Editorial

Artificial intelligence in medicine and medical education

Rifat Hamoudi
Department of Clinical Sciences, College of Medicine, Sharjah Institute for Medical Research, University of Sharjah, Sharjah, United Arab Emirates

Medicine is a multidisciplinary subject that is continuously evolving as medical science advances resulting in new paradigms related to the diagnosis, prognosis, treatment, and patient management of various diseases generating big data consisting of a large number of measurements and clinical data in the process. With this evolution, there is a need to restructure medical education. As artificial intelligence (AI) begins to be used to mine the enormous amount of big data generated from various medical specialties to derive more accurate paradigms for disease models and improve clinical decision-making, there will be a need for a sophisticated computer–doctor interaction to enhance the practice of medicine. Therefore, medical professionals will need to be trained in the understanding of the applications of AI in both basic and clinical medicine including its advantages such as the ability to integrate data from different modalities to arrive at more accurate diagnoses and treatment of complex diseases in a cost-effective and expeditious manner, and its limitations such as the ethics behind the use of AI, transparency, and the inability to fully understand the complex algorithms that AI is built upon.

AI is a discipline in computer science that focuses on the development of algorithms and software that mimic human thought and decision-making. Due to the complexity of the human body and the various disease models, an enormous amount of data was generated in the past 20 years since the completion of the Human Genome Project.[1] Genomics data augmented data from other biomedical disciplines such as radiology, pathology, internal medicine, and surgery to produce more accurate diagnostic and therapeutic strategies for various diseases. AI has become mainstream in medicine as a way to integrate data from different modalities, platforms, and clinical data. Advances in AI that have become key in medical practice include the natural language process used to mine clinical records and data to derive hidden patterns associated with various diseases or medical phenomena.[2,3] In addition, software that relies on AI such as chatGPT[4] has been used in various aspects of medical education, including the construction of medical scenarios with different levels of difficulty to advance existing medical educational tools such as problem-based learning (PBL) by providing different medical scenarios. Speech recognition is another subset of AI that has been used in the diagnosis of various medical diseases, including Parkinson's.[5,6] Virtual chatbots were used in medicine[7] to create personalized learning experiences for students, by analyzing each student's strengths, weaknesses, and learning style and providing tailored content and feedback. Decision management systems and medical expert systems were also used to augment the diagnosis of various medical diseases and in medical education to provide the medical student with ways to test their knowledge in the diagnosis and prognosis of complex medical problems. In addition, machine learning was used to identify specific biomarkers for various cancers by mining multi-OMICs data, including genomics, transcriptomics, and epigenetics.[8] Deep learning was used in identifying hidden phenomena related to basic medical sciences, for example, unraveling the folding of various human proteins using algorithms developed by DeepMind,[9] also AI was used to identify baricitinib as therapy for COVID-19.[10] AI software and algorithms were used to augment hardware in robotic process automation, where it showed some success in automated solvent extraction.[11] In addition, AI is currently

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Address for correspondence: Prof. Rifat Hamoudi,
Clinical Sciences Department, College of Medicine, Sharjah Institute for Medical Research, University of Sharjah, Sharjah 27272, United Arab Emirates.
E-mail: rhamoudi@sharjah.ac.ae

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used to provide more accurate and expeditious diagnosis, to integrate data from different medical specialties such as radiology and pathology in the diagnosis and prognosis of various diseases, reduce human errors, decrease the cost of identifying biomarkers and treatment, reduce repetitive and labor-intensive tasks, and minimally invasive surgery.[12]

