



(REVIEW ARTICLE)



## Education 4.0 In healthcare: How can artificial intelligence help clinical reasoning?

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### Abstract

**Introduction:** Artificial Intelligence (AI) can develop software and systems capable of performing functions that normally require human skills. Its integration with the health field brings numerous optimizations to medical practice. However, it is crucial to ensure that AI does not replace the clinical judgment of the professional because, despite promising advances, challenges and ethical issues arise that need to be widely discussed.

**Objective:** To investigate the use of AI to improve clinical reasoning, highlighting advantages, challenges and ethical implications.

**Methodology:** This integrative literature review searched the following databases: PubMed, LILACS, SciELO, Cochrane Library and Google Scholar, using the descriptors “Artificial Intelligence” AND “Clinical Reasoning”. Publications from 2019 to 2024 in Portuguese and English were included, and 19 articles were selected for the study.

**Results and discussion:** Clinicians have a positive perception of AI in medical practice even though significant challenges remain, such as the integration of clinical reasoning, data protection, unequal access and ethical issues. Despite this, AI has transformative potential, highlighting the urgent need to develop specific discussions, protocols and legislation to ensure its safe and effective use in healthcare.

**Conclusion:** AI should be used as a complementary tool in medical practice, broadening the clinical and objective view, but without replacing the subjectivity of the doctor-patient relationship. Its innovative capacity is crucial for the advancement of health, as long as it respects and preserves the human function in the clinical process.

**Keywords:** Clinical diagnosis; Medical training; Machine learning; Digital health technology

### 1. Introduction

Artificial intelligence (AI) is an area of computer science that focuses on developing software and systems capable of performing functions that require human skills, such as perception, natural language, learning, reasoning, and decision-making. This technological field emerged in 1956, but only gained prominence in 1990, with the advancement of computing and the development of more efficient algorithms. Since then, AI has undergone constant evolution, being applied in various sectors as new discoveries and innovations emerge (Franco, 2024).

It is important to emphasize that the human mind has limitations, among them the ability to store a multitude of information over the long term over the years. Therefore, AI is increasingly being integrated into the health area,

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through systems that offer greater storage capacity, speed, and data accuracy. Over the years, this will result in large-scale experiments and increasingly efficient databases for research and the development of intelligent programs. These advances can support medical practice, assisting in clinical reasoning, in the preparation of examination reports and even in diagnoses, eventually reducing the dependence on certain specialties in the health area (Araújo *et al.*, 2023). Thus, it is worth noting that clinical deliberation involves a reasoning process in which doctors combine various pieces of information relating to a single individual in a coherent and appropriate manner, allowing a diagnosis to be reached and treatment to be planned, aiming to achieve the best prognosis and cure. However, reaching a diagnosis is not simple and requires a series of human skills, which can be susceptible to erroneous conclusions due to several factors. Furthermore, a clinical reasoning support system, based on relevant and well-processed information, developed in collaboration with specialist doctors and with an empirical connection of individual patient data, can generate complex and efficient data patterns. Therefore, these insights will serve as advice to healthcare professionals, and doctors will only need to interpret, integrate and contextualize them to reach a diagnosis with a low error rate. This helps in early treatment, prevention, improved prognosis and reduced healthcare costs (Boon; Verhoef; Baalen, 2021).

