Preparing for the future of medicine: Considering the need for data-literate physicians

The revolution is here: Artificial intelligence and machine learning are being applied to medicine, though there are considerable challenges ahead.

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ABSTRACT: Artificial intelligence will undoubtedly change the landscape of medical practice and give rise to new possibilities for patient care. Today's physicians are in a unique position to lead this era of technological integration and innovation. Large amounts of patient data currently being collected will be leveraged to provide clinical insight into personalized health care on a global scale. However, there remain many barriers to wide-scale implementation of artificial intelligence tools, including our historic practices of collecting and documenting patient data, as well as the organization of our health care system. Furthermore, a lack of training has physicians underprepared to reap the full potential of these tools and safeguard against adverse consequences for patient care. Given the exciting opportunities for the use of artificial intelligence in medicine, ways to overcome associated challenges must be found.

In 2014 the BC Ministry of Health's report, "Setting Priorities for the BC Health System," outlined information management and technology as one of seven strategies to enable efforts toward creating health system change. One subcomponent of this strategy is to build BC's "informatics capacity to use data to enhance decision making and improve outcomes at all levels of the system."[1,2] Thus far, the medical community has started to adopt digitization of health information in practice to better collect, communicate, and store medical data.[3] In 2016, the Canadian Medical Association (CMA) reported that 75% of general practitioners use electronic medical records (EMRs) to enter or retrieve patient notes, an increase from 26% in 2007.[4] More recently, the role of artificial intelligence (AI) in medicine has surfaced.[5] AI is a field that involves computers using data to simulate human cognition, including our ability to reason, discover meaning, generalize, and learn from experiences in order to make informed decisions.[3] As we move into the intelligence age of medicine, physicians will have to adapt in order to harness the true potential and benefits of AI for patients.

Ms Mangalji is a third-year UBC medical student who enjoys exploring how the current practice of medicine could be enhanced, specifically the technologies entering medical practice in rural and remote areas to allow for improved access to quality health care. She hopes this article will spark discussion about how a practitioner's scope could include data-literacy. Mr Karthikeyan is a third-year UBC medical student interested in the intersection of technology and medicine. During the foundational years of his medical studies, he sought out opportunities to engage in machine learning research. He is excited about the prospective roles that machine learning and artificial intelligence could play in augmenting physicians' practices. He hopes to contribute to efforts to foster a community of data-literate physicians equipped to leverage technology to improve patient outcomes and care.

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Benefits of AI integration in medicine

Machine learning (ML), a subfield of AI, has recently received attention for its potential impact on medical practice. ML employs algorithms that can learn patterns from large data sets without being explicitly programmed, and can be equipped with self-correcting tools to improve accuracy with exposure to new data.[6] For example, ML is widely used by online retailers to identify additional products a shopper may be interested in based on their previous purchases.[6] In medicine, ML maps structured data, in the form of patient input variables (e.g., imaging, genetic markers, laboratory results, a patient's age, gender, symptoms, or medications) to an output (outcome of interest), providing a pattern that can be used to make predictions in future cases. To understand how this is playing out in practice to enhance personalized medicine,[7] we look at a few applications of AI in relation to breast cancer.

Genetics

In 2007, the FDA approved MammaPrint, which uses the weighted average of 70 measured genes in patients with early-stage breast cancer to predict 10-year recurrence risk. It is being used clinically by oncologists to select patients for adjuvant chemotherapy treatment.[8]

Imaging

In 2018, the FDA approved Transpara, which identifies soft tissue and calcification lesions on mammograms to generate a cancer suspiciousness score. It is being used clinically to improve the decision-making accuracy of radiologists while reading scans.[9]

Clinical

IBM's Watson for Oncology accesses over 300 medical journals and textbooks to "read" updated literature, guidelines, over 550 breast cancer cases, as well as patient characteristics, medical history, imaging, and laboratory findings to develop patient-specific breast cancer treatment recommendations. It suggests multiple options for each patient.[10]

ML has the potential to significantly assist physicians in proactive decision making. While AI is predicted to first be incorporated into fields that favor structured data such as radiology, dermatology, and pathology, it is relevant to numerous clinical specialties.[11] Not only can it augment clinical decision making, it can also help with logistic operations, clinic performance analysis, continuing education, professional development, and population health.[4] Furthermore, the use of natural language processing is another subcomponent of AI that deals with transforming unstructured data in the form of clinical notes, patient interviews, or medical journals into structured data that can be analyzed by ML, heightening the utility in qualitative aspects of medicine.[12] In order to harness the utility of AI in physicians' day-to-day practices, barriers to integration must first be addressed, and physicians must be taught how to evaluate and use such tools.

