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The indispensable synergy: the future of medicine with artificial intelligence as the physician's co-pilot

A sinergia indispensável: o futuro da medicina com a inteligência artificial como copiloto do médico

La sinergia indispensable: el futuro de la medicina con la inteligencia artificial como copiloto del médico

Leonardo de Abreu Santos[1], Gabriel Cunha Santiago de Oliveira[1], Bruno Fernandes de Oliveira Santos[1].

ABSTRACT

Objective: To present the Artificial Intelligence (AI) applied to healthcare, analyzing its potential to optimize diagnoses and treatments in an era of unprecedented transformation. This study examines the role of physician supervision, clinical judgment, and empathy as fundamental pillars of medical practice. **Bibliographic review:** This narrative review explores the thesis that, rather than replacing human professionals, AI will become an indispensable synergistic tool. Using the analogy of the autopilot system in aviation, the article posits that the physician will act as the "commander of care." At the same time, AI will function as a high-performance "co-pilot," automating analytical tasks and processing large volumes of data. The profound implications for medical education are discussed, highlighting the need for curriculum reform to include data science literacy and strengthen irreplaceable skills such as ethics, communication, and empathy, thereby enhancing the physician-patient relationship. **Final considerations:** It can be considered that the successful integration of AI will depend on the healthcare system's ability to cultivate a collaborative model. In this model, technology does not supplant human capability but enhances it, enabling a medical practice that is more precise, efficient, and, paradoxically, more humane.

Keywords: Artificial Intelligence, Education, Medical, Physician-patient relations, Clinical decision-making, Biomedical technology.

RESUMO

Objetivo: Apresentar a Inteligência Artificial (IA) aplicada à saúde, analisando seu potencial para otimizar diagnósticos e tratamentos em um cenário de transformação sem precedentes. O estudo avalia como a supervisão, o julgamento clínico e a empatia do médico permanecerão como pilares fundamentais da prática médica. **Revisão bibliográfica:** Esta revisão narrativa explora a tese de que, longe de substituir os profissionais humanos, a IA se tornará uma ferramenta sinérgica indispensável. Utilizando a analogia do piloto automático na aviação, o artigo postula que o médico atuará como o "comandante do cuidado", enquanto a IA funcionará como um "copiloto" de alta performance, automatizando tarefas analíticas e processando grandes volumes de dados. Discutem-se as implicações profundas para a formação médica, que exigirá uma reforma curricular para incluir noções de ciência de dados e fortalecer habilidades insubstituíveis como ética, comunicação e empatia, potencializando a relação médico-paciente. **Considerações finais:** Pode-se considerar que a integração bem-sucedida da IA dependerá da capacidade do sistema de saúde de cultivar um modelo colaborativo. Neste modelo, a tecnologia não suplanta, mas potencializa a capacidade humana, permitindo uma prática médica mais precisa, eficiente e, paradoxalmente, mais humana.

Palavras-chave: Inteligência Artificial, Educação, Médica, Relações médico-paciente, Tomada de decisões clínicas, Tecnologia biomédica.

[1] Curso de Medicina, Universidade Federal de Sergipe (UFS), Aracaju - SE.
[1] Health Sciences Graduate Program, Federal University of Sergipe, Aracaju - SE.

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RESUMEN

Objetivo: Presentar la Inteligencia Artificial (IA) aplicada a la salud, analizando su potencial para optimizar diagnósticos y tratamientos en un escenario de transformación sin precedentes. El estudio evalúa cómo la supervisión, el juicio clínico y la empatía del médico permanecerán como pilares fundamentales de la práctica médica. **Revisión bibliográfica:** Esta revisión narrativa explora la tesis de que, lejos de sustituir a los profesionales humanos, la IA se convertirá en una herramienta sinérgica indispensable. Utilizando la analogía del piloto automático en la aviación, el artículo postula que el médico actuará como el "comandante del cuidado", mientras que la IA funcionará como un "copiloto" de alto rendimiento, automatizando tareas analíticas y procesando grandes volúmenes de datos. Se discuten las profundas implicaciones para la formación médica, que requerirá una reforma curricular para incluir nociones de ciencia de datos y fortalecer habilidades insustituibles como la ética, la comunicación y la empatía, potenciando la relación médico-paciente. **Consideraciones finales:** Se puede considerar que la integración exitosa de la IA dependerá de la capacidad del sistema de salud para cultivar un modelo colaborativo. En este modelo, la tecnología no suplanta, sino que potencia la capacidad humana, permitiendo una práctica médica más precisa, eficiente y, paradójicamente, más humana.

