on throat lozenges or using over-the-counter cough suppressants (as directed).

Getting plenty of rest.

Remember to always consult with a healthcare professional for any health concerns and personalized advice.

ST: Is it ok for me to wait to see the doctor until next week? I've a serious meeting that I'm trying to prepare for.

ChatGPT 4.0: I am not a doctor and cannot provide medical advice, but I can offer general information. If your symptoms are mild and you're generally in good health, it might be reasonable to monitor your symptoms for a few days while you prepare for your meeting. However, if your symptoms worsen or you develop additional symptoms, it's important to prioritize your health and consult a healthcare professional.

Keep in mind that many healthcare providers offer telemedicine or virtual consultations, which may be more convenient for you during this busy time. It's always a good idea to err on the side of caution and seek professional advice if you're uncertain about your health.

Remember that I am not a healthcare professional, and this information should not replace the advice of a qualified medical provider.

Conflict of interest

The authors have declared no conflict of interest. References

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Obstetric care providers' perceptions of artificial intelligence (AI) in obstetric care in British Columbia

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Introduction

A rtificial intelligence (AI) is rapidly becoming an integral part of society, and its incorporation into various healthcare specialties is becoming increasingly apparent.^{1,2} In the realm of obstetric care, there is growing interest in harnessing the potential of AI to assist with ultrasound imaging, antenatal screening, disease prediction, and fetal monitoring during labour.^{3,7} Despite being crucial stakeholders, the perspectives of obstetric care providers regarding the incorporation of AI into their practices have received limited exploration. The objective of this study is to investigate obstetric care providers' perceptions surrounding the implementation of AI in obstetric care in British Columbia (BC).

Methods

This research employed a qualitative design that involved five semistructured interviews with 5 obstetric care providers, including a maternal-fetal medicine specialist, obstetrician, family doctor, labor and delivery nurse, and midwife. The study recieved REB approval and utilized convenience sampling and included respondents from both urban and rural areas of BC. Participants were identified through online clinics searches and recommendations from key informants such as hospital research coordinators. Respondents discussed their perspectives regarding the potential role of AI in obstetric care, factors for consideration when integrating AI into the work environment, and the plausible effects on patient care. All discussions were recorded, transcribed verbatim, and analyzed by two team members using thematic analysis with NVivo Version 1.6.2 software.

Results

The role of AI in obstetric care

NVivo analysis unveiled themes highlighting the importance of rigorous testing before implementation, the unique nature of obstetric care that pose challenges for AI incorporation and the role of AI in complementing rather than replacing the healthcare worker. Overall, most respondents felt that AI would not replace obstetric care providers, but rather serve as a supplementary tool in a hybrid human-AI model of care. Several participants believed that incorporating AI could alleviate the workload burden on healthcare staff and enhance the efficiency of healthcare delivery, most notably by expediting patient diagnosis and playing a supportive role to the obstetric care provider by interpreting fetal heart rate tracings, lab results, and ultrasound images. Many respondents emphasized that AI could prove to be particularly beneficial amidst the ongoing healthcare crisis in BC. For instance, one respondent

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Correspondence to Dr. Marianne Vidler (Marianne.Vidler@cw.bc.ca) mentioned, "You just have to watch the news these days. We have a crisis in manpower!" They stressed the urgency for healthcare workers to "harness the power of AI to make the bedside care [they] deliver more efficient."

Opinions among respondents varied regarding the extent and nature of the involvement of AI in obstetric clinical care. One participant expressed a strong belief in the potential for AI to significantly enhance the consistency of care delivered by minimizing errors compared to human doctors. They asserted that AI, with its ability to process numerous variables and learn continuously, would soon surpass humans in diagnostic skill. Conversely, another respondent raised concerns about AI potentially detracting from the human connection in obstetric care. They viewed AI as a "futuristic" and "daunting" technology that may not provide the same level of emotional support as human obstetric care providers, thus potentially depersonalizing healthcare. While the majority of participants expressed low confidence in the capability of AI to independently make obstetric care decisions, one respondent felt, "In the distant future, AI [will] do the vast majority of medical care diagnosis, auditing, and surgery," and stated, "A lot of medicine [could] be taken over by an algorithm".

Considerations prior to implementation

According to respondents, it is essential to ensure adequate technological evaluation prior to implementation. Some respondents noted that previous obstetric technologies, such as continuous fetal heart rate monitoring, had been introduced poorly in obstetrics because historically, "[Obstetrics] technologies are developed first and then we evaluate afterward." To avoid this occurring again, respondents felt that the introduction of AI into obstetric care needs to be done gradually and with the early involvement of healthcare workers and patient advocates. Additionally, in the absence of clear evidence on the usefulness of AI in obstetric care, respondents expressed apprehension towards its adoption. Specifically, respondents wanted proof of "cost-saving or efficiency-saving mechanisms," along with a thorough examination of the potential risks, benefits, and error rates of AI in obstetric care prior to its implementation.

Concerns regarding AI implementation

Concerns regarding the implementation of AI in obstetric care include cost, lengthy staff training, job security, technology overreliance, and data privacy. Some respondents expressed concerns about the complexities involved in developing AI programs that can effectively address the subtle intricacies of obstetric care. As one respondent pointed out, obstetric care encompasses numerous "shades of grey – it's very nuanced." They highlighted that when it comes to managing labour, they would not feel comfortable relying solely on AI, stating, "Every woman and family is different, and they have different feelings in terms of how their birth should go." Another respondent mentioned, "The human body doesn't always follow all the algorithms," highlighting the "art of medicine and sense of gestalt" obstetric care providers encompass cannot be provided through AI programs alone. Furthermore,

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respondents emphasized the importance of obstetric providers retaining their clinical expertise and intuition, underscoring their apprehension towards excessive reliance on technology.

