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REVIEW

Artificial Intelligence in the Intensive Care Unit: Present and Future

Inteligencia Artificial en la Unidad de Cuidados Intensivos: Presente y Futuro

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ABSTRACT

Introduction: artificial intelligence (AI) is significantly transforming critical medicine and intensive care. Its ability to process large volumes of data and generate accurate predictions has improved medical decision-making, optimizing diagnosis, treatment, and reducing the workload of healthcare personnel.
Method: a literature review was conducted between November 2024 and February 2025, consulting databases such as SciELO, LILACS, Scopus, PubMed-MedLine, Google Scholar, and ClinicalKeys. Original articles, case reports, and open-access systematic reviews from the last 5 years were selected, using descriptors in Health Sciences (DeCS) and Boolean operators for the search.
Development: current applications of AI in the ICU include: Monitoring and early detection of adverse events using sensors and machine learning algorithms; diagnosis and prognosis through deep neural networks for medical image interpretation; treatment optimization, including adjustments in mechanical ventilation and pharmacogenomics; efficient management of hospital resources. The future of AI in critical care is oriented towards more explanatory and transparent systems, personalized precision medicine, integration with emerging technologies and automation of clinical processes.
Conclusions: artificial intelligence (AI) is redefining care in intensive care units, improving diagnostic accuracy, optimizing treatments, improving clinical decision-making and thus allowing more efficient hospital management. However, as advanced as it is, it will never replace the empathy and clinical judgment of healthcare professionals. By integrating AI responsibly, we not only save more lives, but we also humanize critical patient care, always remembering that, at the heart of intensive medicine, there is compassion and commitment to each patient.

Keywords: Artificial Intelligence; Intensive Care Unit; Critical Medicine; Machine Learning; Precision Medicine.

RESUMEN

Introducción: la inteligencia artificial (IA) está transformando significativamente la medicina crítica y la terapia intensiva. Su capacidad para procesar grandes volúmenes de datos y generar predicciones precisas ha mejorado la toma de decisiones médicas, optimizando el diagnóstico, tratamiento y reduciendo la carga de trabajo del personal de salud.

Método: se realizó una revisión bibliográfica entre noviembre 2024 y febrero 2025, consultando bases de datos como SciELO, LILACS, Scopus, PubMed-MedLine, Google Académico y ClinicalKeys. Se seleccionaron artículos originales, reportes de caso y revisiones sistemáticas de acceso abierto de los últimos 5 años, utilizando descriptores en Ciencias de la Salud (DeCS) y operadores booleanos para la búsqueda.

Desarrollo: las aplicaciones actuales de la IA en la UCI incluyen: Monitorización y detección temprana de eventos adversos mediante sensores y algoritmos de aprendizaje automático; diagnóstico y pronóstico a través de redes neuronales profundas para interpretación de imágenes médicas; optimización de tratamientos, incluyendo ajustes en ventilación mecánica y farmacogenómica; gestión eficiente de recursos hospitalarios. El futuro de la IA en cuidados críticos se orienta hacia sistemas más explicativos y transparentes, medicina de precisión personalizada, integración con tecnologías emergentes y automatización de procesos clínicos.

Conclusiones: la inteligencia artificial (IA) está redefiniendo la atención en las unidades de cuidados intensivos, mejorando la precisión diagnóstica, optimizando tratamientos, mejorando la toma de decisiones clínicas y así permitiendo una gestión hospitalaria más eficiente. Sin embargo, por avanzada que sea, nunca reemplazará la empatía y el juicio clínico de los profesionales de la salud. Al integrar la IA de manera responsable, no solo salvamos más vidas, sino que también humanizamos la atención del paciente crítico, recordando siempre que, en el corazón de la medicina intensiva, late la compasión y el compromiso con cada paciente.

Palabras clave: Inteligencia Artificial; Unidad de Cuidados Intensivos; Medicina Crítica; Aprendizaje Automático; Medicina de Precisión.

INTRODUCTION

Critical care medicine and intensive care are disciplines focused on the study and management of diseases and injuries that can lead to a patient's critical condition or death. They aim to provide systematic, high-quality medical care, implementing therapeutic strategies that save lives.[1] In this context, artificial intelligence (AI) has emerged as a revolutionary medical tool, especially in highly complex environments such as the intensive care unit (ICU). Its ability to process large volumes of data and generate accurate predictions has significantly improved clinical decision-making.[2,3] AI not only optimizes diagnosis and treatment but also helps reduce the workload of healthcare personnel and improves patient safety. In this context, it is essential to assess the current state of AI in the ICU and to project its future in the care of the critical patient. Artificial intelligence (AI) is the simulation of human intelligence in machines, enabling them to perform advanced analysis and make decisions based on data patterns.

