Use of artificial intelligence in nursing care in the intensive care unit: integrative review

Uso de inteligência artificial cuidados de enfermagem na unidade de terapia intensiva: revisão integrativa

Uso de inteligencia artificial en el cuidado de enfermería en la unidad de cuidados intensivos: revisión integradora

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How to cite: Araújo KLC, Silva LA e Silva RR. Use of artificial intelligence in nursing care in the intensive care unit: integrative review. REVISA. 2024; 13(4): 1017-29. Doi: https://doi.org/10.36239/revisa.v13.n4.p1017a1029

REVISA

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Recebido: 23/07/2024
Aprovado: 12/09/2024

REVIEW

RESUMO

Objetivo: Nosso objetivo aqui é apresentar o estado da arte das publicações expressas na literatura cientifica mundial sobre a temática da incorporação da inteligência artificial no cuidado do paciente crítico. Método: Trata-se de uma revisão integrativa da literatura cuja buscas foram realizadas em diferentes bases de dados utilizando os descritores "Artificial Intelligence"; "Critical Care"; "Intensive Care Units"; "Nursing Care". Que foram definidas a partir do vocabulário dos Descritores em Ciências da Saúde (DeCS), por ser uma terminologia comum à pesquisa, essas foram combinadas entre si, utilizando-se o operador booleano "AND" nas bases de dados eletrônicas: Medical Literature Analysis and Retrieval System Online (MEDLINE) e Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS) via Biblioteca Virtual de Saúde (BVS). Scientific Eletronic Library Online (SciELO), Web of Science (WOS), Cinahl e Scopus via Portal de Periódicos CAPES e Cochrane Library. Resultados: Um total de 208 estudos foram identificados nessas bases de dados. Sendo 40 no Medline, 01 no LILACS, 0 no SciELO, 89 no Scopus, 62 no Web of Science, 9 no The Cochrane Library e 7 no CINAHL, foram excluídos 27 artigos duplicados, restando 181 artigos, deste, 173 artigos foram excluídos pois não foram tratavam diretamente do objeto desta pesquisa que resultou em uma mostra final de 8 artigos. Conclusão: Embora esses avanços na tecnologia demonstrem o potencial da IA e do aprendizado de máquina para melhorar o atendimento ao paciente, quase todas as técnicas mencionadas se concentram na previsão de eventos de emergência que podem ser evitados.
Descritores: Inteligência Artificial; Cuidados Críticos; Unidades de Terapia Intensiva; Cuidados de Enfermagem.

ABSTRACT

Objective: Our objective here is to present the state of the art of publications expressed in the world scientific literature on the thematic incorporation of artificial intelligence in the care of critically ill patients. Method: This is an integrative literature review whose searches were performed in different databases using the descriptors "Artificial Intelligence"; "Intensive care"; "Intensive Care Units"; "Nursing care". Which were from the electronic health survey of Descriptors in Science, which were combined with the Boolean operator si, using the Boolean operator si, using the databases: Medical Literature Analysis and Retrieval System Online (MEDLINE) and Latin Literature -American and Caribbean Studies in Health Sciences (LILACS) via the Virtual Health Library (VHL). Scientific Electronic Library Online (SciELO), Web of Science (WOS), Cinahl and Scopus via Portal de Periódicos CAPES and Cochrane Library. Results: A total of studies were identified in these databases. Being 40 in Medline, 01 in LILACS, 0 in SciELO, 89 in Scopus, 62 in Web of Science, 9 in The Cochrane Library and 7 in CINAHL, 27 duplicate articles were excluded, leaving 181 articles, of which 173 articles were excluded because were not disclosed directly from the object of this research which produced a final sample of 8 articles. Conclusion: While these advances in technology can be used to improve patient care, all of the described event predictions focus on emergence to what may be almost demonstrable.
Descriptors: Artificial Intelligence; Critical Care; Intensive Care Units; Nursing Care.

