Narrative review

Advances in the use of Artificial Intelligence in Latin American Medical Education

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Abstract
Artificial intelligence is the ability of a system to emulate cognitive functions. In healthcare, it is used to support complex decision-making and medical skills training. It is a tool for creating virtual simulation scenarios and evaluating the performance of medical students. This literature review aims to describe the advances in artificial intelligence in medical education in Latin America. The databases PubMed, SciELO, and Google Scholar were consulted; publications in Spanish and English from 2019 to 2024 were included, and keywords and Boolean operators were applied. Artificial intelligence in medical training seeks to replicate cognitive skills in problem-solving and is classified into narrow artificial intelligence and general artificial intelligence. It is a transformative tool that empowers virtual reality, optimizes outcomes, offers opportunities to strengthen the effectiveness of healthcare, and makes improvements in personalizing the learning process. However, its implementation requires addressing ethical and legal challenges for its full exploitation. In Latin America, there is a steady increase in the adoption of artificial intelligence-based tools for medical staff training.

Keywords
Artificial Intelligence, Education Medical, Virtual Reality.

Resumen
La inteligencia artificial es la capacidad de un sistema para emular funciones cognitivas. En el ámbito de la salud, se utiliza como respaldo en la determinación de decisiones complejas y formación de habilidades médicas. Es una herramienta para crear escenarios de simulación virtual y evaluar el desempeño de los estudiantes de medicina. El objetivo de esta revisión bibliográfica es describir los avances en el uso de inteligencia artificial en la educación médica en Latinoamérica. Se consultaron las bases de datos PubMed, SciELO, y en Google Académico; se incluyeron publicaciones en español e inglés del período 2019 al 2024, se aplicaron palabras clave y operadores booleanos. La inteligencia artificial en la formación médica busca replicar habilidades cognitivas en la resolución de problemas, y se clasifica en inteligencia artificial estrecha e inteligencia artificial general. Es una herramienta transformadora que potencia la realidad virtual, optimiza los resultados, ofrece oportunidades para fortalecer la efectividad de la atención sanitaria y hacer mejoras en la personalización del proceso de aprendizaje. Sin embargo, su implementación requiere abordar desafíos éticos y legales para su pleno aprovechamiento. En Latinoamérica, se observa el constante aumento de la adopción de herramientas basadas en la inteligencia artificial para la formación del personal médico.

Palabras clave
Inteligencia Artificial, Educación Médica, Realidad Virtual.

Introduction

Artificial intelligence (AI) is defined as the ability of a digital platform to mimic cognitive functions.[i] The development of this technology and its introduction into the medical profession contributes to the development of diagnosis and therapy. The trend indicates that AI applications will increasingly integrate into the healthcare system. Healthcare professionals are responsible for ensuring that the use of these systems is of benefit to the patient; however, uncertainty arises as to whether AI will consolidate

itself as a tool or whether it could replace physicians in the future.[ii]

The idea of AI dates back to 1950 when Alan Turing formulated the Turing test ,designed to assess whether a machine can fool an interrogator into believing its answers were human. In this test, the interrogator must distinguish between a human and a machine by means of its answers; if it identifies the machine, the machine has failed the test.[iii] At the Dartmouth Conference in 1956, John McCarthy introduced the term "Artificial Intelligence", marking the formal beginning of the field of AI study.[iv]

In 1986, the University of Massachusetts created DXplain, a novel approach to medical decision management. This system produces a variety of alternative diagnoses by examining particular symptoms. In addition to its diagnostic utility, DXplain has established itself as a valuable educational resource for medical students.[v]

AI made significant advances in the 1980s and 1990s when it began to be applied in clinical settings, including fuzzy expert systems, Bayesian networks, artificial neural networks, and hybrid intelligent systems. By 2016, most of the investments in AI research went to the use of this tool in healthcare,[v] presenting itself as a novel tool to manage patient information and facilitate decision-making.[vi]

The PubMed and SciELO databases were consulted, as well as Google Scholar; publications in Spanish and English from 2019 to 2024 were included; in addition, keywords and Boolean operators were used in the search strategy. This review aims to describe the advances in the use of AI in Latin American medical education, including its types, tools, opportunities, and challenges in the region.