AI should not be confused with machine learning (ML) or deep learning (DL), which operate on the principle of identifying the identification of recurring patterns in a data set.[4] AI and machine learning have helped doctors in various labor-intensive tasks, such as rapid diagnosis and prediction of patient outcomes, risk stratification, optimization of resource allocation, and continuous patient monitoring. Recently, the role of AI in emergency and intensive care settings has become a topic of interest. AI can automate the monitoring of critical patients and predict prognosis.[5] The growing interest in implementing AI and machine learning in intensive medicine has driven the development of models capable of predicting the prognosis of critical patients. For example, Elhazmi et al.[6] used machine learning algorithms called decision trees to identify predictors of 28-day ICU mortality in critically ill COVID-19 patients. However, the literature addressing these applications is still limited, especially in middle-income countries such as Bolivia and other Latin American countries. This review article analyzes numerous applications of AI in critical care medicine, its disadvantages, the future, and possible changes in the training of future critical care specialists.[7]

METHOD

A literature review covered the period from November to December 2024 and January to March 2025. Original articles, case reports, and systematic reviews with open access in peer-reviewed academic publications published in the last five years were consulted in the databases SciELO, LILACS, Scopus, PubMed-MedLine, the search engine Google Scholar, as well as in the services ClinicalKeys. For the search, the thesaurus of Health Sciences Descriptors (DeCS) was used, and the keywords were selected and combined using Boolean operators with search formulas according to the syntax requested by each database. To guarantee the quality and relevance of the chosen information, letters to the editor and conference proceedings were excluded. In addition, case series, original articles, and systematic reviews were prioritized to guarantee that the review would have the best available evidence.

DEVELOPMENT

1. Current applications of AI in the ICU

- *Monitoring and Early Detection:* Artificial intelligence has enabled continuous and automated ICU monitoring of patients' vital signs. Advanced sensors collect real-time data, which is processed using machine learning algorithms to identify abnormal patterns. These systems have been shown to predict adverse events such as sepsis, respiratory failure, and hemodynamic shock more accurately than traditional methods.[8]
- *Diagnosis and Prognosis*: AI algorithms and intense neural networks have been shown to perform on par with specialists in interpreting medical images. In addition, predictive models make it possible to estimate the clinical evolution of patients in the ICU, facilitating personalized medical decision-making. Likewise, analyzing biomarkers and electronic records based on AI tools has shown efficacy in risk stratification and selecting the optimal treatment for each patient.[9]
- *Optimization of Treatment*: Advances in AI have led to the development of systems capable of adjusting mechanical ventilation parameters according to the patient's physiological responses, optimizing their respiratory support. AI has also been used in pharmacogenomics, allowing therapies to be personalized according to the patient's genetic profile, reducing adverse effects, and improving treatment efficacy.[10]
- *Resource Management:* The application of predictive models in the ICU facilitates optimizing the allocation of beds, equipment, and medical personnel. AI has proven to be a key tool in reducing unnecessary hospitalization times and improving the operational efficiency of critical care units, contributing to the sustainability of the healthcare system.[11]

2. Future of AI in Critical Care

- *Explanatory and Transparent AI:* Artificial intelligence algorithms are being developed that, in addition to being accurate, are understandable and transparent, allowing doctors to understand and trust their recommendations. This is crucial for the effective integration of AI into clinical decision-making. [12]
- *Precision Medicine in the ICU:* AI is expected to continue advancing toward the personalization of treatments in the ICU, using genomic and clinical data to predict each patient's response to different therapies. This will allow for more effective treatments with a lower risk of adverse effects.[13]
- *Integration with Emerging Technologies*: Combining AI with smart devices, portable sensors, and telemedicine systems will enhance remote monitoring and real-time decision-making. These advances will enable the early detection of complications, even before the patient reaches a critical state.[14]
- Automation of Clinical Processes: AI is expected to contribute to the automation of various clinical and administrative tasks within the ICU, such as medical record management, drug dosing, and clinical report generation. This will allow medical staff to focus on direct patient care.[15]
- *Ethical and Technical Challenges*: Despite its many benefits, implementing AI in the ICU raises significant challenges, especially data privacy and system security. It is essential to establish clear regulatory frameworks that guarantee AI's responsible and ethical use in intensive medicine.[16]