However, integration of AI in medical practice and health care presents many challenges that need to be overcome. These include the inability to fully understand and characterize the algorithms used by AI to arrive at the outcome. This was illustrated by many studies, including a study involving the use of deep learning algorithms to diagnose colorectal cancer from digital histopathology hematoxylin and eosin (H and E) slides where the deep learning algorithms used feature extraction and segmentation to identify the novel way to diagnose colorectal cancer based on morphological patterns.[13] However, the algorithm required training on around 12 million H and E image slides from 2042 patients and the researchers involved in the study mentioned that they are unsure how the algorithm detects those patterns when expert gastrointestinal pathologists were not able to do so. Another example is the study involving the construction of a deep learning algorithm trained on more than 100,000 schizophrenia patients. The algorithm was able to predict the onset of schizophrenia with a high level of accuracy outperforming the experts in the field. However, the main issue with this from medical education perspective is that there is no way to pinpoint how the system constructed this prediction and what factors were taken into consideration as the algorithm mimics human thought, of which the mechanism is not fully understood. This is sometimes referred to as the Black Box phenomenon and this makes it difficult to implement in clinical medicine as the physician needs to understand the inputs as well as the algorithms used to process the inputs and interpret the AI-proposed diagnosis to ensure no errors are made which can compromise patient safety. Other limitations include the issue of privacy as AI-based algorithms require access to an enormous amount of patient data and they are vulnerable to cybersecurity attacks which can comprise access to patient data and alter the AI algorithms to misclassify medical information. Another issue related to AI-based algorithms is the liability where it is not clear who is to blame when a patient is misdiagnosed, leading to the wrong treatment. Furthermore, the clinical records in many developed and developing countries are not complete, this can lead to AI-based algorithms providing the wrong outcome misleading the physician and possibly harming the patient. In addition, both physicians and patients need to be aware of the strengths and limitations of the AI-based chatbots that are currently being used in medicine where such medical expert systems might lead to misdiagnosis or advice on the wrong treatment for patients based on the input provided.[7]

The advent of computers and the Internet revolutionized all fields, including medicine. In the past 20 years, AI entered all aspects of medicine at both basic science and clinical medicine. Since the advent of the COVID-19 pandemic, many universities and educational institutions had to move to online education. This made it ideal to trial AI-based algorithms in the field of medical education with some degree of success. Medical doctors undergo extensive training before specialization. Despite major changes in medicine, medical education still largely follows traditional curricula comprised core preclinical phase followed by clinical-based training. The preclinical phase consists of memorizing as much information as possible from different biomedical domains and applying it to patient care. AI can help by reducing the amount of memorization needed by the use of medical expert systems and chatbots and providing the relevant information needed through mobile applications or the Internet. In addition, AI can help to construct different PBL scenarios with different levels of difficulties during the preclinical phase and create a more accurate patient simulation, for example, using virtual reality (VR) technologies allowing the medical student to experience the reality of patient–doctor relationship at an early stage in the medical education. This can make them better doctors once they get to the clinical phase and later go into clinical training and specialization. Reduction of didactic learning and memorization will put more emphasis on teaching and improving other skills needed by medical doctors such as empathy which is needed when managing difficult patients and relaying terminal disease diagnoses to the patient and their family while maintaining a clear distance between the physician and the patient.

For the clinical phase, AI can help by integrating data from various medical specializations taught at this phase, including radiology, pathology, surgery, gynecology, pediatrics as well as others. In addition, AI can help in mining enormous clinical health records deriving association that is hidden within the data, which are not easy to identify using classical computing or statistical algorithms. In addition, AI can be used to simulate some of the clinical techniques taught, such as the use of AI in robotic surgery, to train students on complex surgical techniques such as neurosurgery as well as minimally invasive surgery. In addition, the advent of the metaverse will revolutionize medical education by providing the ability to simulate real-life holographic patients using VR

glasses with various clinical ailments[14] and monitoring the interaction of the medical student with the holographically simulated patient and guiding the student along the scenario of diagnosis, treatment, and management of the patient using AI-based algorithms.

In conclusion, the combination of doctors and machines working in synergy has powerful potential to improve clinical decision-making and patient diagnosis and treatment. AI is able to mine the enormous data within medical records and integrate them with other medical specialisms such as genetic tests, pharmacy notes, radiology, pathology, and internal medicine to provide a more accurate diagnosis, prognosis, treatment, and patient management strategies. However, AI cannot replace physician empathy which is required as part of the patient's care. As AI becomes more mainstream in medicine and health care, medical students and physicians need to have knowledge of AI, computer science, and mathematics in addition to ethics and legal issues concerning AI. The improvement of technologies such as the metaverse will mean that in the near future, AI will become essential in medicine and medical education and physicians and medical specialists who have knowledge of AI and its applications in medicine will replace physicians who do not have the necessary background and knowledge that will be needed in their daily practice. Therefore, medical education has to change to incorporate AI from the 1st year and throughout the medical course and beyond to ensure that next-generation medical practitioners are well-versed in AI technologies including their limitations. This can lead to a massive advancement in medicine, improving patient health care as well as gaining a deeper understanding of disease models.

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