Currently, the doctor-patient approach centered on the patient as a whole has helped in the combination of large volumes of data and the use of AI software, providing better innovations and creations. However, this integration of medical intelligence with AI, despite reducing errors, raises many ethical and legal issues that still need to be evaluated and discussed. This is because, when a doctor uses artificial intelligence software and it indicates a diagnosis different from the hypothesis raised by the professional, if he chooses to ignore it without performing a thorough analysis and the result is erroneous, he becomes responsible. On the other hand, if he follows the diagnosis proposed by AI and causes harm to the patient, the circumstances must be carefully evaluated before holding him responsible. Thus, it is clear that these tools do not replace medical sovereignty and should be used as support. After all, the responsibility always falls on the healthcare professional responsible for the case (Nogaroli; Silva, 2020). In this regard, it is undeniable that AI has provided numerous benefits to healthcare as it advances, including practicality, speed, assistance in the development of medicines and research, reformulation of services and bioethical investigation. The Health 4.0 era, described by the robotic practice in surgical procedures and exams, the internet of things, characterized by the use of mobile devices for health monitoring and 3D printing, improves the quality of healthcare services and the well-being of patients. Thus, these innovations have been viewed positively and represent an opportunity to expand access to healthcare in remote or hard-to-reach areas, resulting, in the long term, in the improvement of the country's public health (Souza; Dias, 2024).

In view of the above, this study aims to investigate the use of Artificial Intelligence (AI) to improve clinical reasoning, highlighting its advantages, challenges, and ethical implications. The research seeks to analyze how AI can assist in medical practice, offering more accurate diagnoses and personalized treatments. The importance of this study lies in its transformative potential, since AI can improve the quality of health services and the well-being of patients. In addition, the work addresses significant challenges, such as the integration of clinical reasoning, data protection, inequality of access, and ethical issues, which are crucial for the safe and effective implementation of AI in healthcare. Finally, it highlights the urgency of developing specific discussions, protocols, and legislation to ensure the safe use of AI, respecting the human role in the clinical process.

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## 2. Methodology

This study is an integrative literature review, which uses a model that includes analyses of relevant research that assist in the resolution and improvement of clinical practice, enabling the synthesis of the state of knowledge on the use of artificial intelligence in clinical reasoning. Regarding the methodological procedure, it is a way of obtaining, identifying, analyzing and synthesizing directed at a specific theme that allows for a broad investigation of the literature, addressing discussions on published methods and results (Dantas *et al.*, 2022).

The identification of the articles included in this work was done through a search in the following electronic databases: PubMed, LILACS, SciELO, Cochrane library and Google Scholar, with no restriction on the type of study for the search. The search was conducted to identify articles relevant to the theme, using the following descriptors: "Artificial Intelligence" and "Clinical Reasoning", joined by the Boolean operator "AND".

The search resulted in 4.884 articles, of which 19 were selected to compose this review. The inclusion criteria were articles published in journals indexed in the chosen databases, in Portuguese and English, available in full, freely available from 2019 to July 2024, and that addressed the study question: "How can Artificial Intelligence assist in clinical reasoning?".

Articles that did not cover the review methodology, studies that did not provide the full text, duplicate articles, and research that went beyond the defined time period were excluded. Studies that did not address the topic of artificial intelligence applied to medicine were also discarded. In addition, studies that did not analyze the main advances and challenges on the topic were excluded.

**Table 1** Search strategy in the PubMed, Scielo, LILACS, and Google Scholar databases, published between 2019 and July 2024

Database	Search strategy	Article Found	Selected article
PubMed	“Inteligencia Artificial” AND “Raciocinio Clinico”	264	5
LILACS	“Inteligencia Artificial” AND “Raciocinio Clinico”	30	1
SciELO	“Inteligencia Artificial” AND “Raciocinio Clinico”	0	0
Google Academico	“Inteligencia Artificial” AND “Raciocinio Clinico”	4500	13
Cochrane Library	“Inteligencia Artificial” AND “Raciocinio Clinico”	0	0
total		4884	19

Source: Author's own (2024).