Discussion

The study findings indicate that obstetric care providers in BC are generally receptive to the idea of incorporating AI into obstetric care, provided that its implementation is done gradually and backed by clear evidence of its usefulness and limitations. The respondents' apprehensions, ranging from cost implications to job security to technology over-reliance, underscore the need for a meticulous and thoughtful strategy for AI implementation. It is imperative that AI implementation ensures a well-defined plan for staff training that strikes the balance of equipping care providers without overwhelming them.

This research provides preliminary insights that can assist in designing strategies for integrating AI into obstetric practice in ways that are acceptable and meaningful to providers in BC. Limitations to this study include a small sample size, underscoring the need for further research to delve deeper into care providers' concerns regarding AI integration, including understanding optimal training strategies for staff.

Conflict of interest

The authors have no conflicts of interest to declare.

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Misinformation in social media: A review

Samantha Reeves¹, Alina Constantin² Citation: UBCMJ. 2023: 15.1 (11-13)

Abstract

Social media has revolutionized the accessibility and communication of medical information, but it has also become a breeding ground for medical misinformation. This review aims to provide a brief overview of the prevalence of medical misinformation on social media, along with consequences of misinformation, and strategies for combatting it. Medical misinformation is widespread on social media platforms, with some studies showing that up to 67% of analyzed content contains misinformation. Misinformation varies depending on the topic and social media platform. The acceptance of and spread of misinformation are dependent on both individual factors and the presentation of misinformation. The spread of misinformation on social media is also dependent on the algorithm each platform employs to recommend new content to users. The danger of misinformation was emphasized during the COVID-19 pandemic, with misinformation on the internet responsible for spreading panic, anxiety, and fear, perpetuating negative and overly optimistic attitudes towards vaccines, and influencing self-treatment decisions resulting in injury and death within the population. With the rise of artificial intelligence and the increased use of chatbots in medicine, there are concerns about the validity and accuracy of information being communicated which may lead users to unknowingly promote the spread of misinformation. Combatting medical misinformation on social media presents challenges due to low levels of health literacy in portions of the population and restricted public access to good quality scientific research. Recommendations to help medical professionals correct misinformation include the use of non-statistical messaging, the combination of text and images, and using videos when targeting individuals with lower health literacy. In conclusion, healthcare professionals should be aware of current trends of misinformation on social media and be prepared to educate patients using trustworthy corrections in an easy-to-understand format.

Introduction

Cince the start of social media in the early 2000s, it has become Ja valuable tool for both the communication and accessibility of medical information. Social media has led to increased awareness of different health conditions, a decrease in mental health stigma,¹ and has provided a place where patients with similar health struggles can connect and share experiences.² Social media allows for a large volume of information to reach a wide range of individuals. Unfortunately, much of the circulating information is not supported by scientific research.^{3,4} Medical information on social media platforms is often unregulated and disclaimers are rarely provided about false information, or unverified claims, which creates an environment that allows the dissemination of false information without consequence to the content creator.⁵ In this review, we will present a brief overview of the prevalence of false medical information on social media, negative consequences of misinformation during the COVID-19 pandemic, the potential for misinformation with the increasing use of artificial intelligence, and some strategies to combat misinformation.

Misinformation on social media platforms

There are two definitions when discussing incorrect information on social media: disinformation and misinformation. Disinformation is false information that is deliberately used to mislead whereas misinformation is false information that is shared without the intention of misleading.⁶⁷ For this review, both will be referred to as "misinformation" as the motivations behind perpetuating disinformation will not be discussed. When conducting research on social media platforms, difficulties arise due to the number of platforms and the changes in platform popularity over time, geographical location, and age demographics. Studies published later in the COVID-19 pandemic demonstrate this change

Correspondence to Samantha Reeves (srreeves@student.ubc.ca) in popularity by focusing on the video-sharing platform TikTok which surged in popularity during the initial lockdowns of 2020,^{1,8} whereas research published before 2021 did not typically include TikTok in their analysis even though the platform started in 2016. For this review, we decided to focus on research associated with the social media platforms of Meta (Facebook and Instagram), Twitter (prior to merge with X Corp.), YouTube, and TikTok.

Medical misinformation is found across every social media platform with one study showing 67% of the content analyzed contained only misinformation;⁹ however, its prevalence varies by medical topic and between platform. Another study assessing misinformation surrounding attention deficit hyperactive disorder on TikTok found that approximately 50% of analyzed videos contained at least one piece of misinformation.¹ A qualitative study compared the accuracy of information on urinary tract infections between YouTube and TikTok and found experts rated YouTube videos to be higher in scientific information, credibility, and lower in misinformation.⁸ Each of the above studies commented that most of the videos containing misinformation where uploaded by non-healthcare professionals.^{1,8,9} Despite the everchanging popularity of different social media platforms, the overall message remains the same: Medical content on social media is fraught with misinformation.

