Review article: Impact of Artificial Intelligence in Medical Education

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Abstract

Cutting edge educational technologies such as AI and virtual reality are widely utilized in higher education to develop virtual learning resources. Therefore the application of artificial intelligence in clinical practice is considered a promising area of expansion in medical education. This study aimed to explore the current use of artificial intelligence in medical education. The researcher highlighted gaps and the area of future research. Majority of articles published on the role of AI in medical education highlight the demand for curriculum reforms based on the latest technologies in education. computer-based decision support systems will make a difference in the traditional medical curriculum and changes in the student's knowledge, problem-solving, and information-seeking skills. These articles highlight the challenges related to the implementation of AI in medical education for its sustained growth. There is apprehension that e-learning may impact negatively the students who benefit from human-human interaction. However, faculty training, seminars, and workshops can enhance the faculty and students' perspectives about the role of AI in medicine.

Keywords: Artificial intelligence in medical education; Machine learning; Deep learning models; Educational technologies; Curriculum reforms; computer-based decision support systems

Introduction

In the current era, artificial intelligence (AI) is playing an extraordinary role in medical education to improve the quality of training. AI, machine learning, and associated new technologies assist in big data management and eventually improves educational aspects in medicine. AI is commonly referred to as machine intelligence and it is defined as the use of machines that have some of the qualities which the human mind carries, such as the ability to
understand language, recognize pictures and patterns to diagnose disease (Du-Harpur et al., 2020).

Shifting to AI uses in medicine started in the twenty-first century and these days it is going on a steep rise. However, the concerns and challenges regarding privacy, ethical, legal issues, equity, and security need to be addressed carefully (Car et al., 2019; Cath, 2018). While many fear that AI will deactivate the physician’s task (Fogel and Kvedar, 2018). For instance, enormous diagnostic support in medical education through AI is helping educators and health professionals for early detecting diseases. When computer-based decision support systems are merged in medical education, they are leading a dramatic change in the traditional medical curriculum (Berner and McGowan, 2010).

Artificial intelligence (AI) in medical education

With the accelerating level of health digitalization, AI tools and applications have escalated due to heightened demand among the medical educators, educational organizations, and industries associated with the medical field. However, it is worth stating that there has been little known about the impact of AI in medical education. Besides, an in-depth investigation is desirable to comprehend the user’s experience and apprise guidelines in medical education (Aboueid et al., 2019). For instance, the usage of AI in medical education can support learners mostly through its capability to deliver individualized feedback.

Few studies determined the advantages and challenges that are encountered when AI is incorporated into medical education (Bhatarai et al., 2019). However, little stress is noticed on the curriculum review and assessment of students’ learning due to the lack of digitalization and the complex nature of examinations, respectively (Chan and Zary, 2019). This study aimed to explore the current use of artificial intelligence in medical education. The researcher will highlight gaps and the area of future research. Findings will help medical experts, educators, and policymakers to integrate AI in medicine for the optimum training of health through enhancing the concept of digital health.

Method

In this literature review, we utilized the PRISMA systemic review guidelines to collect information, analyze, and present data. To identify relevant research, we used academic databases including; Cochrane Library, Medline, PubMed Central, Web of Science, and Google Scholar. Besides reference searching was done in an attempt to recognize further relevant studies. The following keywords were used to find published articles: Artificial intelligence, machine intelligence, medicine, medical education. Then we narrowed down our research to be more precise and used the following keywords Artificial intelligence, medical education.

Three authors independently reviewed the article search results to select peer-reviewed, English language articles, determining the role of artificial intelligence in medical education in a diverse context of the studies and different fields of medicine. Our study included the original articles (Peer-reviewed published & approved), commentaries, editorials, and conference news in medical education. This strategy ensured that the information obtained is vast and non-ambiguous. To ensure that the information that is incorporated into the research is not outdated, the researchers stick to academic papers that were published between the years January 2019 and July 2020.

Results

For this review article, we found 4355 articles identified published from January 2010 to May 2020 using keywords: Artificial intelligence, machine intelligence, healthcare system, medical education. 4067 articles were excluded after title review (Clearly irrelevant) and were not matching to initial keywords and we read 288 abstracts. 256 articles were excluded as three reviewers commented that these articles were more focused on the role of AI in the
healthcare system and advanced technologies in hospital setups. Figure 1 presents the flowchart of the research based on inclusion criteria of keywords (Artificial intelligence; machine intelligence; medicine; Medical education).