### 3. Results

**Table 2** Summary of information obtained from eligible articles in the investigation regarding how Artificial Intelligence can assist in clinical reasoning

Título	Autor/Ano	Objetivo/Método	Resultados/Conclusão
“How Clinicians Perceive Artificial Intelligence–Assisted Technologies in Diagnostic Decision Making: Mixed Methods Approach”	Hah and Goldin (2021)	The main objective is to understand how clinicians perceive and interact with AI technologies in healthcare settings. The study uses a mixed-methods approach, combining qualitative and quantitative analysis.	The results indicate that clinicians have a positive perception of AI technologies, but face challenges related to the interface and integration with their clinical reasoning processes. The effectiveness of AI in improving clinical decision-making has not been clearly demonstrated.
“AI-Enabled Medical Education: Threads of Change, Promising Futures, and Risky Realities Across Four Potential Future Worlds”	Knopp <i>et al.</i> (2023)	To investigate how AI is transforming medical education, identify opportunities and challenges in implementing AI, and provide insights into the responsible use of AI in this context. Literature review.	The study identified the potential benefits of AI in medical education, such as personalizing teaching, improving clinical practice, and improving learning efficiency. However, it also highlighted challenges, such as increasing complexity, privacy concerns, and inequalities in access.
“Personalizing Care Through Robotic Assistance and Clinical Supervision”	Sorrentino <i>et al.</i> (2022)	The main objective is to develop a personalized and adaptive robotic assistance system, integrating technologies based on artificial intelligence to support healthcare professionals and patients with diverse health needs. The study	The study demonstrated the feasibility and effectiveness of a cyclical procedure to support healthcare with robots, allowing personalization and adaptation of care behaviors. The robot's interaction parameters could be adjusted according to the residual abilities and cognitive profile of the people with whom they interacted.

		presents an applied research approach, focused on the implementation and evaluation of a robotic assistance system.	
"Addressing the Challenges and Barriers to the Integration of Machine Learning into Clinical Practice: An Innovative Method to Hybrid Human-Machine Intelligence"	Ed-Dirouch <i>et al.</i> (2019)	The goal is to integrate human intelligence into the learning process of ML algorithms to improve the accuracy of predictions of the course of MS. Development of a clinical decision support system (CDSS) for multiple sclerosis (MS) based on a collaboration between humans and algorithms.	The study demonstrated that collaboration between humans and algorithms in creating predictive models can significantly improve the predictive ability of MS. The conclusion highlights the importance of integrating human intelligence into the learning process of ML algorithms to overcome barriers to implementing ML-based systems in healthcare. The hybrid approach of human and artificial intelligence shows promise for improving clinical outcomes in medical practice.
"From clinical decision support to clinical reasoning support systems"	Baalen, Boon and Verhoef (2021)	To argue that the proper implementation of the clinical reasoning algorithm (CRSS) allows combining human and artificial intelligence in hybrid intelligence, where both perform clearly delineated and complementary empirical tasks.	CRSS can be a valuable tool for improving clinical practice if there is careful and responsible integration by clinicians, ensuring that the information provided by the system is understandable and useful to support informed clinical decisions..
"Artificial intelligence and imaging diagnosis - has the future arrived?"	Araujo-filho, Pinto and No mura (2019)	To present a balanced view on the topic with a focus on the present and future of cardiac imaging. Literature review.	Artificial intelligence should not be seen as a threat or replacement for human work, but rather as an opportunity to increase efficiency and accuracy in personalized patient care. This includes optimizing workflows and integrating diagnostic, predictive, and prognostic data. Clinical and pathophysiological knowledge remains essential to utilize and interpret in a balanced way the vast amount of new data generated by these tools.
"The Impact of Artificial Intelligence on Improving the Diagnosis and Treatment of Diseases in Patients"	Melo <i>et al.</i> (2021)	Address the role of artificial intelligence as a resource to optimize the process of diagnosing and treating various diseases in patients. Bibliographic review.	AI is a versatile technology that can be applied in many areas of healthcare, including clinical decision-making, public health, biomedical research, drug development, healthcare system management, and service redesign. Healthcare professionals have benefited from faster and more accurate diagnoses, individualized treatments, and proactive disease management by using AI algorithms to analyze large volumes of data. To ensure the responsible use of AI in healthcare, it is crucial to address issues such as data protection, algorithm transparency, and ethical concerns.
"The significance of artificial	Lemos <i>et al.</i> (2023)	Describe how physicians use these technologies in	Artificial Intelligence should not be seen as a replacement for doctors, multidisciplinary teams