Discussion

When AI reaches widespread use, it often ceases to be considered as such, a phenomenon known as the "AI effect". This happens when observers less familiar with the subject dismiss the behavior of an AI program by arguing that it does not reflect genuine intelligence.[vii] AI integrates technological tools and essential processes of human behavior in order to simplify work and achieve goals.[viii]

The creation of machines capable of surpassing skills in terms of workload, efficiency, accuracy, endurance, strength and repeatability. However, a constant in all these creations is that the purpose is to replace, perfect or go beyond the physical abilities of human beings.[ix]

AI refers to problem-solving and learning by simulating human intelligence through the use of machines such as computers or robots that have been programmed to mimic cognitive functions,[x] using artificial neural networks that mimic the architecture of the brain through layered and interconnected nodes that replicate neural activity.[ix] In the medical field, AI has rapidly emerged as a major player, thanks to its ability to collect data to support clinical decisions based on solid evidence.[x] AI replicates human thinking through tactics such as machine learning and natural language processing.[xi]

According to Martínez-García *et al.*, AI is classified into two main groups based on its cognitive capacity: narrow, limited, or weak AI, which is developed for specific functions and does not possess the ability to reason or acquire knowledge of new circumstances, and general or strong AI, which demonstrates broad human cognitive capacities such as reasoning, knowledge acquisition and the approach to problems that allow it to adapt to unfamiliar tasks.[xii] Vidal Ledo *et al.* add that weak AI assumes that computers can only simulate the reasoning process, while strong AI using a computer can possess mental states, which would allow at some point the creation of a machine with all human mental capabilities.[xiii]

Morandín-Ahuerma classifies AI into four main categories according to their degree of autonomy: reactive AI, deliberative AI, cognitive AI and autonomous AI. Reactive AI is capable of carrying out specific functions independently, but cannot remember previous experiences or foresee future eventualities. Deliberative AI can evaluate situations and actions to achieve specific goals, and can adjust to dynamic environments by using historical and prospective information. Cognitive AI simulates human cognitive capabilities and can adjust to new situations and environments. Finally, autonomous AI works independently with its environment, making decisions and assimilating knowledge from new situations.[xiv]

AI-based tools used in Latin America

In medical education, AI seeks to support clinical practice by providing learning resources that simplify student understanding. This allows access to novel pedagogical approaches that facilitate both the assimilation and use of knowledge gained more easily.[xv]

During the COVID-19 pandemic, the weaknesses of Latin American healthcare systems became evident, leading to the

need to resort to the alternative of telemedicine to reduce the demand for face-to-face services. AI has allowed dialogue in a medical consultation to be transcribed automatically, creating a paradigm shift for future physicians with the use of this technology.[xvi]

Among the AI-based tools used in Latin America are large linguistic models (LLM) that employ Deep Learning techniques to simulate human linguistic skills; they allow mimicking and predicting human interaction with language. Examples of these are ChatGPT and DALL-E by OpenAI, Segment Anything Model (SAM) and LLaMA by Meta, and LaMDA by Google.[xvii]

ChatGPT's chatbot has had a great impact on millions of Latin Americans because of its accessibility and ease of use. It is capable of writing essays, synthesizing research, and even answering questions accurately.[xviii] The quality of the result of an LLM is based on the information available to generate coherent answers; therefore, if they receive insufficient data from the user or have incomplete information, the result may contain incorrect information.[xix]

Although useful, an advanced chatbot does not completely replace human reasoning in simulation education. The educator's experience and adaptability are essential for unforeseen situations. It is crucial not to rely too much on technology and to use AI as a complement, not as an exclusive resource.[xx]

Carrasco *et al.* evaluated the ability to solve ChatGPT questions in the MIR 2022 exam (access exam to Specialized Health Training in Spain), reaching 51.4 % of correct answers, which represents approximately 69 net answers, enough to pass the cut-off mark and choose among several specialties;[xxi] while in the Netherlands, AI is used to analyze their healthcare system, identify treatment failures and optimize processes to prevent unnecessary hospitalizations.[v]

In Antigua and Barbuda, the American University of Antigua reported that 33 % of medical faculty used ChatGPT, mostly to generate questionnaires; there was also a wide acceptance for using this tool in faculty and student workflows.[xxii]

AI is closely related and incorporated into virtual reality technology and programming. Personalization, detection and adaptation to user behavior, as well as improving object identification capabilities and optimizing the quality of graphics in virtual reality visualization, are all part of the application of AI.[xxiii]

In recent decades, this relationship has gained importance as the ability to recreate real environments through virtual reality has become critical, training students in the development of new skills and abilities.[xxiv] Simulated clinical practice in medical education provides students with scenarios that provide the opportunity not only to gain hands-on experience, but also to receive direct guidance. Simulated clinical practice in medical education provides students with scenarios that provide the opportunity not only to gain hands-on experience, but also to receive direct guidance. This combination greatly enriches the learning process for students, improving their preparation for real situations in the medical field.[xxv]