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Challenges of AI integration in medicine

Data availability

The successful integration of AI into medicine will depend largely on the quantity and quality of accessible electronic data. The data are required to train and test ML models, whether diagnostic, treatment, or administrative. The current structure of the health care system makes obtaining this data challenging. The required data are currently stored in isolated data silos used by pharmacies, laboratories, hospitals, clinics, administrative systems, and others. The data need to be collated before they can be used for ML purposes.[13] Furthermore, while the use of EMRs may be widespread among primary care physicians, the use of electronic health records (EHRs) in hospitals remains limited, although it is underway. Barriers to data access are compounded by privacy and security issues related to patient data sharing between health authorities.[13] In 2016, the CMA reported that due to the structure of the system, harnessing the utility of big data analytic opportunities may be restricted to primary care for now.[4] The exchange of data between computer systems and health records is vastly complex, and there is currently no simple, economical way to achieve it.[14] Despite these challenges, there are multiple interoperability plans in the works in BC and nationally, offering an optimistic future.[15,16]

Data quality

When training ML algorithms, patient variables (e.g., age, sex, vitals, and lab results) must be available and represented in a standardized format to allow for aggregation of data sets. Furthermore, these predictor variables should be low cost and commonly collected by physicians.[6] However, the variability in recording and formatting data poses a challenge to its use in ML. Patient data are often reported using common clinical terms rather than standardized vocabulary. The nature of medical notes adds another complication as many components lack mathematical characterization.[13] Without a foundation of vast amounts of high-quality data, ML models can perform poorly.

There are also important considerations regarding ethical challenges, such as the mirroring of human biases in decision making. The application of ML algorithms outside the health care setting has highlighted some of these concerns, including a propensity for racial discrimination. Similar biases may also enter medicine. For instance, if algorithms are trained only on data from certain populations, they may be prone to conclude false generalizations to other groups.[6,17,18] Poor representation of populations has been a long-standing issue in the academic community. For example, the Framingham Heart Study poorly predicts the risk of cardiovascular events in non-white populations due to sampling bias.[19] Thus, it is paramount to establish measures to minimize these biases from affecting ML models through early critical evaluation of methodological practices, preventing exacerbation of the disparities that currently plague the medical community. Physicians must advocate for their patients by being at the forefront to ensure that core ethical principles are preserved in the development of ML tools.

To augment this process, one suggestion is that data warehouses be built before the data are used. This way, the data can be reused by multiple researchers or developers for a variety of purposes and the collecting and cleaning process does not need to be repeated.[13] In addition, having physicians equipped with skills to critically evaluate, develop, and deploy such models will help inform appropriate use.

The future physician's role

As the role of ML in medicine expands, physicians practising clinical medicine will need to evolve.[17] With the help of ML, physicians will be able to leverage greater amounts of information from the biological, psychological, and social aspects of patients' lives to further augment personalized patient care. To make this possible, continuous, detailed, and affordable monitoring of patients will contribute to big data sets.[3] However, it is of the utmost importance that physicians have a baseline understanding of the tools they are using. They will have to become

familiar with the legal implications of these new tools, as they protect the privacy and security of their patients.

Many argue that medical education must begin to incorporate some of these topics. Despite medical curriculums being time-constrained, it may be necessary to alter teaching strategies and incorporate concepts that are going to revolutionize the field. It may be unrealistic for medical students to become developers or data scientists, but we can begin to train future physicians to become data literate. Students should understand the concepts within ML and AI to critically appraise how data were aggregated and analyzed, and ensure they are appropriately applied.[3] Students should also be competent in navigating the terminology.[6] Furthermore, they should understand what it means to practise in a data-rich environment. One study suggests having a foundation of the four Vs of big data: volume of data being collected, variety of data being collected from different sources, velocity of data generation, and veracity of data (i.e., its quality).[3] In addition, understanding the output of ML algorithms and being able to interpret the prediction will help guide clinical decision making. Lastly, medical students will need to learn how to communicate the information to patients and their families.[20]

While curriculums begin to transform, alternate options such as accredited CME courses can be provided to begin educating current medical professionals.

The need for this shift in thinking is being recognized. For example, Boston University School of Medicine has an introductory ML course,[21] and Stanford University has an AI-assisted health care course available to their medical students.[22] While curriculums begin to transform, alternate options such as accredited CME courses can be provided to begin educating current medical professionals.

Conclusion

As we experience the transformation of the medical landscape through the integration of AI, many new possibilities arise. Physicians will play an important role in ensuring these new tools will maximize benefits to all health care stakeholders. However, we anticipate challenges that require system-level preparation. Data literacy will enable physicians to evaluate the role of these tools, optimize their use in patient care, and help to mitigate any pitfalls that may arise. This can potentially open the way for active participation in the research and development of AI-centred medical tools. This is an exciting revolution: we will be able to draw from the insight gathered from the culmination of billions of patients and their outcomes to inform the care of future patients. ■

Competing interests
None declared.

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