The belief in and spread of misinformation is dependent on individual characteristics (or personality) and the presentation of the misinformation, among other factors. Misinformation often gains more user engagement (through "likes", "comments", "saves" and "shares") than accurate information as it is designed to grab a viewer's attention through emotional content and misleading titles.^{7,10} The posture with which the misinformation is presented (positive tone vs negative tone) also plays a role in how widely misinformation disseminates. Although both positive and negative misinformation can be corrected, misinformation that is critical or holds a negative attitude is more likely to maintain its influence even after correction.¹¹ Individual factors, such as lower level of education,¹² a conservative political view,^{13,14} and being a self-identifying minority are correlated with the belief and spread of misinformation.¹⁴ An additional difficulty is presented when fake social media accounts (or "bots"), inauthentic accounts that imitate real people, become the main

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agency in the dissemination of misinformation.¹⁵ Moreover, repetitive exposure to misinformation increases its believability compared with information believability after a single exposure.⁷

The spreading of misinformation on social media is also dependent on the algorithm each platform employs to recommend new content to users. The two main types of algorithms are follower-based algorithms (such as Twitter or Instagram), or user-engagement-based algorithms (such as TikTok or YouTube). In follower-based algorithm, users often see content from accounts they "follow". In user-engagement-based algorithm, users primarily see content similar to previous content they have engaged with through likes, comments, and shares.¹⁶ Each platform has some combination of the two algorithms. Regardless of the algorithm, all users are at risk of creating echo chambers and filter bubbles.¹⁷⁻¹⁹ An echo chamber is the formation of a group of likeminded individuals with similar opinions, or beliefs that are reinforced through repetitive interactions with peers or sources of information.¹⁷ Social media platforms organized around social networks or "friends/ followers" (i.e., Facebook and Twitter) favor the development of echo chambers. Echo chambers can decrease the interaction between those with opposing viewpoints allowing users to be safe from having their opinion challenged and can contribute to polarizing or extreme viewpoints.¹⁸ Filter bubbles are created when users are exposed to a small selection of available information that fits the individual's pre-existing attitudes or beliefs.¹⁹ An example of filter bubbles occur in everyday life when individuals seek out like-minded friends. The downside of filter bubbles is the creation of polarizing and extreme viewpoints through the reinforcement of previously held views, which places the viewer at high risk of perpetuating misinformation.¹⁷

COVID-19 and misinformation

The danger of misinformation had been long known to healthcare professionals, but its effects were magnified during the COVID-19 pandemic. Throughout the pandemic, misinformation on the internet was responsible for spreading panic, anxiety, and fear,²⁰ perpetuating negative attitudes towards vaccines,^{4,14} and influencing self-treatment decisions, such as taking non-pharmaceutical chloroquine phosphate, resulting in injury and death within the general population.²¹ In the initial months of the pandemic, government communication was felt to be poor, contradictory, and hypocritical leaving individuals feeling confused and anxious.⁴ In this setting, one UK study asked participants about misinformation on social media and its influence on vaccine hesitancy.⁴ Participants commented how quickly stories were shared over social media and noted stories were shared faster if they were more controversial or more dramatic and emotive. With a lack of clear government messaging, misinformation thrived on social media resulting in an overwhelming amount of information available, thus leading to greater confusion. This misinformation lead to mistrust in government and health services and contributed to vaccine hesitancy among participants.⁴ A study from Lebanon assessing attitudes towards COVID-19 vaccines found a negative correlation between Facebook use and the belief of the safety and efficacy of COVID-19 vaccinations whereas Twitter use was associated with a better attitude toward vaccine uptake.²² A separate study looking into misinformation on social media in five countries showed on average 70% of people surveyed did not report misinformation to be reliable, however this number was higher in countries with lower numeracy rates.¹⁴ Factors that increase susceptibility to COVID-19 misinformation included

exposure to information from social media (compared to exposure to information through the World Health Organization), political conservatism, and being a self-identifying minority.¹⁴ Interestingly, older age was inversely associated with susceptibility to misinformation which differs from research done in politics where older age is associated with increased susceptibility to misinformation.¹⁴ All studies reviewed found that belief in misinformation about vaccines and the COVID-19 pandemic correlated with an increase rate of vaccine hesitancy among individuals.^{4,20,22}

Misinformation with artificial intelligence

With the rise of artificial intelligence (AI) in medicine and the increased use of AI chatbots, such as ChatGPT, concerns have been voiced in the scientific community around the potential for misinformation through the creation of "artificial hallucinations" and invalid research being cited.²³⁻²⁵ Artificial hallucination describe the situation where the AI generates a convincing response to a posed question, however the information is entirely fictious.²⁴ This issue has been described by both researchers and physicians who use AI in practice to summarize relevant literature on a clinical topic.^{24,26} If information generated by AI is not properly evaluated by the reader, artificial hallucinations can promote the spread of medical misinformation by presenting inaccurate information that appears reliable and correct. One study used AI to create an authentic-looking but a completely fraudulent medical article and subsequently had experts analyze the article for errors and inconsistencies.²⁵ Some mistakes identified in the AI generated article included: a smaller than expected number of references and shorter length of article when compared to similar articles; a lack of comment on the trends when discussing results; and inconsistencies in the citations, including citing non-existent sources.²⁵ Researchers found that experts were quick to point out inaccuracies on close inspection, particularly in the citations.²⁵ However, these inaccuracies and errors would not be so obvious to an untrained reader and may lead a non-expert reader to assume the information in the fraudulent article is correct.

As technology advances and improves, AI generated misinformation will continue to be an issue, especially with the dissemination of fictious information that appears accurate and reliable.²⁶ If AI is used as a replacement for fact checking or critical thinking, there is an increased risk of unknowingly perpetuating misinformation both in research and clinical settings.²⁴ However, as the use of artificial intelligence in medicine is an emerging phenomenon, more research is warranted when discussing the benefits and pitfalls of this tool.