Palabras clave: Inteligencia Artificial, Educación, Médica, Relaciones médico-paciente, Toma de decisiones clínicas, Tecnología biomédica.

INTRODUCTION

Contemporary medicine is on the cusp of a monumental shift, driven by rapid advances in artificial intelligence (AI). Recent reports from the World Health Organization (WHO) indicate that global investment in digital health, including AI, is expected to exceed $400 billion by 2025, reflecting an unprecedented acceleration in the adoption of these technologies to address challenges such as population aging and chronic disease management (WHO, 2024). This volume of investment signals a paradigm shift, where healthcare infrastructure and professional training will need to rapidly adapt to incorporate data-driven solutions.

These computational systems, equipped with the ability to learn, reason, and make decisions from vast data sets, are progressively becoming integrated into clinical practice. Their integration promises to redefine the standards of diagnosis, treatment, and health management. The potential of AI, particularly the subfield of deep learning, to identify patterns in medical images with accuracy that rivals or even surpasses that of human experts is a notable example of its disruptive power. From radiology to genomics, from robotic surgery to the discovery of new drugs, AI is emerging as a catalyst for innovation, offering the prospect of more precise, personalized, and efficient medicine (TOPOL EJ, 2019).

In the Brazilian context, this transformation is also gaining momentum. Initiatives such as the Ministry of Health's SUS Digital program seek to structure digital transformation in the public health system, envisioning the use of AI to optimize queue management, predict epidemiological outbreaks, and support clinical decision-making through smarter electronic medical records (BRASIL, 2020). The use of machine learning algorithms is already a reality in centers of excellence for analyzing imaging exams and stratifying patient risk, demonstrating the potential to improve care in a healthcare system of continental dimensions, although it faces challenges of scalability and equity in access.

However, this technological revolution does not occur without profound questions and, at times, concerns. The central question that arises is: what will be the physician's place in a healthcare ecosystem that is increasingly automated and dependent on algorithms? The growing sophistication of AI, capable of performing complex cognitive tasks, raises questions about the sustainability of the traditional role of the physician, historically centered on the accumulation of knowledge and the interpretation of clinical data (VERGHESE A, et al., 2018). This debate is crucial, as it will shape not only the future of the profession, but also the very nature of the therapeutic relationship and healthcare.

The current transformative landscape demands a nuanced and balanced analysis that transcends the simplistic "human versus machine" dichotomy. It is crucial to explore how the unique capabilities of human intelligence—such as abductive reasoning, empathy, ethical judgment, and the ability to understand the patient's sociocultural context—can be synergistically combined with the computational efficiency of AI

(PIRRERA A, et al., 2023). The history of technology in medicine highlights that the most impactful innovations were not those that replaced physicians, but rather those that augmented their abilities, such as the stethoscope, the microscope, and MRI. In this context, AI should be seen not as a threat, but as the most powerful tool for augmenting medical cognition ever developed.

Therefore, this narrative review proposes to deconstruct the notion of replacement, advocating for a model of enhanced collaboration and cooperation. The objective of this study is to present and summarize, through a logical argument grounded in current scientific literature, the future of medical practice as a symbiotic partnership between human and artificial intelligence, using the analogy of the pilot and the autopilot system in aviation as a guiding principle. It will explore how AI can optimize analytical and procedural tasks, freeing physicians to focus on the more human and complex aspects of care, such as communication, shared decision-making, and emotional support, which remain irreducible to algorithms.

BIBLIOGRAPHIC REVIEW

The state of the art of artificial intelligence in clinical practice

The application of AI in healthcare has already transcended the conceptual phase to become a tangible reality in several specialties. In radiology, convolutional neural network (CNN) algorithms demonstrate remarkable performance in detecting anomalies in imaging exams. Studies have shown that AI systems can identify lung nodules in chest computed tomography (CT) scans (ARDILA D, et al., 2019) or classify skin lesions suspected of malignancy with accuracy comparable to that of experienced dermatologists (ESTEVA A, et al., 2017).