intelligence in medicine: applications and perspectives”		their clinical practices. Scoping review.	or humanized treatment, but rather as a powerful ally. It cannot replicate the empathy, clinical judgment and experience that human professionals offer. Medical care is not limited to data analysis; it also encompasses understanding the emotional and individual needs of patients.
“Artificial Intelligence in the diagnosis of neurodegenerative diseases: a systematic literature review”	Brito <i>et al.</i> (2021)	Answer which artificial intelligence methods are used to diagnose degenerative diseases, but also, their application in other stages such as treatment and prognosis. Integrative literature review.	AI is a powerful resource to aid in the early diagnosis and management of neurodegenerative disorders, deepening the investigation of these pathologies, and can provide more practicality in the treatment of these diseases, and may be important for future research into early diagnosis, especially in the context of multimodal methods.
“Considerations on the legal challenges of using Artificial Intelligence in Medicine”	Lucas and Santos (2021)	Analyze the characteristics of AI systems in medicine, reflect on liability for damages caused and discuss the lack of specific legislation in Brazil on liability for autonomous AI actions. Literature review.	The study concludes that AI processes large amounts of data in a short time and with high precision, but it also presents challenges in terms of security and accountability. Furthermore, the work shows that there is no specific legislation in Brazil on accountability for autonomous AI actions in the medical field. The study shows the impact of AI on medicine, including: the development of computing, cloud storage, fast and accurate interpretation of images, improved workflow and potential reduction of medical errors.
“The Evolution of Medical Semiology: from Anamnesis to New Technological Approaches”	Aro <i>et al.</i> (2023)	Analyze the influence of new technologies (AI, 3D printer) on clinical practice and highlight the relevance of semiology in the current clinical context, even in the face of technological advances. Literature review.	The study concludes that a patient-centered clinical examination is essential, as is the relationship between the professional and the patient, which humanizes care and reinforces the importance of semiology even as technology continues to advance. The ideal is to integrate the two, aiming for a comprehensive and personalized approach, since understanding and interpersonal relationships are essential for the quality of clinical practice.
“Artificial Intelligence to assist in disease diagnosis processes”	Paz and Melo (2020)	To demonstrate the use of AI as an auxiliary tool in the diagnosis of diseases, exploring the feasibility of its use for more accurate and agile diagnoses. Literature review.	The study shows that AI is promising for its application, relevance, and potential positive impact in assisting disease diagnosis processes, based on significant results from previous studies that used intelligent systems to diagnose diseases. There is progress in improving medical care and quality of life, demonstrating the relevance and importance of AI as a tool. In addition, there is potential for AI development and new research that explores and expands its use in diagnostics, using it as a complementary tool in the health area, contributing to decision-making and the evolution of medical practice.
“Artificial intelligence in diagnostic analysis: benefits, risks and	Araújo <i>et al.</i> (2023)	Highlight the role of AI as an important resource for optimizing the diagnosis and treatment process of various diseases.	AI has the potential to revolutionize healthcare by improving diagnostics, treatments, and predictions. Its ability to process and analyze large volumes of data is essential to optimizing patient care. However, it is crucial to address