In 2022, the University of El Salvador inaugurated a virtual reality laboratory with the capacity for ten students to interact in the resolution of clinical cases, while the rest of the students visualize the visual content of the virtual immersion room from an adjacent classroom. Through this, clinical scenarios are created so that students hear, see and act as if they were in a real environment.[xxvi]

In Mexico, a virtual surgical simulation tool was developed where pediatric surgery residents are immersed in laparoscopic procedure scenarios, reproducing real distractions within the operating room.[xxvii] In addition, approximately 14 % of medical schools or faculties in Peru during 2019 incorporated some type of virtual reality interface.[xxviii] Additionally, an Argentine university evaluated the impact of virtual reality on the perceived learning of anatomy by health sciences students, comparing it with traditional tools, and found that it has a positive effect, offering to reinforce teaching strategies.[xxix]

The Pontificia Universidad Católica de Chile introduced the C1DO1 platform, which offers evaluation and support to improve the quality of feedback during the review of student videos, allowing for automated evaluation. This platform allows instructors to identify areas for improvement in their feedback. It also facilitates the automatic generation of editable summaries of all feedback, making use of AI LLM models. Instructors can customize these summaries, providing an effective tool for communicating information in a clear and useful way to students.[xi]

In Chile they also introduced an AI algorithm to evaluate a simulated basic laparoscopy course, with the application of convolutional neural networks such as U-net and YOLO v4 to analyze videos of laparoscopic exercises. This algorithm detects the position of the surgical tools and the movement of the objects, such as their fall and the transfer of figures, calculating the time required to complete the exercise. The results are compared with expert standards, providing

objective measurements of student performance in basic simulated laparoscopy.[11]

Opportunities in the implementation of AI for medical education

Future clinicians and healthcare leaders have a crucial role in the clinical implementation of AI-based technologies. Currently, a wide range of technological resources are available that have enabled humans to achieve previously unattainable goals, AI being one of them. Its inclusion in medical education has aroused vast interest because of its ability to increase the quality of teaching and learning for trainees.[xxx-xxxi]

Arbelaez Ossa *et al.* highlighted the need to incorporate dynamic teaching strategies with a practical approach to the use of AI in medical training and to develop computational thinking, a skill that transcends the theoretical foundations of programming code, due to the need of institutions for the technical use of this tool in the clinical context.[xxxii] AI also provides us with adaptive educational content that is suitable for the knowledge gaps and learning speed of each student by analyzing huge amounts of data and using machine learning algorithms. This personalized approach fosters a deeper understanding of complex medical ideas and increases the engagement of the physician-in-training.[xxxiii]

In contemporary medical practice, it is estimated that physicians spend only 12 % of their day interacting with patients who are hospitalized. This situation is largely due to the numerous administrative tasks they must perform, which significantly affects the time available for direct care. AI could represent a solution to relieve them of these repetitive activities.[xxxiv] The need for medical curricula to include the principles of Electronic Medical Record design and develop skills to provide unbiased input to them, which would be used by AI systems to inform the results of their algorithms, has been put forward.[i]

AI enables optimal manipulation of large amounts of clinical and scientific history, which are constantly updated. This allows both medical students and graduates to quickly and accurately access relevant and up-to-date information. This resource is especially useful in experience-based medicine, facilitating informed decision making.[xxxv]

In performance analysis in university education, AI could optimize results, streamline administrative work, and drive immediate feedback by decreasing the time to grade and encourage student progress. This would be beneficial with large groups of students, as it could play a role in automatically reviewing open-ended questions and even make use of facial recognition for taking attendance.[xxxvi]

Feedback is essential in education and is most effective when it is detailed, rapid and personalized for each student. The introduction of AI in medical education can enrich communication between teachers and students by simplifying tasks such as transcribing, translating and summarizing the feedback provided.[xi]

LLMs such as ChatGPT in medical education can be useful if used correctly. These tools provide teaching-learning opportunities for teachers and students by allowing personalized learning, research assistance, quick access to information, generation of clinical cases, quizzes, summaries and translations to facilitate learning.[xxxvii] Answers in ChatGPT can vary in accuracy, sometimes generating incorrect or fictitious information that is not based on the data provided by users. On the other hand, OpenEvidence, another LLM, provides concise explanations with references to relevant research articles when answering specific clinical questions.[xix]

AI makes it possible to create different virtual scenarios for training and learning that simulate real interventions. These environments allow students to put into practice both the theoretical knowledge and the technical skills acquired, without exposing any patient to real risks.[xxxviii]

Technology changes medical training by allowing visualization of anatomical structures without the need for cadavers. The use of mock-ups and software replaces traditional dissections, reducing costs and improving learning safety.[xxxix]