**Figure 1.** Flowchart of the research based on inclusion criteria of keywords (Artificial intelligence; machine intelligence; medicine; Medical education)

- **4355 Articles identified** through data base seaching, published during January 2019 and July 2020
  - **Key words:** Artificial intelligence, machine intelligence, medicine, medical education.

- **288 Selected for abstract review**

- **4067 Excluded after title review** (Irrelevant, not meeting inclusion criteria, duplicated)

- **256 Excluded after abstract review** because they mentioned the role of AI specifically in healthcare system with use of advanced technology

- **46 Articles** were selected for full manuscript reading because these were focused on **role of AI in Medical Education**

- **30 Articles** specifically mentioned the role of Artificial intelligence in Medical education

- Excluded after full article study (Reason)
  - 6 Editorals
  - 8 Conferences comments
We included 46 articles for full manuscript study and these articles were mentioning different types of intelligent information systems in medical education and digital tools assisting medical educators. These studies stated the challenges linked to the implementation of AI in medical education and debate on key areas to contrivance AI in medical education. Table 1 presents the summary of themes discussed in 30 articles on the role of AI in medical education. Table 2 showed the author's details, the title of articles context/method of study, and the conclusion of each article.

Table 1: Themes discussed in 30 articles on the role of AI in Medical Education

| No | Themes of published articles                                      | Number of published articles |
|----|-------------------------------------------------------------------|------------------------------|
| 1. | Curriculum reforms in medical education                          | 8                            |
| 2. | Deep learning models in medical education                        | 7                            |
| 3. | Virtual Reality in medical education                             | 5                            |
| 4. | Challenges for implementation of AI                              | 6                            |
| 5. | Future predictions and apprehensions about AI                    | 4                            |

Table 2: Summary of 30 articles mentioning the role of artificial intelligence in medical education