physician responsibility”		Literature review with a qualitative theoretical approach.	issues of data protection, algorithm transparency, and ethical concerns. As AI continues to develop, it promises to transform the healthcare industry, resulting in better care and outcomes for patients.
“The role of information and artificial intelligence in diagnostics with medical devices”	Souza, Dias and Dias (2024)	Identify the relevant information from the daily life of patients with implanted medical devices that can help guide medical diagnosis in technological solutions with artificial intelligence. Bibliographic review.	Machine learning tools can analyze this information in real time and provide personalized guidance to patients, as well as help doctors make more informed treatment decisions based on individual patient needs. The use of electronic health records is being mentioned to detect early signs of sepsis through multimodal deep learning, containing information such as vital signs, body temperature, blood oxygen levels, medical history, and prescribed medications. This helps in medical diagnosis, as sepsis can affect different body systems and present with a variety of symptoms.
“Artificial intelligence in medicine: advances and challenges”	Franco (2024)	Literature review on the automation and precision of surgical robots, combined with their ability to perform tasks with high precision and dexterity, have provided notable advances in medicine.	The convergence of robotics and medicine is emerging as a narrative filled with transformative potential, offering both substantial benefits and intricate challenges. The ever-evolving technology of robotics in medicine stands out as a valuable tool for improving the precision and efficacy of medical interventions, providing remarkable advances in surgical procedures, diagnostics, and personalized treatments. However, to maximize these benefits, it is imperative to carefully address ethical, regulatory, and educational issues. Responsible implementation of these technologies requires a delicate balance between scientific innovation, patient safety, and ethical considerations, to ensure that progress in robotic medicine is guided by humanistic principles and an unwavering commitment to the well-being of those we serve.
“Artificial intelligence in health, innovation or illusion?: study of multiple cases of implementation and use of artificial intelligence in hospitals in Brazil”	Silva (2023)	The aim of the study is to investigate how artificial intelligence can be implemented in hospitals, identifying dynamic capabilities, success factors and risks associated with this implementation. Multiple case study.	Artificial intelligence in healthcare is expanding and offers many opportunities to improve clinical processes, patient safety, and operational efficiency. However, successful implementation depends on factors such as data quality, healthcare worker engagement, organizational support, and open innovation. Revision of protocols and legislation is necessary to maximize the benefits of AI in healthcare.
“Artificial intelligence in medicine: surgical robots, digital neural networks, big data in health, infodemiology and	Andrade, Morais and Ramirez (2023)	The aim of this article is to explore the various applications of artificial intelligence in medicine, including the use of surgical robots, digital neural networks, big data	The paper concludes that artificial intelligence has significant potential to transform medicine on a number of fronts, from robot-assisted surgery to personalizing treatments based on big data. However, for these technologies to be fully integrated and used effectively, technical, ethical

bioprinting for tissue regeneration”		in health, infodemiology and bioprinting for tissue regeneration. Literature review.	and organizational challenges need to be addressed.
“Healthcare 4.0 – challenges and opportunities for the implementation of artificial intelligence in hospital environments”	Gatringer <i>et al.</i> (2022)	The objective of this article is to analyze the challenges and opportunities related to the implementation of artificial intelligence in hospital environments, in the context of Healthcare 4.0. Case study and systematic review.	The paper concludes that, despite significant challenges, the implementation of artificial intelligence in hospital settings offers enormous opportunities to transform healthcare. The success of this transformation depends on an integrated approach that considers technological, organizational and human aspects.

Source: Author's own (2024).

#### 4. Discussion

When analyzing the results obtained, it is possible to see that the view of doctors regarding the use of artificial intelligence, as evidenced in the study by Han and Goldin (2021), is positive. In this sense, according to Melo *et al.* (2021) and Araújo *et al.* (2023), the main challenges related to this new perspective are linked to the integration of clinical reasoning, as well as the maintenance of privacy, data protection, transparency of algorithms, and ethical concerns. This is due to the fact that the algorithm requires access to information and will produce data that must be carefully processed and stored (Nascimento *et al.*, 2020).