Combating misinformation

The difficulty in combatting medical misinformation on social media lies not only in the dissemination of correct information but also in decreased public access to good quality scientific research and lower levels of health literacy in select populations.²⁷ Scientific findings are often communicated through dense, jargon-rich scientific articles geared toward expert audiences, making it difficult for the public to understand research results,²⁸ prompting more of the public to "do their own research" by looking for scientific facts themselves. The problem arises when the most accessible and most easily understood information may be deemed by experts to misrepresent, oversimplify, or overdramatize the reported scientific findings.^{28,29} Some solutions include journals themselves disseminating research findings through social media (increasing accessibility), collaborating with social media influencers to promote evidence-based health information to target audiences, and creating a space for dialogue between content creators and users.³⁰

Communication of health information presents challenges when addressing individuals with lower health literacy. Health literacy is described as the ability to use general literacy skills (reading, writing, numeracy etc.) to acquire, understand, and evaluate health-related information.³¹ Individuals with lower health literacy are less likely to trust information from health professionals, may struggle to identify higher quality information from lower quality information,³² and are more likely to obtain health information from lower quality resources like social media, television, friends, or celebrity endorsements.³² Medical professionals can help counter medical misinformation through engagement on social media in a professional capacity but often refrain from doing so to prevent blurring the lines between personal and professional boundaries.³⁰ However, the presence of healthcare professionals on social media has the potential to help reinforce public health policies or assist other experts in the communication of accurate medical information, especially if they obtain the celebrity-like status that can come with social media fame. Many healthcare providers, such as podiatrist, Dr. Dana Brems (@footdocdana on all platforms); emergency physician, Dr. Fayez (@lifeofadoctor on TikTok, YouTube and Facebook, and @doctorfayez on Instagram); and dermatologist, Dr. Muneeb Shah (@dermdoctor on TikTok and YouTube, and @doctorly on Instagram), have succeeded in engaging the public on multiple social media platforms by providing quality medical information to their millions of followers while being both entertaining and professional.

With the rise of medical misinformation on social media, recommendations have emerged to help correct misinformation including the use of non-statistical messaging,³³ the combination of text and images,³³ and using videos instead of text or pamphlets when targeting individuals with lower health literacy.³² When correcting misinformation on social media, Lewandowsky and colleagues proposed a simple formula of facts-myth-fallacy-facts: Start by presenting simple concrete, plausible facts; mention the myth or misinformation once after a disclaimer about the incorrect information; explain how the misinformation is misleading; end with reinforcing facts.^{7,29} This method allows for the repetition of accurate information and may help decrease the risk of "backfire effect," a phenomenon where even though corrected, misinformation is unintentionally reinforced through repetition.²⁹

Conclusion

Misinformation in social media is a long-standing issue, moreover, combatting misinformation on social platforms has proven to be a difficult fight to win. Medical misinformation is found on every social media platform, leading to anxiety, fear, negative attitudes toward vaccines, and poor patient outcomes, as highlighted during the height of the COVID-19 pandemic. Healthcare providers need to be aware of current trends of misinformation on social media so they can better educate patients. This includes the potential for misinformation that can arise from using artificial intelligence tools, such as ChatGPT. When confronted with misinformation, it is important for medical professionals to understand patient factors contributing to their belief in misinformation and provide trustworthy corrections in a format that is easiest for patient to understand.

Conflict of interest

The authors have no conflicts of interest to declare.

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REVIEW

Artificial intelligence from classroom to clinic: Where is the starting point?

S. Aryan Ghaffarizadeh¹, Nikola Pupic¹, Caroline Kim¹, Rohit Singla¹ Citation: UBCMJ. 2023: 15.1 (15-16)

Abstract

Artificial intelligence (AI) has enormous potential to revolutionize medicine by assisting clinicians in diagnosis, treatment, and clinical management. Despite this potential, the lack of AI education in medical curricula has left many healthcare providers unprepared to answer questions about AI implementation and to leverage its benefits in their practices. While there are concerns about the impact of AI on healthcare, there is also a strong eagerness among medical students to learn about it. Students believe that curricular integration of AI education is the most effective method for incorporating it into medical education. To bridge this gap, medical schools should introduce AI early in the curriculum and progressively build upon it. Additionally, incorporating concepts such as understanding AI strengths and weaknesses, recognizing different forms of AI and their purposes, and comprehending the functioning and design of AI algorithms will empower clinicians to evaluate and implement AI tools in their practice. By adopting these recommendations, medical schools can play a crucial role in fostering a new cohort of healthcare providers who are adept at harnessing the power of AI to elevate patient care and transform healthcare outcomes.

A rtificial intelligence (AI) has the potential to revolutionize the field of medicine by assisting physicians in diagnosis, treatment, and clinical management. AI has already been used to improve medical imaging, make treatment recommendations, and detect decompensation risk among patients.¹⁻⁴ Correspondingly, the use of AI in medicine has been increasing in recent years, with the market for AI in healthcare growing by 40% in the U.S. from 2014-2021,⁵ and there are no expectations for this growth to slow.⁶ Therefore, we believe that an AI curriculum in undergraduate medical education (UGME) should be incorporated to prepare students to use and interpret AI tools in practice. This commentary will delve into the perspectives held by the academic medicine community regarding the incorporation of AI in existing UGME curricula and will identify the crucial areas of AI that healthcare providers must acquaint themselves with.

