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Artificial intelligence in medicine: Clinical applications, ethical implications and challenges in medical training

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Abstract

Artificial intelligence (AI) has burst onto the medical scene as a transformative tool, with applications ranging from clinical image analysis to robotic surgery and computational drug discovery. This narrative review aims to critically analyze the role of AI in contemporary medicine, with an emphasis on its clinical, ethical, and educational implications. Technologies such as deep learning, radiomics, autonomous surgical intelligence, and generative models are addressed, as well as their impact on clinical decision-making and the training of future healthcare professionals. Through a critical synthesis of recent literature, the benefits of AI in reducing diagnostic errors, therapeutic personalization, and operational efficiency are examined, along with the risks associated with limited explainability, data security, and professional responsibility. It concludes that AI should not be understood as a substitute for clinical judgment, but rather as a complement that requires new ethical, technical, and cognitive skills in the practice and teaching of medicine.

Keywords: Artificial intelligence; Medical diagnosis; Clinical ethics; Medical training; Deep learning; Robotic surgery

1. Introduction

Artificial intelligence (AI) has become a transformative technology in contemporary medicine, with applications ranging from computer-assisted diagnosis to robotic surgery, drug discovery, and personalized nutrition (1–4). These advances have improved diagnostic accuracy, reduced human error, and optimized clinical decision-making in complex contexts such as critical care medicine (5).

However, its implementation raises fundamental questions about professional autonomy, clinical data security, accountability for algorithmic errors, and the preservation of the physician-patient relationship (6). The absence of consciousness, intuition, and sensitivity limits the ability of automated systems to adapt to unexpected clinical situations, requiring their use to be complementary to human medical judgment (7).

Furthermore, the conceptual evolution of AI from symbolic models (AI 1.0) to generative models (AI 3.0) implies a paradigm shift in medical training. Future professionals must understand not only the technical functioning of algorithms, but also their ethical, legal, and clinical implications (8).

The purpose of this narrative review is to critically analyze the impact of AI on medical practice, its current applications, its ethical implications, and its influence on professional training, in order to determine whether it represents a complementary diagnostic tool or an evolving ethical dilemma.

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2. Materials and methods

This work is a non-experimental narrative review of recent scientific literature on artificial intelligence (AI) in medicine, with an emphasis on its clinical applications, ethical implications, and challenges in medical training. Sources were selected between September and October 2025, using indexed databases such as PubMed, Nature, JAMA, and other high-impact scientific journals (9).

Review articles, experimental studies, and editorial perspectives published between 2018 and 2024, in English and Spanish, were included if they addressed at least one of the following topics: AI-assisted diagnosis, robotic surgery, drug discovery, personalized nutrition, safety and regulation of AI systems, medical training, and ethical dilemmas (9, 10).

A total of twelve articles were analyzed, selected for their relevance, timeliness, and disciplinary diversity. The information was organized thematically and critically synthesized, highlighting key findings, clinical applications, methodological limitations, and future projections. No meta-analysis criteria were applied, nor was systematic review software used, as the objective was to construct an integrative and reflective view of the current state and challenges of AI in medicine (9).

Since this study did not involve experimentation with humans or animals, no ethical approval or informed consent was required. All articles analyzed are publicly available in indexed academic sources.

3. Results

The review included twelve scientific articles published between 2018 and 2024, selected for their relevance in the analysis of clinical, pharmacological, surgical, nutritional, and ethical applications of artificial intelligence (AI) in medicine. AI has proven useful in cancer detection through deep radiomic analysis, avoiding invasive procedures such as biopsies. These tools allow predictive models to be generated from non-invasively acquired medical images and h , correlating patterns invisible to the human eye with molecular and clinical-demographic profiles (4).

Although skepticism persists among surgeons, autonomous actions in AI-assisted surgery already exist, especially in interventional radiology and endoscopy. The integration of computer vision, deep learning, and natural language processing has enabled advances in automated surgical movements. The adoption of computational haptics could accelerate the transition to more independent procedures (5).