| No | First Author, year and DOI of the article | Title of Article                                                                 | Context/Methods                                                                 | Conclusion                                                                 |
|----|-------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| 1. | Birbara, (2019): DOI: 10.1002/ase.1921.  | Virtual Reality in Anatomy: A Pilot Study Evaluating Different Delivery Modalities.| Anatomy students participant to assess highly immersive stereoscopic and less immersive desktop deliveries of the VLR. | Desktop VLR delivery reduces the risk of disorientation and discomfort accompanied by more immersive modalities. |
| 2. | Briganti, (2020): DOI: 10.3389/fmed.2020.00027. | Artificial Intelligence in Medicine: Today and Tomorrow. | Discuss AI's current application in medicine, challenges, future direction, and its impact on physicians, healthcare institutions, medical education, and bioethics. | The implementation of AI in medicine is promising however, health policies should take into consideration to focus on ethical and financial issues of AI. |
| 3. | Car, (2019): DOI: 10.1186/s12916-019-1382-x. | Beyond the hype of big data and artificial intelligence: building foundations for knowledge and wisdom. | Discuss real-world data, AI implementations, digital records, and ethical considerations. | Developing data and connectivity has now the opportunity to collect data, lab interventions, and home care pathways. |
| 4. | Chan, (2019): DOI: 10.2196/13930. | Applications and Challenges of Implementing Artificial Intelligence in Medical Education: Integrative Review. | Literature review of using telemedicine technology in medical education to improve quality of life, easy access for patients, and reduce cost. | Application of the telemedicine syllabus into undergraduate medical education is highly recommended and worthy. |
| 5. | Chan, (2020): DOI: 10.1002/ase.1936. | Artificial Intelligence or Natural Stupidity? Deep Learning or Superficial Teaching? | Chatbots, anatomy learning robots with AI teaching students and explain the tasks they can do. | AI education through robots with deep learning is in development and will make a change in academy education but only time knows if it's naturally will remain stupid. However, Human needs humanity. |
|   | Author(s)                          | Year | DOI                                      | Title                                                                 | Artificial intelligence in radiology | Highlight an AI-integrated framework to augment radiology education and provide use case examples informed by our own institution’s practice. | AI-augmented radiology might enable to precision in medical education. |
|---|-----------------------------------|------|------------------------------------------|----------------------------------------------------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| 6. | Duong, (2019)                     | DOI: 10.1259/bjr.20190389.          | Artificial intelligence for precision education in radiology       | highlight an AI-integrated framework to augment radiology education and provide use case examples informed by our own institution’s practice. | AI-augmented radiology might enable to precision in medical education.                                                     | AI-augmented radiology might enable to precision in medical education. |
| 7. | Gallix, Benoit; Chong, Jaron (2019)| DOI: 10.1007/s00330-018-5995-9.    | Artificial intelligence in radiology: who's afraid of the big bad wolf? | Discuss the medical students' concerns about AI and future job loss. Discuss AI principles in radiology. | AI-augmented radiology might enable to precision in medical education.                                                     | AI-augmented radiology might enable to precision in medical education. |
| 8. | Garg, Tushar (2020)               | DOI: 10.1016/j.amjmed.2019.08.017. | Artificial Intelligence in Medical Education | Highlights the implementations of AI in medical education: curriculum expansion and analysis, learning, and assessment. | AI is important in training future doctors. It also helps students to recognize knowledge gaps and respond to them effectively. | AI is important in training future doctors. It also helps students to recognize knowledge gaps and respond to them effectively. |
| 9. | Han, (2019)                       | DOI: 10.1186/s12909-019-1891-5.     | Medical education trends for future physicians in the era of advanced technology and artificial intelligence: an integrative review | Identify and synthesize the estimate that medical educators demand to implement in the curricula. Introduce education programs. | The detailed programs introduced in this article can be useful in undergraduate medical education for the future development of curricula. | The detailed programs introduced in this article can be useful in undergraduate medical education for the future development of curricula. |
| 10. | Hardy, (2020)                     | DOI: 10.1259/bjr.20190840          | Artificial intelligence in diagnostic imaging: impact on the radiography profession | Discuss AI applications and highlight the changes that AI conducts. | Elevate cross-modality education and working, enhancing patient care, rise technological expertise, and expansion of radiologist responsibility. | Elevate cross-modality education and working, enhancing patient care, rise technological expertise, and expansion of radiologist responsibility. |
| 11. | Kowalewski, (2019)                | DOI: 10.1007/s00464-019-06667-4.   | Sensor-based machine learning for workflow detection and as key to detecting expert level in laparoscopic suturing and knot-tying | Compared the experience levels in laparoscopy, implemented a suturing and knot tying task on silicon samples for skill level valuation and phase detection. | Machine learning algorithms aid in explaining complex surgical motion input.                                                                 | Machine learning algorithms aid in explaining complex surgical motion input. |
| 12. | Kurowecki, (2020)                 | DOI: 10.1016/j.acra.2020.01.016.   | Resident Physicians’ Perceptions of Diagnostic Radiology and the Declining Interest in the Specialty | Resident physicians identifying features affecting career choice and estimate levels of concurrence using AI in radiology. | Recent graduates are worried about AI replacing radiologists more than radiology applicants. early training exposure is recommended for a positive viewpoint of the profession. | Recent graduates are worried about AI replacing radiologists more than radiology applicants. early training exposure is recommended for a positive viewpoint of the profession. |
| 13. | Kyaw, (2019)                      | DOI: 10.2196/12959.                | Virtual Reality for Health Professions Education: Systematic Review and Meta-Analysis by the Digital Health Education Collaboration | Evaluate the efficacy of virtual reality for teaching medical staff and improving their skills by using the GRADE approach. | Evidence supports VR education improves health professionals’ knowledge and skills compared to traditional education. | Evidence supports VR education improves health professionals’ knowledge and skills compared to traditional education. |
| Page | DOI | Title                                                                 | Abstract                                                                                                                                  |
|------|-----|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 14.  | Liaw, (2020) DOI: 10.2196/17279. | Nurse-Physician Communication Team Training in Virtual Reality Versus Live Simulations: Randomized Controlled Trial on Team Communication and Teamwork Attitudes | Undergraduate medical and nursing students were exposed to VR and live simulation and evaluated their communication performance by interprofessional attitude surveys after a period. The inferiority of team training using virtual reality when compared with live simulations, which supports the potential use of virtual reality to substitute conventional simulations for communication team training. |
| 15.  | Lynn, (2019) DOI: 10.1186/s13037-019-0188-2. | Artificial Intelligence Systems for Complex Decision-Making in Acute Care Medicine: a review | Importance of AI in acute care medicine and medical education. Deep neural networks can have high efficiency in the detection and making decisions compared to conventional protocols in acute care. |
| 16.  | Masters, (2019) DOI: 10.1080/0142159X.2019.1595557. | Artificial Intelligence in Medical Education | The impact of AI on medicine and medical education. Consider the impact of AI on medicine and the implications of this impact for educators trying to educate future doctors. |
| 17.  | Paranjape, (2019) DOI: 10.2196/16048. | Introducing Artificial Intelligence Training in Medical Education | AI is important for health care to improve outcomes and reduce effort on the physician. Medical trainers should have the capability to understand the essential concepts of AI and involved AI in medical education as a core curriculum. |
| 18.  | Park, (2019) DOI: 10.3352/jeehp.2019.16.18 | What Should Medical Students Know About Artificial Intelligence in Medicine? | Provides medical students a synopsis about artificial intelligence. Medicine has an enormous opportunity in artificial intelligence which proves in some technologies are used now. Medical students should be fully aware of artificial intelligence for the future. |
| 19.  | Paton, (2019) DOI: 10.1055/s-0039-1677898 | An Open Science Approach to Artificial Intelligence in Healthcare | How can open science support Artificial intelligence development and answer all concerns? Artificial intelligence has opportunities with open science in many aspects includes clinical decision, education, and research. |
| 20.  | Pinto Dos Santos, (2019) DOI: 10.1007/s00330-018-5601-1. | Medical Students’ Attitude Towards Artificial Intelligence: A Multicentre Survey | Use a questionnaire assessing the medical students’ knowledge of artificial intelligence in radiology. Medical educators should make a move in to educate students to address their apprehensions about AI’s role in radiology and future career perspectives as a radiologist. |
| 21.  | Sanal, (2019) | Artificial Intelligence and Deep Learning: The Future of Medicine and Medical Practice | Argues that the clinical algorithms and human experience cannot be replaced by machines. The heterogeneous disease needs artificial intelligence to rapidly prediction, decision making, and treatment to help and reduce the effort on physicians. |
| 22.  | Sheikh, (2019) DOI: 10.1016/j.thorsurg.2019.03.011. | Artificial Intelligence: Can Information Be Transformed Into Intelligence in Surgical Education? | Discusses the integration of various medical applications in healthcare. A potential application of AI in surgical education is as a teaching coach or mentor that interacts with the users via virtual and/or augmented reality. |
| 23.  | Sit, Cherry, (2020) DOI: 10.1186/s13244-019-0830-7. | Attitudes and Perceptions of UK Medical Students Towards Artificial Intelligence and Radiology: A Multicentre Survey | A survey conducted among 484 United Kingdom medical students about how important artificial intelligence. 88% of students reported that artificial intelligence plays an important role in medicine. And AI should be a core curriculum in medical schools. |
Table 1: Summary of Articles and Discussions