In cardiology, for example, algorithms have already demonstrated superior performance than cardiologists in interpreting electrocardiograms (ECGs) to detect complex arrhythmias, optimizing diagnostic time in emergencies (BARTUSIK-AEBISHER D, et al., 2025). Similarly, in ophthalmology, AI has been successfully used to screen for diabetic retinopathy, a prevalent cause of blindness, enabling early and widespread detection (GULSHAN V, et al., 2016). These tools are not intended to replace radiologists or ophthalmologists, but rather to act as a support system, prioritizing urgent cases, reducing workload, and minimizing diagnostic errors due to fatigue or inattention.

In surgery, AI is enhancing existing robotic platforms. Systems like the Da Vinci robot, when assisted by AI, can analyze videos of surgical procedures to identify best practices, provide real-time feedback on the surgeon's technique, and even automate repetitive tasks, such as suturing, with superhuman precision and consistency (HASHIMOTO DA, et al., 2018). Furthermore, AI plays a crucial role in preoperative planning, creating 3D models from patient imaging scans, allowing surgeons to simulate and optimize surgical approaches before even entering the operating room, resulting in safer and more effective procedures.

In the field of anesthesiology, AI-guided closed-loop systems promise safer and more personalized administration of anesthetic drugs. These systems continuously monitor a range of patient physiological variables (electroencephalogram, blood pressure, heart rate) and adjust the infusion of anesthetic agents in real time to maintain the patient at the optimal level of sedation, avoiding both underdosing and overdosing (CONNOR CW, 2019).

Beyond procedural-focused specialties, AI is transforming internal medicine and chronic disease management. Natural language processing (NLP) algorithms can extract clinically relevant information from unstructured electronic health records, such as progress notes and discharge summaries, enabling the identification of patient cohorts for clinical trials or adverse event monitoring (WANG Y, et al., 2018). Predictive models, using data from multiple sources, can already identify patients at high risk of developing conditions such as acute kidney injury or sepsis in the hospital setting, enabling early, life-saving interventions (NEMATI S, et al., 2018).

In oncology, AI is driving precision medicine by analyzing genomic and molecular data to recommend personalized targeted therapies for each patient, increasing treatment efficacy and minimizing toxicity (KUMAR

A, 2024). Tools like IBM Watson Health, although complex to implement, have pioneered the attempt to aggregate vast volumes of medical literature and patient data to suggest cancer treatment plans. More recently, large language models such as Google's Med-PaLM 2 have demonstrated the ability to answer complex medical questions with high accuracy, approaching the level of human experts in medical licensing exams, signaling the potential of generative AI as a tool to support clinical reasoning (SINGHAL K, et al., 2023).

The autopilot analogy: the physician as commander of care

The evolution of commercial aviation offers a powerful and illuminating parallel for understanding the future relationship between doctors and AI. Modern aircraft are equipped with highly technological and sophisticated autopilot software (Flight Management Systems), capable of managing most of the flight, from takeoff to landing, with an efficiency and precision that far exceeds human capabilities under normal conditions (WIENER EL, 1989). However, the presence of human pilots in the cockpit remains an unquestionable legal and safety requirement.

The reason for this lies not in a distrust of technology, but in the recognition of its intrinsic limitations in the face of the unexpected. As argued by several experts in human factors and technology, and exemplified by the famous case of US Airways Flight 1549, in which the pilot was forced to make an emergency landing on the Hudson River, technology is designed to operate within predefined parameters (SULLENBERGER BS, 2009). It performs specific tasks with excellence, but it cannot improvise, make creative decisions, or manage complex crises that its programmers did not anticipate.

The human pilot is trained not only to operate the technology but, crucially, to monitor it and intervene when it fails or when it encounters an atypical situation—the so-called "perfect storm" of unforeseen events. Their role has evolved from constant manual control to one of supervision, systems management, and strategic decision-making in critical moments (BAINBRIDGE L, 1983). Similarly, the physician of the future will act as the "commander" of patient care. AI will be its high-performance "copilot," performing analysis of large volumes of data, identifying subtle patterns in exams, calculating diagnostic probabilities, and recommending treatment plans based on millions of clinical cases and the latest scientific literature (TOPOL EJ, 2019). This automation of routine cognitive tasks will free the physician from a purely analytical, memorization-based workload.