RESUMEN

Objetivo: Nuestro objetivo aquí es presentar el estado del arte de las publicaciones expresadas en la literatura científica mundial sobre la incorporación temática de la inteligencia artificial en el cuidado del paciente crítico. Método: Se trata de una revisión integrativa de la literatura cuyas búsquedas se realizaron en diferentes bases de datos utilizando los descriptores "Inteligencia Artificial"; "Cuidados intensivos"; "Unidades de cuidados intensivos"; "Cuidado de enfermera". Las cuales fueron de la encuesta electrónica de salud de Descriptors in Science, las cuales fueron combinadas con el operador booleano si, utilizando el operador booleano si, utilizando las bases de datos: Medical Literature Analysis and Retrieval System Online (MEDLINE) y Latin Literature -American and Caribbean Association in Ciencias de la Salud (LILACS) a través de la Biblioteca Virtual en Salud (BVS). Scientific Electronic Library Online (SciELO), Web of Science (WOS), Cinahl y Scopus vía Portal de Periódicos CAPES y Cochrane Library. Resultados: Un total de estudios fueron identificados en estas bases de datos. Siendo 40 en Medline, 01 en LILACS, 0 en SciELO, 89 en Scopus, 62 en Web of Science, 9 en The Cochrane Library y 7 en CINAHL, se excluyeron 27 artículos duplicados, quedando 181 artículos, de los cuales 173 artículos fueron excluidos por no fueron divulgados directamente del objeto de esta investigación que produjo una muestra final de 8 artículos. Conclusión: si bien estos avances tecnológicos se pueden utilizar para mejorar la atención al paciente, todas las predicciones de eventos descritas se centran en la aparición de lo que puede ser casi demostrable.
Descriptores: Inteligencia Artificial; Cuidados Críticos; Unidades de Cuidados Intensivos; Atención de Enfermería.

Introduction

The human intelligence is defined by the mental capacity to think abstractly, use reason to solve problems, make plans, understand complex ideas and learn from experience[1] . Much of human intelligence involves pattern recognition, a process that combines a visual stimulus or other similar type of information stored in our brains[2].

An Artificial intelligence (AI) refers to a computerized hardware and/or software system that can perform physical tasks and cognitive functions, solve various problems or make decisions without explicit human instructions, endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meanings, generalize or learn from past experiences[3]. They can perform tasks that normally require human intelligence, such as controlling an autonomous car or influencing consumer purchasing decisions[4]. A variety of techniques and applications fall under the broad domain of AI[5].

With the use of algorithms, neural networks, intelligent machine learning system, and pattern recognition[6], AI is considered a technology that approaches a human replacement force: it is capable of augmenting or replacing human tasks and activities in a wide range of industrial, intellectual, and social applications with potential impacts on productivity and performance[7].

For example, a computer application that uses sophisticated algorithms to solve a problem in the management and flow of beds.[8] AI applications generate personalized recommendations for customers based on analysis of a large data set.[9] Thus, it is believed that it is possible to perform tasks better than the best humans and experts in any field.[10]

In the health area, it has been used in drug discovery, diagnostics and personalized therapies, molecular biology, bioinformatics, and even in nursing care[11]. AI applications are also able to discern disease patterns by examining and analyzing large amounts of digital information stored in electronic medical records[12].

In a recent proposal aimed at regulating AI software in medical devices[13], the U.S. Food and Drug Administration (FDA) states that "artificial intelligence-based technologies have the potential to transform healthcare by deriving important new insights from the vast amount of data generated during the delivery of healthcare every day"[14].

The COVID-19 pandemic has challenged health systems and their professionals around the world. Intensive care units and urgent and emergency units in badly hit areas have been overwhelmed by the increase in patients suspected or diagnosed with COVID-19. There has been significant pressure on health resources, requiring new avenues of diagnosis and care to rationally deploy scarce emergency health and critical care resources.[16]

Strategies and recommendations on clinical management and resource rationalization are based on past experiences of experts[17], however, there has been a growing interest in new applications of AI to assist in nursing care in intensive care units[18]. More recent studies in this field of technology evidence predictive models and make real-time inferences of patients for purposes that include alerts and predicting the length of hospital stay[19].

Several of these approaches focus on intensive care, using physiological data that are routinely recorded in intensive care units[20]. Other studies suggest that AI may perform as well or better than humans in key health tasks, such as diagnosing diseases[21].