AI has already been used to make algorithms widely used in practice, such as the PECARN head trauma rule which helps physicians determine which children may not need CT scans after traumatic brain injury.¹ AI's ability to analyze large amounts of data has been leveraged in clinical settings, such as assisting physicians in referring certain patients to palliative care instead of prescribing aggressive treatments,² showing potential to provide personalized treatment recommendations. AI has also improved the accuracy of a wide range of medical procedures, from point-of-care ultrasound exams ³ to decompensation risk identification in general internal medicine wards.⁴ Although concerns regarding data security and privacy limit the widespread implementation of AI in medicine today, the proven benefits of AI suggest that it will be incorporated in many aspects of medicine.^{5,6}

The integration of AI in medicine brings out both concerns and excitement from the academic medicine community. Currently, few UGME programs have any sort of AI education implemented in their curricula, and those that do, such as the University of Toronto, have only one lecture dedicated to the topic, with one multiple choice question on their exam.⁷ In a recent survey of 128 medical students from 48 countries, 94% of respondents believed that AI would improve medicine

Correspondence to S. Aryan Ghaffarizadeh (sghaff01@student.ubc.ca) and 90% anticipated its use within their work within the next decade.⁸ These findings are significant as they show that medical students are aware of the trend toward digitization of medicine. Furthermore, 95% of students expressed a desire to learn about the basic principles of AI, with 92% stating that the best way to teach AI would be to include it in the core medical curriculum.8 This was supported by Reeder and Lee9 who surveyed 463 medical students from 32 medical schools in the United States, and Teng et al.¹⁰ who surveyed 2167 students across 10 healthcare fields from 18 universities. Considering the large sample size of respondents from various countries, schools, and disciplines, the generalizability of these responses is high. On the other hand, Ejaz et al.8 found that 43% of students expressed worry about harmful impacts of AI in medicine, such as unintentionally worsening health outcomes in underrepresented populations due to data bias. Taken together, these survey findings highlight the eagerness of students to learn about AI and emphasize student interest in integrating AI education in the UGME curriculum. However, education should prioritize addressing student concerns, potentially through teaching how to critically appraise AI tools.

Although data show that students want formal training in AI in medical school, there exist limitations to formal curriculum changes. UGME curricula across schools and countries are already dense and students across different countries have identified their studies as being a significant source of high rates of stress, fatigue, and burn-out.11 Moreover, most Canadian medical students have a poor understanding of AI,¹⁰ so the incorporation of AI in formal education could overwhelm medical students and add to already high levels of stress. Incorporating AI in UGME curriculum at this stage could also disadvantage universities that lack the resources and faculty required to develop and execute a well-formulated AI curriculum. This could lead to differences in educational outcomes across universities, giving some students an advantage in AI familiarity. Finally, AI in medicine is an evolving landscape, and arguments could be made that AI tools will not be similar in just a few years in the future. Thus, incorporating AI in UGME may prove to have limited utility for future physicians.

In our analysis of current AI education within UGME programs, we observe that its integration is nascent and the scope of its implementation is severely limited. For instance, at the University of Toronto, the extent of AI education is minimal, with only a single lecture followed by one multiple-choice question on the topic.⁷ This approach

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represents the very beginning of incorporating AI into the medical curriculum. Similarly, at UBC, while there are discussions about using advanced tools like ChatGPT in the FLEX program, these do not constitute a comprehensive AI education.⁷ The curriculum lacks explicit AI competencies and principles in its core objectives, exemplifying the field's initial stages of integrating AI into medical education.⁷ This scenario underscores the urgent need for a more structured and in-depth incorporation of AI education, reflecting the rapidly evolving nature of the field.

Although the above limitations are valid, we believe that fundamental concepts concerning AI should be taught early in medical education to ensure future clinicians are comfortable evaluating AI and determining their suitability for implementation in their practice. It can be argued that medicine is a field that constantly evolves, and the purpose of medical school is to build students' knowledge and skill sets that will be further refined in residency.¹² There should be a focus on teaching concepts that are generalizable to the developing field of AI to ensure that medical students can apply their education even if the AI tools they use in practice are unfamiliar. Such concepts include data analytics to understand the risk of bias, algorithm selection to understand appropriate algorithm usage based on input data and desired outcomes, and the importance of training, testing, and validating models to ensure their generalizability. Understanding the basics of AI could also help students feel more confident approaching AI tools and guide them towards critical appraisal of available AI tools.

In conclusion, integrating AI education into undergraduate medical education is crucial to equip future clinicians with the knowledge and skills necessary to navigate the evolving landscape of healthcare. By addressing the barriers to AI adoption, such as regulatory, economic, and organizational culture factors, medical schools can ensure that their graduates are well-prepared to leverage AI tools effectively and responsibly. Potential limitations for curricular implementation are university resources, availability of credible faculty, and student hesitation of an unfamiliar topic in their curriculum. Such limitations could be mitigated by collaboration within university departments, across universities, and progressive reinforcement and development of basic concepts of AI throughout medical school. AIrelated competencies that are important for medical students to know include understanding the principles and limitations of machine learning algorithms used in healthcare, as well as being able to critically evaluate and interpret AI-driven diagnostic tools to ensure patient safety and effective clinical decision-making. Additionally, medical students should also develop an awareness of ethical considerations and privacy concerns surrounding the use of AI in healthcare. Though the current undergraduate medical curricula are dense and difficult to change, adopting AI into formal curriculum can ensure that medical schools play a crucial role in fostering clinicians who are adept at safely harnessing the power of AI to elevate patient care and transform healthcare outcomes.

Conflict of interest

The authors have no conflicts of interest to declare.

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Artificial intelligence in neuropathology and neurology: Could AI antiquate the microscope?

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Abstract

Neuropathology is a diagnostic medical subspecialty dealing with diseases of the central nervous system and often relies on complex, labour-intensive techniques. With advancements in artificial intelligence (AI), algorithms may have the potential to yield more accurate and standardized diagnoses. Such tools may also provide further detail and subclassification, although the relevance of this for day-to-day clinical decision making is unknown. Logistical and practical hurdles, and the untested hypothesis of whether AI indeed provides clinically actionable advantages, have kept AI from being integrated into common practice. This commentary incorporates two differing perspectives from distinguished neuropathologists at Vancouver General Hospital to discuss the timely topic.