| Article Details | Title | Discussion |
|-----------------|-------|------------|
| Sorin, (2020) | Creating Artificial Images for Radiology Applications Using Generative Adversarial Networks (GANs) | Literature review about GANs applications in radiology between 2017-2019. GANs are implemented in radiology applications and used to enhance clinical care, research, and education. |
| Van der Niet, (2020) | Where Medical Education Meets Artificial Intelligence: 'Does Technology Care?' | Debates that medical education has been slow to respond to the demands of early learning about AI in undergraduate medicine, and discusses that engaging with AI will become a key factor in the identity constructions of doctors of the future. |
| Wartman, (2019) | The Empirical Challenge of 21st-Century Medical Education | Recommends specific curricular emphases for 21st-century medical education. Engage technology in the medical curriculum is faced with many challenges such as in deeply ingrained values, resistance to change the traditional way of care and education, and the future rule of the doctor-patient relationship. |
| Waymel, (2019) | Impact of the Rise of Artificial Intelligence in Radiology: What Do Radiologists Think? | Discusses the information overload crisis among learners is the fact that physicians' skill sets now must include collaborating with and managing artificial intelligence (AI) applications. AI will reduce the radiological imaging error and gives better outcome in medical practicing. |
| Winkler-Schwartz, (2019) | Artificial Intelligence in Medical Education: Best practices Using Machine Learning to assess surgical expertise in virtual reality simulation | Developed a checklist to provide a general framework when reporting or analyzing studies involving virtual reality surgical simulation and machine learning algorithms. An algorithm in machine learning applications to assess surgical expertise is helping enormously in medicine and education. |
| Winkler-Schwartz, (2019) | A Comparison of Visual Rating Scales and Simulated Virtual Reality Metrics in Neurosurgical Training: A Generalizability Theory Study | Compared visual rating scales with simulated metrics in a neurosurgical virtual reality task. Suggest adopting a hybrid educational approach using visual rating scales in an operative environment, supplemented by simulated sessions to uncover potentially problematic surgical techniques. |