The high demand for health services and the growing capabilities of artificial intelligence have led to the development of interactive agents[22], designed to support a variety of health-related activities, including behavior change, treatment support, health monitoring, training, screening, management and automation[23]. This research is justified given that, for example, the automation of tasks is already a reality in many countries, which use them to improve the speed and accuracy of disease diagnosis and screening[24]; assist in clinical care; strengthen health research and drug development and support various public health interventions, such as disease surveillance, outbreak response and health systems management[25].

In this sense, this study is relevant to science since AI holds great promise for improving the delivery of health and medical services worldwide[26]. The aim of this study is to present the state of the art of publications in the world's scientific literature on the use of AI in intensive care units in the care of critically ill patients..

Methodology

This is an integrative review of the literature. A method that is characterized by gathering and synthesizing research results on a topic, in a systematic and orderly manner. The research question was defined based on the PICO27 strategy, which provides for the definition of the participant (P), intervention (I), comparison (C) and outcome/outcomes (O). It is intended to answer the guiding question: What are the benefits of AI approaches in the nursing care of critically ill patients within intensive care units?

What are the benefits of approaches (O), AI (I) in nursing care (C) of critically ill patients (P)? Next, the keywords "Artificial Intelligence"; "Critical Care"; "Intensive Care Units"; "Nursing Care" were defined based on the vocabulary of the Health Sciences Descriptors (DeCS), as it is a terminology common to the research.

These were combined using the Boolean operator AND in the databases and/or electronic libraries: Medical Literature Analysis and Retrieval System Online (MEDLINE), Latin American and Caribbean Literature on Health Sciences (LILACS) and Scientific Electronic Library Online (SciELO).

The same search strategy was carried out in all databases and/or electronic libraries. The inclusion criteria for the articles for analysis were: articles published between 2012 and 2022, available in full, in Portuguese, English, and Spanish, which dealt with the theme of the incorporation of artificial intelligence in the care of critically ill patients. Opinion articles, editorials, duplicate articles, and publications that did not deal with the theme were excluded.

The collection period took place from November 2021 to February 2022. For data analysis, an analytical framework was constructed (Table 1) that made it possible to gather and synthesize the key information of the studies. The data collection instrument gathered the following information: title, author(s)/year of publication/country, objective, method, and main results. The level of evidence identified in the analyzed articles was classified according to the

Oxford Centre Classification for Evidence-based medicine[27], a system considered sensitive for grading the quality of evidence[4].

In this system, the quality of the evidence is described in four levels: high, moderate, low, and very low (Chart 1). Evidence from randomised controlled trials starts at a high level and evidence from observational studies at a low level.[28]

Chart 1 - Levels of evidence, São Paulo, SP, 2022.

Level	Definition	Implications
High	There is strong confidence that the true effect is close to that estimated	It is unlikely that further work will change the confidence in the estimate of the effect
Moderate	There is moderate confidence in the estimated effect	Future work could modify the confidence in the effect estimate, with the possibility of even modifying the estimate
Low	Confidence in the effect is limited	Future work is likely to have an important impact on our confidence in the effect estimate
Very Low	Confidence in the effect estimate is very limited. There is a significant degree of uncertainty in the findings	Any estimate of effect is uncertain

Results and Discussion

A total of 208 studies were identified in these databases, as illustrated in (Figure 1), which followed the recommendations PRISMA29 to describe the search process in the literature. Of these, 27 duplicate articles were excluded, leaving 181 unique articles. Next, the titles and abstracts were read, observing the inclusion and exclusion criteria. As a result of this process, 143 articles were excluded and another 2 articles returned for inclusion and exclusion criteria, but only 1 of them was reinstated. 39 articles met the eligibility criteria. The full and in-depth reading of these studies by two independent reviewers was then initiated. In a new analysis, 8 were excluded because they were studies with children and 23 articles dealt with cannabis for recreational purposes. Any disagreements among the evaluators, which arose during this stage, were worked on and resolved by consensus, which resulted in a final sample of 8 articles. The articles included in this synthesis (Figure 1) were developed in six different countries: United States (n= 4), Singapore (n= 1), China (n= 2), and Germany (n= 1).