However, the ultimate responsibility will always fall to the physician, who will perform functions that AI, by its nature, cannot fulfill. The first is critical oversight. The physician must be able to understand the algorithm's outputs, question its recommendations, and identify potential biases in the data on which the AI was trained, which could lead to incorrect recommendations for specific patient populations (OBERMEYER Z, et al., 2019). The risk of algorithmic bias is one of the most significant ethical concerns, as algorithms trained on demographically homogeneous data can perpetuate or even amplify existing health disparities, harming minorities and vulnerable populations (CHEN RJ, et al., 2023).

The second function is contextual integration. AI can process clinical data, but it does not understand the patient's life context: their values, beliefs, socioeconomic status, and personal preferences. It is up to the physician to integrate the AI's technical recommendation into the patient's life plan, in a shared decision that respects their autonomy (AHUJA AS, 2019). Finally, and perhaps most importantly, there is the human and relational function. Medicine is not only a science, but also an art of caring. The ability to communicate a difficult diagnosis with empathy, to offer comfort, to build a therapeutic alliance based on trust, and to be present in the patient's moments of greatest vulnerability are exclusively human skills that form the core of medical practice and are, in themselves, therapeutic (VERGHESE A, 2011).

The need for adaptation and the reform of medical education

The integration of AI into clinical practice will not be optional; it will be inevitable. Professionals who refuse to embrace and understand these new tools will face a serious risk of professional obsolescence, not because AI will replace them, but because colleagues who effectively utilize AI will be able to provide higher-quality, safer, and more efficient care (KOLACHALAMA VK and GARG PS, 2018). Consequently, medical education faces the urgent challenge of adapting to this new reality. Traditional medical curricula, heavily focused on

memorizing facts, will need to be redesigned to cultivate the skills that will be most valued in the AI era (MASTERS K, 2019).

One of the key changes should be the introduction of fundamental concepts in data science, statistics, and AI literacy. The physician of the future will not need to be a programmer. However, they will need to understand the basic principles of how machine learning algorithms work, their potential, and, crucially, their limitations and sources of error (JOHNSTON SC, 2018). This understanding is essential for critically evaluating the AI tools they will use in their daily practice, rather than accepting them unquestioningly. The ability to interpret the results of a predictive model, to understand concepts such as sensitivity, specificity, and the importance of external validation of an algorithm, will be as fundamental as knowing how to interpret an electrocardiogram. This digital literacy is the foundation for effective and ethically responsible clinical supervision.

Beyond technical training, medical education must further strengthen the development of so-called "human skills." In a world where factual information is instantly accessible through intelligent systems, the ability to think critically, solve complex problems, communicate effectively, and work in interdisciplinary teams will become the key differentiator of the human professional (COOKE M, et al., 2010). Training in empathy, medical ethics, and clinical communication must cease to be an ancillary component of the curriculum and become central. Clinical simulation, structured feedback, and reflection on practice will be essential pedagogical tools for developing these skills (DOSHI A, et al., 2019).

Training must, therefore, cultivate a mindset of "constructive skepticism," where technology is seen as a hypothesis to be verified by clinical judgment, rather than as an absolute truth. Ultimately, medical education should prepare future professionals not to compete with AI in tasks where the machine is superior, but to collaborate with it intelligently and to excel in those dimensions of care where humanity is, and likely always will be, irreplaceable.

Bioethics and medical education: the balance between automation and humanization

The inclusion of AI in medicine raises complex bioethical dilemmas that require in-depth reflection in medical training. The question of professional liability is central: in the event of an AI-assisted diagnostic or therapeutic error, who is responsible? The physician who oversaw the decision, the hospital that acquired the technology, or the company that developed the algorithm? The lack of a clear legal framework creates a zone of uncertainty that needs to be debated (RATTI E, et al., 2025). Another critical point is informed consent. Patients have the right to know when AI is being used in their care and to understand its limitations. From the patient's perspective, informed consent acquires new layers of complexity.

It is not enough to simply consent to a procedure; the patient must understand, in accessible terms, the role of the algorithm in their care journey, including its margins of error and the guaranteed human oversight. Building trust in this new triangular therapeutic relationship (doctor-patient-AI) will be fundamental to the acceptance and success of these technologies. Furthermore, the protection of health data, considered sensitive, is paramount. In Brazil, the General Data Protection Law (LGPD) imposes strict rules for the processing of this data, and the use of AI algorithms must guarantee anonymization and security to prevent the misuse of personal information.