Discussion

AI assistance in the educational learning environment

Majority of articles published on the role of AI in medical education highlight the demand for major curriculum...
reforms based on the cutting-edge technologies in education. In the future, computer-based decision support systems will make a difference in the traditional medical curriculum and changes in the student's knowledge, problem-solving, and information-seeking skills (Berner and McGowan, 2010). Mostly published articles highlight the challenges related to the implementation of AI in medical education for its sustained growth. Medical instructors may use this AI-assisted authoring tool to generate their diverse characters that will interact efficiently with the students in the e-learning environment (Alepis and Virvou, 2011).

These days, educational technologies such as AI and virtual reality are widely utilized in higher education to develop virtual learning resources (VLRs). These tools are found to be very effective to enhance the learning experience for learners (Birbara, Sammut, and Pather, 2019). Therefore the application of artificial intelligence in clinical practice is considered as an auspicious area of expansion, especially for diagnostic medicine, teleconsultation, and genomics (Briganti and Le Moine, 2020). Additionally, the concept of using the Chatbots can help the medical students by engaging in pedagogically sound discussion, evaluating students, and giving instant feedback (Chan and Pawlina, 2020).

There is apprehension that in the future e-learning may impact negatively the students who benefit from human-human interaction. To determine the attitudes of undergraduate medical students regarding AI, the majority of studies do not support that AI will replace human physicians (Pinto Dos Santos et al., 2019). However, faculty training, seminars, and workshops can enhance the faculty and students' perspectives about the role of AI in medicine. Medical educators could find the chance to use this tool to create their way to interact effectively with their students (Alepis and Virvou, 2011).

Research Gaps & Areas for Further Inquiry

In this review, we ended with a lot of questions that need to be answered by medical educators in the modern medical education era.

- Should AI be a compulsory part of medical education at undergraduate and postgraduate training?
- How AI can be embedded in the undergraduate medical curriculum?
- Will diverse curriculum models need different approaches to amalgamate AI?
- Will medical educators adapt to AI tools and virtual reality environments through enhancing the knowledge are skills required for AI in medical education?
- How can medical educators prepare and proact swiftly to future evolutions in AI-oriented medical education?
- Whether machines will achieve the insight and intelligence of human educators?
- Should we arrange workshops and awareness campaigns for the rapid adaptation of AI in medical education?
- Although virtual reality and simulation have been developed in medical education, how can engagement of AI in the real education system be sustained?
- How will faculty development progress in the AI era?
- An issue that saturates most of these questions is: will the next generation of medical students remain the same as that of now?

These questions challenge a considerable schema for future research and advance an open debate among medical professionals and educators.
A quote from Ray Kurzweil (American inventor and futurist 2020) is appropriate: "Artificial intelligence will reach human levels by around 2029. Follow that out further to, say, 2045, and we will have multiplied the intelligence – the human biological machine intelligence of our civilization – a billion-fold."

Limitations

The article represents the rational and thoughtfulness of 3 independent reviewers and interpretation may differ. However, the conclusive comments are agreed upon by all authors.

Conclusion

Cutting edge educational technologies such as AI and virtual reality are widely utilized in higher education to develop virtual learning resources. Therefore the application of artificial intelligence in clinical practice is considered a promising area of expansion in medical education. Majority of articles published on the role of AI in medical education highlight the demand for major curriculum reforms based on the latest technologies in education. Computer-based decision support systems will make a difference in the traditional medical curriculum and changes in the student's knowledge, problem-solving, and information-seeking skills. These articles highlight the challenges related to the implementation of AI in medical education for its sustained growth. There is apprehension that in the future e-learning may impact negatively the students who benefit from human-human interaction. However, faculty training, seminars, and workshops can enhance the faculty and students' perspectives about the role of AI in medicine.

Take Home Messages

- Artificial intelligence (AI) has an extraordinary role in medical education.
- There is an intense demand for curriculum reforms based on the latest technologies in education.
- The diverse challenges related to the implementation of AI in medical education need to be understood by medical educators.
- Faculty development programs can enhance the perspectives about the role of AI in medicine.

Notes On Contributors

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Figure 1: Author is Dr Shazia Iqbal; the creator/owner of copyright.

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Appendices

None.

Declarations

The author has declared that there are no conflicts of interest.

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