A conversation among neuropathologists

To comprehensively discuss this contentious topic, we interviewed two neuropathologists with differing stances on the utility of artificial intelligence (AI) in the field. Here, Dr. Stephen Yip, Consultant Neuropathologist at Vancouver General Hospital (VGH) and Medical Director of the Cancer Genetics and Genomics Laboratory of the BC Cancer Agency, and Dr. Veronica Hirsch-Reinshagen, Consultant Neuropathologist at VGH and Assistant Professor at the University of British Columbia, discuss their perspectives on the use of AI in neuropathological practice.

Introduction to the field of neuropathology

Neuropathology is a clinical specialty that focuses on the diseases of the brain and spinal cord.¹ The field saw its origins in the early 1800s when Jean-Martin Charcot contributed to a paradigm shift in medicine whereby the clinical presentation of many neurological diseases became associated with their counterpart pathology in tissues both at the naked-eye level as well as under the microscope.² As the technology of the microscope advanced further, so too did the ideology of staining techniques. Built largely upon Golgi and Cajal's Nobel Prize-winning work in 1906, an entire cellular landscape became unmasked, brimming with analytical potential. With these staining techniques, Alois Alzheimer identified the pathology underlying a dementia which later acquired his name.² Modern pathological analysis of the nervous system relies on methods stemming from these early discoveries, complemented with more recent immunohistochemical and genetic methods.

Artificial intelligence

The term AI was coined in the 1950s by McCarthy et al.,³ and refers to a computer science whereby a machine is taught to extrapolate from a training algorithm and make future predictions to recapitulate the thought patterns of humans. Within AI falls the field of machine learning, of which deep learning is a further subset. Machine learning was established in the 1980s and pertains to multi-layered and hierarchical artificial representations of neural networks.⁴

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For neuropathological diagnosis

Histopathology, the microscopic analysis of tissue sections, has historically been the gold standard for the study and diagnosis of most neurological and neuro-oncological disorders, with advancements in neuroimaging and molecular genetics now also playing an important role.⁵ Because these techniques are labour-, skill-, and time-intensive when conducted by individual physicians, AI could provide an opportunity to enhance diagnostic practices.

In cancers of the brain, microscopic tissue analysis of the infiltrating mass is often paramount for diagnosis, prognostication, and treatment selection. Because this clinical diagnostic tool is more nuanced and subjective than a quantitative blood marker, for example, different diagnostic interpretations (and potentially prognosis estimates) may result from different pathologists, especially in difficult cases. It has been argued that machine learning may provide a way to standardize this and improve diagnostic accuracy.⁶

A 2018 study by Capper et al. compared the diagnostic capacities of a machine learning algorithm to those of trained pathologists by training the computer using a data set of physician-classified tumours for comparison.⁷ Based on methylation patterns, the computer classified tumours into pre-existing or computer-generated categories according to established and novel patterns. They found that although it was unable to diagnose all of those classified, the algorithm yielded more accurate diagnoses, and could subclassify the tumour characteristics further than pathologists.⁷ AI performance in the diagnosis and management of gliomas was deemed acceptable in another study.⁸ These results are certainly promising, but authors still maintain the difficulties in rendering such methods commonplace and advocate for continued use of traditional histopathological examination.^{6,8}

Yip describes the benefits of AI in this context centred around accuracy, efficiency, standardization, and the potential to augment existing clinical expertise.

Hirsch-Reinshagen acknowledges the utility of AI in the field but anticipates it will have more of an adjunct role alongside neuropathologists and other healthcare professionals. She still believes that a neuropathologist can give a primary diagnosis on a slide much faster than AI, and although AI may allow us to classify tumours further than the human eye, she questions the clinical utility of such subclassifications given the limited available treatments. That is, treatments between such subclassifications may be identical, in which case this further AI-specific diagnostic step would not be clinically meaningful.

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For research and personalized medicine purposes

Further, AI may be useful in identifying novel biomarkers for neurological disorders. Through large-scale analysis of medical images, genomic data, and clinical records, AI has the capacity to detect previously unrecognized characteristic patterns.^{9,10} Indeed, peripheral d-glutamate levels have been associated with Alzheimer's disease (AD) detection through machine learning algorithms,¹¹ and a 2021 study published in Nature showed that multiple sclerosis clinical phenotypes may be stratified by MRI.¹² From this, the authors demonstrated that patient disability progression and treatment response could be subsequently predicted, which would better establish individual prognoses as well as inform best practices for subject groupings in future clinical trials.¹²

Yip describes a multitude of roles for AI in both clinical and research realms. In the clinical context, he suggests AI can help to support decision making and aid in creating differential diagnoses, optimize workflow through algorithms, and analyze large datasets to identify prognostic factors and potentially predict patient treatment responses. AI can leverage data analysis, pattern recognition, and machine learning for personalized medicine applications. Remote monitoring devices may further allow for the supervision of various applicable metrics, depending on context, such as activity levels, vital signs, and medication adherence. AI may also allow the analysis of genomic profiles, clinical data, and treatment responses, and identify most effective treatment options based on the patient's unique genetic makeup, pre-existing conditions, and characteristics. It may also aid in pattern and biomarker recognition by analyzing large datasets, which will help to further cater treatments to unique patient profiles, Yip offers.

Hirsch-Reinshagen, however, is unsure about the parameters under which we would utilize AI for this purpose. She thinks that eventually this would prove immensely powerful, but that the research and subclassification-specific treatment options are just not advanced enough yet. Hirsch-Reinshagen says, "Eventually I see AI applying algorithms where you can input demographics, past medical history, genetics and diagnosis, and the system outputs a treatment plan. But at this point how much treatment plans differ from one another is an unanswered question." That said, Hirsch-Reinshagen agrees there are certainly research questions currently being asked regarding molecular and genetic changes in tumours we would not be able to answer without AI. Yip also adds that AI has the potential to bridge the research and clinical domains by translating research findings into clinical applications and generating novel research hypotheses based on clinical data.