Given this scenario, medical training must incorporate a robust debate on the ethics of AI. National and international authors argue that curricula should prepare future physicians to be conscious "digital citizens" capable of navigating the ethical challenges of automation. This requires not only understanding the technology but also developing a critical sense of its social impact. The main challenge is finding the balance between automation and humanization. Excessive technological reliance emerges as a tangible risk, potentially stunting clinical reasoning and the physician's ability to improvise when faced with atypical scenarios not anticipated by the algorithm.

A significant ethical hurdle is the "black box" nature of many advanced deep learning models. When an algorithm provides a recommendation without a clear and interpretable rationale, it challenges the physician's ability to critically evaluate and take full responsibility for the decision. This opacity undermines the principles

of accountability and transparency, making it imperative that medical education prepares future physicians with the skills to question and demand explainability from the technologies they employ. There is a real risk that overreliance on technology will lead to the dehumanization of care, transforming the consultation into an interaction mediated by screens and data, and eroding fundamental clinical skills such as history taking and physical examination. The physician may become a mere "system operator," losing the capacity for independent clinical reasoning.

However, a forward-looking and optimistic view suggests otherwise: AI can, paradoxically, contribute to a more humanized medical practice. By automating bureaucratic and analytical tasks that currently consume a large portion of a physician's time—such as filling out medical records, reviewing exams, and searching for literature—technology can free professionals to dedicate more time to what truly matters: talking to patients, providing a personal touch, listening attentively, and building a relationship of trust. In this vision, AI acts as a "bureaucratic filter," absorbing the administrative and repetitive tasks that, according to studies, consume up to two-thirds of a physician's time.

This workflow optimization is not an end in itself, but a means to recover quality clinical time, enabling longer consultations, more active listening, and truly person-centered care, strengthening the therapeutic alliance that is, in itself, a vital component of the healing process. Contemporary medical training must therefore focus on preparing physicians for this new reality, teaching them to use AI as a tool to enhance, not replace, human interaction.

Future directions and policy recommendations

The path forward to achieving a human-centric integration of AI in medicine is not one of passive observation, but of active construction. This requires a concerted, multidisciplinary effort from medical schools, regulatory bodies, and health systems to co-design a future where technology serves humanity. As a direct response to the challenges outlined, several lines of research and policy action become imperative. Future research should prioritize longitudinal studies to measure the real-world impact of AI on the development of clinical reasoning in medical students and residents, clarifying whether these tools act as a cognitive support or a crutch. Concurrently, it is crucial to develop and validate ethical frameworks for auditing algorithmic bias, ensuring these tools are fair and effective across diverse populations, such as Brazil's heterogeneous society.

From a policy perspective, the ambiguity surrounding legal liability must be addressed. The development of clear public policies that establish guidelines for responsibility in cases of AI-related error is a critical step to provide legal security for professionals and patients. This effort must be coupled with educational reform, moving beyond isolated initiatives to establish national curricula for digital literacy in medical schools. Finally, to foster innovation without compromising patient safety, practical recommendations include the creation of “regulatory sandboxes”. These controlled environments would allow for the safe and supervised development and testing of new AI tools within public healthcare systems, such as Brazil's Unified Health System (SUS). Such initiatives are fundamental to ensuring that technological advances promote equity and improve access to high-quality care, rather than exacerbating existing disparities, ultimately allowing machines to handle data so that humans can focus on healing.

FINAL CONSIDERATIONS

Artificial intelligence represents not the end of medicine, but its next great evolutionary leap, framed within a model of synergistic collaboration where the physician remains the ultimate commander of care. This narrative review argues that the future lies in a partnership where AI, with its ability to process vast data, acts as a powerful assistant, while the physician applies wisdom, ethical judgment, and empathy to oversee the technology and care for the person behind the illness. The debates presented reinforce the urgency of addressing ethical and legal challenges, such as professional liability and algorithmic bias, requiring proactive reform in medical education that integrates digital literacy and AI bioethics. Although this study is prospective due to the evolving nature of the technology, the path forward demands active construction through joint efforts. Future research should focus on the impact of AI on clinical reasoning, the creation of frameworks for auditing

bias, and the development of public policies for legal liability, ensuring that this technological revolution serves to restore the sanctity of the doctor-patient relationship by allowing humans to focus on healing.

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