In addition, a factor that requires attention would be inequality of access, considering the scenario of discrepancy in access to technologies in different medical schools and health units. In this context, the study by Knopp *et al.* (2023) highlighted the growing complexity of technological democratization in the health system, which ends up reflecting on the way innovations are viewed and accepted by the individuals involved. This implies the development of prejudice, the result of ignorance towards the new and unknown (Barbosa, 2023). From this perspective, Lucas and Santos (2021) discuss the personalization of care provided by AI, since, through its use, it is possible to manipulate a large volume of data. This reality, as stated by Araújo-Filho, Pinto and Nomura (2016) and Paz and Melo (2020), allows the optimization of the workflow and the integration of diagnostic, predictive and prognostic data, which facilitates the expanded vision of the multidisciplinary team in front of the patient (Nascimento *et al.*, 2020). Furthermore, as cited by Lemos *et al.* (2023), such technologies have provided a great advance in the improvement of education and research, which directly influences the care provided in the health system (Pinto *et al.*, 2022).

Also in this context, the studies by Knopp *et al.* (2023) and Sorrentino *et al.* (2022) state that there is an improvement in clinical practice through the use of AI, which tends to provide greater viability and effectiveness of cyclical procedures, as well as the adaptation of care behaviors (Barreto *et al.*, 2023). Furthermore, the work of Andrade, Morais and Ramirez (2013) demonstrated the promising use of robots that interpret people's cognitive profile, and the parameters of this interaction can be adjusted, aiming at improving clinical practice. In this vein, the study by Baalen, Boon, and Verhoef (2021) points to the clinical reasoning algorithm (CRSS) as a valuable tool for improving clinical practice, provided that there is careful and responsible integration by the individuals who handle it. This reinforces the need to not see AI as a threat, since its effectiveness depends directly on the professionals who operate it. This paradigm reinforces the need to disseminate reliable information with the reality that permeates this innovative scenario (Brandes *et al.*, 2020). Following this logic, Lemos *et al.* (2023) and Aro *et al.* (2023) reinforce that artificial intelligence is not capable of developing empathy and attentiveness, which are fundamental for the humanization of medicine. This highlights the need for experienced clinical judgment, which exercises the person-centered clinical method (PCCM), using AI as the tool it truly is, with the aim of expanding the clinical and objective perspective, without leaving aside the subjectivity inherent in the humanity of the physician and the patient (Cruz *et al.*, 2020).

This panorama highlights the hybrid approach cited by Ed-Dirouch *et al.* (2019), which explains and discusses, applying it to multiple sclerosis (MS), the collaboration between humans and artificial intelligence in predicting and monitoring the disease. From this perspective, other possibilities are opened, among them, according to Brito *et al.* (2021), the use of AI for early diagnosis and management of neurodegenerative disorders, as well as in the detection of early signs of sepsis, as evidenced in Souza, Dias and Dias (2024), which is undoubtedly an evolution for medicine and society (Braga *et al.*, 2019).

In this context, Franco (2024) and Gatringer *et al.* (2022) complement the integration of technological, organizational, and human aspects into robotics, defending its intricate transformative potential. This narrative is based on precision and effectiveness, especially in surgical interventions. In this sense, in order to achieve the expected success, studies point to the urgency of a protocol that aims, first and foremost, to regulate patient safety, which requires a delicate balance between innovations and humanization (Barros *et al.*, 2020).

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## 5. Conclusion

In conclusion, the integration of Artificial Intelligence into medical practice represents an unprecedented opportunity to improve clinical reasoning and the quality of healthcare. The potential benefits, such as more accurate diagnoses, personalized treatments, and the ability to handle large volumes of data, are undeniable. However, it is essential that this implementation takes place responsibly, taking into account the ethical and legal challenges that arise with the use of AI. Continuous training of healthcare professionals and the creation of clear protocols are essential to ensure that the technology complements, and does not replace, human clinical judgment.

In addition, the need for an open dialogue between technology developers, healthcare professionals, and policymakers is crucial to establishing guidelines that ensure the safe and effective use of AI in medicine. Only through a collaborative approach will it be possible to maximize the benefits of AI while minimizing the associated risks. Thus, the future of health 4.0 depends not only on technological innovation, but also on the commitment to preserving the humanization of care, ensuring that the doctor-patient relationship continues to be the core of medical practice.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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