For example, deep learning methods have been developed for modeling polygenic risk in AD—that is, the disease risk is not solely attributable to one gene—using high-dimensional genomic data and neural networks.¹³ Deep learning not only outperformed other statistical methods for modeling risk of AD, but also evaluated potential differential pathological processes at play between patients,¹³ opening doors in personalized patient care for a neurodegenerative disorder without many currently available treatment options.¹⁴ Although this is an attractive sentiment, Hirsch-Reinshagen argues that with the status of the current knowledge base in neuropathology, such personalization may not be appreciably different. Focusing AI into the research corridor would be far more useful, and perhaps in turn lend itself to meaningful clinical developments down the line. analysis is the generalizability of such algorithms to the widespread array of tissue sections in routine clinical practice.¹⁵ Variability can stem not just from the samples themselves, but from staining techniques, scanner heterogeneity, and other upstream methods in acquiring the sections. Multi-layered complexity in the tissue acquisition to analysis pipeline make a systematic AI overhaul challenging.

Difficulties in implementing such largescale processes also include the considerable amount of high-quality data required for computer training purposes, ethics involving privacy and potential biases, and regulation of such practices.⁶ Ethicists are cautious of the broader societal and interpersonal ramifications of such novel technology,¹⁶ and experts believe that, at least in the context of radiology, AI will not *replace* specialists *per se*, but that those who utilize it are at a significant advantage.¹⁷ Some experts attribute the overwhelming presence of AI in the media and literature to the "Gartner Hype Cycle",¹⁸ a model which describes every new technology following five stages of evolution in society. Mainly, it states that, "...society tends to overestimate the potential effect of a new technology initially and underestimate the effect in the long run."¹⁷ This is mirrored by the fact that we have yet to see a routine integration of AI into clinical practice.

Both neuropathologists interviewed here agree that AI is unlikely to ever fully replace the physician's role. There are many unknown factors that must be evaluated: For example, what is the underlying environmental impact of implementing AI into routine practice? How does it compare to a neuropathologist looking down the microscope for a few minutes to render a clinically actionable diagnosis? Neuropathologists possess extensive training, expertise and knowledge, and an overall contextual understanding that vastly outweighs AIgenerated data analysis which often occurs in a vacuum. They also must consider ethical and legal aspects of patient care, which is challenging to wholly integrate into an AI algorithm. AI models are also trained on specific datasets and are limited in their capacity for generalization: Novel cases or evolving knowledge are challenging to incorporate into their infrastructure.

We have a limited amount of information at our disposal and tumours that are only slightly histologically different, a discrimination that may only be made possible by AI, may behave the same. Hirsch-Reinshagen likens it to the advent of immunohistochemistry, which she says, "did not replace our bread-and-butter hematoxylin and eosin stain." Despite the many firm stances in favour of or fundamentally against AI, used appropriately, the technology is a valuable tool in the field of neuropathology. Guidelines for clinical trials involving the use of AI have been published,¹⁹ and writings contextualizing such technological advancements are emerging.^{20,21} Its current contention aside, AI seems to be, above all, an opportunity to augment existing clinical systems in the field of neuropathology for better patient outcomes.

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Conflict of interest

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Examining workforce preferences to retain rural and remote physicians: Post-pandemic considerations

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Abstract

Before the COVID-19 pandemic, researchers identified factors that influence physician practice in rural and remote locations. This body of research continues to be important in informing ongoing physician shortages in rural and remote communities across Canada. However, the pandemic appears to have changed physician workforce preferences, especially among those who shifted to telemedicine. This commentary discusses the investigation of post-pandemic workforce preferences among rural and remote physicians as a contemporary research priority and offers initial research directions for this work.

Introduction

The COVID-19 pandemic has left a mark on the global workforce. Post-pandemic employees continue to exhibit pandemic workforce preferences including increased scheduling flexibility, reduced work hours, and work from home policies.¹ Considering these changes in workforce preferences across many sectors, most notably in finance and technology, it is worth exploring whether physicians' preferences have changed similarly.¹⁻² However, little research has been done to explore this professional group's preferences post-pandemic.³

In rural and remote settings, where there have been persistent challenges in recruiting and retaining physicians, research on physician workforce preferences may be of particular importance.⁴⁵ These challenges are well-documented: For example, from 2005 to 2020 the total percentage of physicians serving rural and remote communities in Canada decreased from 9.3% to 7.6%, which falls short of the 17.8 % of the nation's population residing there.⁴⁶⁻⁷ Canadian physician shortages have also been linked to decreased access to healthcare, poor continuity of care, and adverse health outcomes for rural residents.⁸

Although a wealth of pre-pandemic studies on the factors that incline physicians towards rural and remote practice exist, these factors are complex, and comprehending the next steps for resolution can be difficult.⁹ As other industries have found implementing the findings of research on workforce preference has improved recruitment and retention, we contend that to adequately address rural and remote physician shortages, any changes to workforce preferences must be understood.¹⁰ An additional understanding of physician workforce preferences could inform future policy and program implementation in these regions.