AI has also transformed drug design through virtual screening, de novo design, toxicity prediction, and synthesis planning. Algorithms such as deep neural networks and quantum mechanics-based models allow molecular interactions to be modeled with high precision, reducing costs and development times (3).

In the field of clinical nutrition, AI has enabled automated food recognition, dietary assessment, and prediction of metabolic diseases. These tools contribute to the personalization of nutritional interventions and the monitoring of eating habits (10).

In critical care medicine, the AI Clinician model demonstrated that automated decisions were less risky than human decisions when safety constraints were applied. This finding suggests that AI-based clinical systems can improve therapeutic safety if properly validated (1).

Table 1 Clinical applications of AI in medicine and their ethical implications

Subject area	Main applications	Notable benefits	Ethical and clinical risks
Assisted diagnosis	Radiomics, cancer prediction	Accuracy, non-invasiveness	Limited explainability
Robotic surgery	Telemanipulation, surgical automation	Efficiency, reduction of human error	Lack of haptics, algorithmic autonomy
Drug discovery	Virtual screening, de novo design	Cost reduction, personalized therapies	Experimental validation

Personalized nutrition	Food recognition, metabolic prediction	Individualized intervention	Data privacy
Critical care medicine (AI Clinician)	Sepsis treatment, automated decisions	Therapeutic safety	Professional responsibility

4. Discussion

Artificial intelligence has transformed multiple areas of medicine, offering improvements in diagnostic accuracy, operational efficiency, and therapeutic personalization. In the field of diagnosis, deep radiomic analysis has made it possible to correlate medical images with molecular profiles, reducing the need for invasive procedures and improving early cancer detection (4).

In surgery, the development of robotic systems with telemanipulation and autonomous action capabilities has generated new clinical possibilities. Although the lack of haptics has limited their adoption, it is proposed that advances in computational perception could overcome this barrier, allowing for more independent surgical movements (5).

Computational drug discovery has been revolutionized by AI algorithms that enable highly accurate modeling of molecular interactions. These tools have significantly reduced development costs and times and expanded access to personalized therapies (3).

In the field of nutrition, AI has enabled the development of systems capable of recognizing foods, evaluating diets, and predicting metabolic risks. These technologies not only improve therapeutic adherence but also allow for interventions that are more tailored to the individual patient's profile (10).

From a regulatory perspective, explicit evidence of safety and explainability is required to ensure professional confidence. In the case of AI Clinician, automated decisions were shown to be less risky than human decisions when safety constraints were applied, suggesting that AI-based clinical systems can improve therapeutic safety if properly validated (1).

The conceptual evolution of AI from symbolic models (AI 1.0) to generative models (AI 3.0) implies a paradigm shift in medical training. Future professionals must understand not only the technical functioning of algorithms, but also their ethical, legal, and clinical implications (8).

Finally, although AI is a powerful tool, it should not be considered a foolproof solution or a substitute for clinical judgment. Its use should be complementary, guided by bioethical principles, and supported by comprehensive medical training (6). This review proposes that the real challenge is not technological, but educational: integrating AI as a critical ally in medical practice without losing sight of human responsibility.

5. Conclusion

Artificial intelligence has established itself as a transformative tool in contemporary medicine, with clear benefits in diagnostic accuracy, operational efficiency, and therapeutic personalization. However, its implementation raises ethical, legal, and educational challenges that require critical reflection.

AI lacks consciousness, intuition, and sensitivity, which limits its ability to adapt to unexpected clinical situations. Therefore, it should not be considered a substitute for clinical judgment, but rather a complement that requires new technical, ethical, and cognitive skills in healthcare professionals.

Medical training must incorporate critical analysis of algorithmic systems, understanding of their limitations, and the development of skills for their responsible use. The integration of AI into medicine must be guided by bioethical principles, rigorous scientific validation, and clear regulation that ensures patient safety and professional responsibility. This approach will allow the potential of AI to be harnessed without compromising the fundamental values of medical practice.

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