In virtual reality and medical simulation environments, AI offers immersive and challenging experiences to improve clinical skills. The training provides personalized feedback based on the learner's strengths and weaknesses, identifying areas for development. This objective feedback enhances the learning process by providing scenarios with realistic parameters.[xi]

AI in surgery makes it possible to detect patterns used in simulations and virtual reality environments for interactive and realistic training. During real procedures, neural network algorithms analyze complex data from the surgical field to assist in choosing the next step to follow.[xi]

Obstacles to incorporating AI in medical education

Currently, medical education is facing a formidable challenge: the progressive growth of sciences and the continuous advancement of these revolutionary tools make conven-

tional teaching obsolete. This implies that universities invest in the integration of virtual learning environments, which brings with it challenges such as: lack of knowledge on the part of the educator regarding the use of AI, little evidence regarding the impact of this pedagogical model, scarcity of interactive material and little funding for infrastructure and acquisition of teaching equipment.[xl]

Even with AI being accurate and efficient, it is crucial to recognize its susceptibility to error, and human oversight is necessary. Because healthcare professionals are ultimately responsible for implementing AI-based suggestions, medical education programs should develop a range of scenarios to identify misdiagnoses or incorrect prescriptions generated by AI, providing practical experiences in managing AI errors with corrective actions.[xli]

The introduction of language models in medical education poses ethical and operational challenges. There is a risk of academic dishonesty, as they could be used to answer exams or create fraudulent essays, compromising educational integrity.[xi]

The use of AI in medical training raises serious ethical concerns. In addition to fundamental ethical principles, AI ethics addresses recurring issues such as transparency, explainability, accountability, and fairness. Algorithms may contain developer biases and amplify them with the data they handle, increasing inequities. These ethical challenges also involve the security of personal information in health services. This dilemma may be considered unavoidable, as it is through this circulation of private information that the database enhances the deep and machine learning algorithm.[xlii]

The legal framework regulating AI is another significant challenge. Globally, its use is predominantly governed by the regulatory frameworks of software as a medical device. In 2021, the Chamber of Deputies in Brazil approved the Brazilian Legal Framework for AI to regulate the use and development of AI; furthermore, in 2022, the Senate of the same country presented the draft for an AI Law, the latter classified healthcare applications as high-risk AI systems.[xliii] Countries such as Colombia have made progress in developing laws to establish guidelines for the implementing AI in heterogeneous sectors of the country.[xliv]

Inconsistency in AI responses is a significant challenge, potentially confusing by providing different answers for the same message. There is a risk of algorithmic bias, where models can perpetuate stereotypes present in training data, which requires ethical attention and great care for its use in education[xi] with emphasis on the concept of plagiarism, image manipulation, authorship and copyright in fake student-led research.[xlv-xlvi] Therefore, educators must create clear guidelines regarding the ethical inclusion of AI and to motivate students' critical thinking.[xlvii]

Dependence on AI can hinder the development of crucial skills, such as critical thinking and verbal communication. The limitation in human interaction and emotional expression is evident, as language models are restricted to a textual interface, unable to recognize gestures or express emotions, crucial aspects for a comprehensive education.[xi] This could have a negative impact on dialogue and synergy among future physicians since these skills are fundamental in most common medical practices.[xlviii]

Challenges in implementing AI classrooms in universities include poor adaptability to changing scenarios on the part of administrators, a lack of digital literacy among professors, a dearth of research on their impact, and limited resources to invest in technology and infrastructure.[xl]

The lack of Internet connectivity in Latin America represents a delay in adapting advanced technologies; the region continues to register one of the lowest volumes of mobile data traffic globally, with an average of 449 terabytes per month. This figure represents only one-seventh of the traffic observed in the Asia-Pacific region.[xlix]

Finally, with the integration of AI into medical practice, healthcare professionals must acquire knowledge of data management, the ethical and legal considerations of using such tools, and identify cases where algorithms are not accurate, with this conscious use being a new challenge for students, resident physicians and teachers.[l]

Conclusion

AI uses computer systems, digital platforms, and machines to replicate and enhance human cognitive abilities in problem-solving and decision-making. In Latin America, the use of AI-based tools is expanding in various healthcare sectors, including medical education. These tools are used to optimize processes, offer personalized consultations, and improve decision-making by teachers and students; they provide immersive and personalized learning environments together with virtual reality.

The integration of AI in medical education improves the effectiveness and personalization of learning; however, it is critical to address challenges related to ethics, legal and implementation issues in order to make full use of AI in Latin American

medical education. Furthermore, it is crucial to find the right balance between technology and traditional medical education, as empathy and personalized patient care cannot be substituted.

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