Previous literature on the rural and remote physician workforce

Understanding how to recruit and retain physicians in rural regions as an attempt to rectify shortages has become a well-established field of research in the last two decades.⁹ From this research, a robust list of factors that influence physicians practicing in rural and remote communities has been created, largely classified as either 'personal', such as spousal employment, age, and rural upbringing, or 'professional' such as legislation, scope of practice, and training.⁹ Despite this volume of evidence, knowledge gaps and challenges in retaining rural and remote physicians persist. For instance, there is no consensus on the most influential or important factors in this field. A review of systematic reviews hypothesized that the absence of a dominant influencing factor was from the complex, interrelated nature of factors.⁹ Another study suggested that the influence of factors changes over a physician's career and the importance of factors may shift with significant life events.⁵ Perhaps, as no one influencing factor has been explanatory for systemic physician shortages in rural and remote Canada, research of workforce preferences amongst physicians could be an important adjunct to this previous work.^{9,11}

Rural and remote physician preferences have likely changed post-pandemic, due to evidence reporting massive upheaval in their workplace routine during the pandemic.¹² One Canadian study reported that rural physicians experienced widespread cancellation of clinic appointments and a shift to virtual or acute care settings during the first waves of COVID-19.¹² Changes in work-life balance and professional roles were also reported throughout the pandemic, which may have left rural and remote physicians open to new ways of practicing medicine in the future.¹² Most notably, a decline in mental health saw rural and remote physicians seek to decrease their workload and outsource administrational duties.¹² Considering how these 'pandemic-induced' changes translate into long-term workforce preferences will be helpful for rural health human resource planning.

Directions for future research

Based on our review of existing literature, the following thematic areas are posed as valuable directions for further research on physician workforce preferences.

Telehealth

From the limited research conducted on physician workforce preferences post-pandemic, telemedicine has already emerged as a prominent topic.^{3,13} In conducting virtual clinical visits, physicians now have the option for the first time to work from home and create additional flexibility in their schedules, yet questions remain about how these preferences translate into clinical work.¹²⁻¹³ For example, it is important to understand what physicians' preferred formats are for remote visits (telephone, video, secure texting), what resources are available to implement virtual care, and what concerns should be explored regarding the decision-making process for virtual versus inperson visits. In the context of rural and remote communities, there appears to be no post-pandemic analysis of physician preferences for telemedicine. Such an analysis may be important when considering

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physicians who prefer to live in urban centres with occasional locums to rural communities and physicians who seek relief from full-time remote practice.¹³

The rural and remote population surge

During the COVID-19 pandemic, masses of urban dwellers relocated into rural and remote regions of Canada, a movement now termed the 'pandemic migration.^{7,14-15} Though some of those who moved rurally during the pandemic have returned to urban living since, a majority are thought to have remained and the trend is suspected to continue.¹⁴ Statistics support this sentiment, revealing Canada had the fastest growing rural population between 2016 and 2021 among G7 developed nations.⁷ Considering this recent revitalization in Canada's rural and remote populations, future research on physician preferences could seek to understand what has been the impact of changing rural and remote populations upon both longstanding and new physicians, who may have also participated in the pandemic migration, to these regions.

Learning from other nations

The workforce preferences of healthcare professionals in other nations are also just beginning to be assessed post-pandemic. Perhaps there may be something to glean from international jurisdictions on comprehending and managing new healthcare workforce preferences post-pandemic. Just as the global community learned from one another to slow the transmission of COVID-19 during the pandemic, there may be value in examining trends of the post-pandemic workforce amongst other nations.¹⁶ National studies and quality improvement programs may be especially telling for post pandemic differences in the rural and urban physician workforces. For Italy, the national leadership has chosen to examine the country's entire healthcare workforce with the hopes of holistically redesigning the larger healthcare system.¹⁷ Meanwhile, Brazil noted professional inequities were exacerbated during the COVID-19 pandemic and hopes to approach understanding their physician workforce as a singular professional group.¹⁸ Rural and remote areas are not homogenous globally, but hints of what to focus our attention on in rural and remote regions of Canada could be imparted from these international studies.7

Researching workforce preferences alongside burnout

The COVID-19 pandemic and the healthcare workforce must be discussed within the larger context of professional burnout. Studies during and after the pandemic revealed that although a pre-existing phenomenon, burnout has increased across all healthcare professions due to COVID-19 and contributed to heightened staffing shortages post-pandemic.¹⁹⁻²⁰ Similarly, physician burnout has been linked to decreased patient safety, patient satisfaction, and quality of care.²⁰

We suggest there is value in examining workforce preferences as an antecedent to addressing burnout. Although physician burnout increased during the COVID-19 pandemic, reported rates of professional burnout were significantly lower among physicians than other professional groups, such as nursing.²⁰ Examining physician preferences may offer insights about burnout specifically related to physician work. Likewise, burnout studies have been used in the past as a proxy for mental health and well-being among workers.²⁰⁻²¹ Since unmet workforce preferences can also harm an employee's mental health by triggering a disorder, one can conclude that studying burnout alone is not enough to understand

the complex interrelationship between work and mental health.²² Finally, in literature exploring how to rebuild health systems after the pandemic, researchers considered workforce preferences an important component of determining system resilience.²¹ Despite these strong reasons to investigate workforce preferences alongside burnout there is limited literature in this area of medicine.¹²

Conclusion

In general, we believe there is both space and need in the academic landscape for understanding rural and remote physicians' workforce preferences post-pandemic. Our hope is this commentary will spark meaningful discussion and prompt a new research 'take' on an already well-established but complex topic in Canada among both practicing clinicians and academics. The persistent global nature of physician shortages in rural and remote areas creates only greater significance and urgency for this work.¹¹

For the future physician workforce of rural and remote Canada, we imagine understanding post-pandemic workforce preferences among rural physicians may be especially helpful for educators. Recruiting preceptors, designing curricula, and selecting trainees with characteristics that align with the contemporary field of rural medicine may be meaningful in obtaining adequate medical coverage in these regions during the years to come. With the first two authors just beginning their medical education, we feel a vested interest in this topic. Currently, limited work has been undertaken but we intend to pursue this line of inquiry in the future and welcome correspondence on this commentary, which will serve as a starting point for forthcoming projects.

Conflict of interest

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