3. Clinical Validation and Implementation Barriers

- *Clinical Validation:* The clinical validation of AI models is essential to demonstrate their accuracy, robustness, and reproducibility in real-world settings. This involves conducting controlled clinical studies, both prospective and retrospective, that evaluate performance metrics (sensitivity, specificity, predictive value, and area under the ROC curve) in diverse patient populations. In addition, these models must undergo multicenter testing, which allows for validating their applicability and generalization in different hospital contexts and geographical regions.[17]
- *Barriers to Implementation*: Integrating AI into clinical practice faces significant barriers. Incorporating new algorithms into existing workflows can generate resistance, as healthcare professionals require specialized training to interpret and safely use the recommendations of these systems. Likewise, it is necessary to rigorously address ethical and regulatory aspects such as protecting personal data, informed consent, and defining responsibilities in case of errors. Challenges are accentuated in contexts with limited resources. Standardizing validation protocols and promoting inter-institutional collaborations are indispensable to achieving safe, effective, and widespread adoption.[18]

4. Future Prospects and the Need for Multidisciplinary Research

- *Ethical Integration and Ongoing Regulation:* The advancement of AI in intensive medicine must be accompanied by a moral and regulatory framework that guarantees patient safety, equity, and data protection. Constant updating of regulations and ethics training for professionals are essential to mitigate biases and prevent liability in case of failure. Transparency in the development and evaluation of algorithms, together with the active participation of all stakeholders, will facilitate a sustainable and responsible adoption of these technologies.[18]

- *Innovation and Collaboration*: The consolidation of the use of AI in intensive care depends on close collaboration between clinical specialists, engineers, data scientists, and regulators. Multidisciplinary synergy is essential to develop solutions that respond to the real needs of the hospital environment. Encouraging joint research initiatives, sharing data, and establishing collaborative networks between institutions will create robust, adaptive models with a greater capacity for generalization.[19]

Table 1. Main AIs available in the ICU and their program description.

Type of AI	Program description
DeepSOFA [20]	It constitutes a new acuity scoring framework (DeepSOFA) that leverages temporal measurements and interpretable deep-learning models to assess the severity of illness at any point during an ICU stay. This model produces significantly more accurate predictions of in-hospital mortality. Deep models are suitable for identifying ICU patients who need life-saving interventions before an unexpected adverse event occurs and for informing shared decision-making processes between patients, providers, and families regarding goals of care and optimal resource utilization. DeepSOFA significantly outperformed traditional SOFA models in external validation cohorts, regardless of which cohort was used for model development
APRICOT-Mamba [21]	Prediction of acuity in the intensive care unit (APRICOT-M) is a neural network based on the state space of 1M parameters to predict the acuity, transitions, and the need for life support therapies in real-time among ICU patients. The model integrates ICU data from the previous four hours (including vital signs, laboratory results, assessment scores, and medications) and patient characteristics (age, sex, race, and comorbidities) to predict acuity outcomes over the next four hours. APRICOT-M significantly outperforms the baseline acuity assessment and the Sequential Organ Failure Assessment (SOFA) for predicting mortality in both external and prospective cohorts, as well as for predicting instability. This tool can help doctors carry out timely interventions by predicting the transition between acute states and making decisions about life support within the next four hours in the ICU
CHARTWatch [22]	The use of CHARTWatch, an artificial intelligence early warning system developed at Unity Health Toronto that monitors hospitalized patients in real-time, identifies those at high risk of an unexpected death or transfer to an intensive care unit, and alerts doctors and nurses to intervene early. This AI model shows a 26 % reduction in unforeseen mortality after implementing the tool in the internal medicine ward at Unity Health Toronto's St. Michael's Hospital. CHARTWatch records more than 100 aspects of a patient's medical history and current health status routinely stored in the hospital's electronic medical record

CONCLUSIONS

Artificial intelligence (AI) is redefining care in intensive care units, improving diagnostic accuracy, optimizing treatments, improving clinical decision-making, and thus enabling more efficient hospital management. However, although this technology is complex, multifaceted, and rapidly advancing, we must maintain an ethical approach that guarantees safety, privacy, and fairness in its implementation. As AI evolves, its integration with precision medicine and robotics will radically transform critical patient care. However, AI should be seen as a strategic ally in intensive medicine, and however advanced it may be, it will never replace the empathy and clinical judgment of healthcare professionals. By integrating AI responsibly, we save more lives and humanize the care of the critical patient, always remembering that at the heart of intensive medicine, compassion and commitment to each patient beats.

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CONFLICT OF INTEREST
The authors declare that there is no conflict of interest.

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