As for the method, all of the researchers used the qualitative or quali-quanti approach to describe and analyze, in depth, the different dimensions in which technology occurs, artificial intelligence has enormous potential to improve the health of millions of people around the world, this fact characterizes the totality of the articles as being of low level of evidence[30].

Figure 1 - Selection of articles by descriptors in the databases, São Paulo, SP, Brazil, 2022.

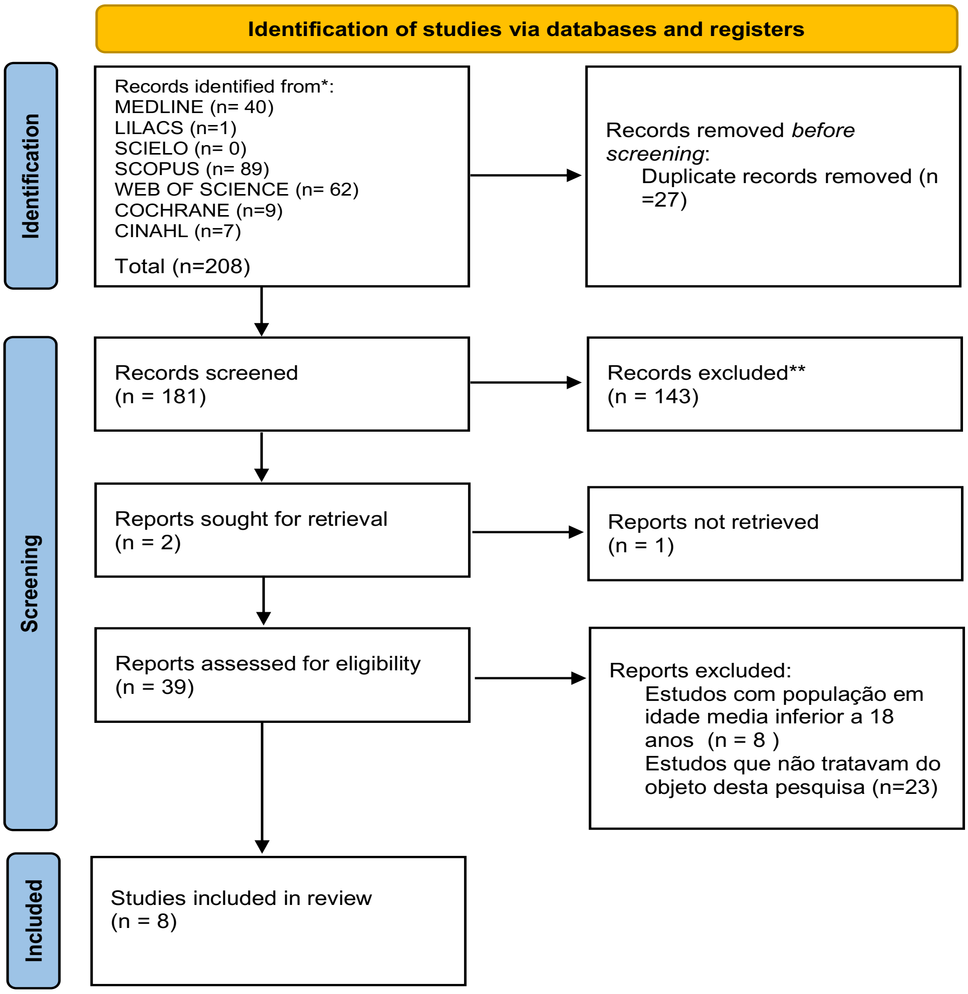

Table 1 - Analytical table of the studies. São Paulo, SP, Brazil 2022.

Title	Author / Year / Country	Objective	Method	Results	Level of Evidence
Artificial Intelligence in Healthcare: Review and Prediction Case Studies	Roung, G., 2020 China	Keeping up with new scientific achievements, understanding the availability of technologies, appreciating the tremendous potential of AI in biomedicine and providing researchers in related fields with inspiration. It can be said that, like AI itself, the application of AI in biomedicine is still in its infancy.	Review Study	AI has been used for signal and image processing and for predicting changes in function, such as urinary control, epileptic seizures and stroke predictions.	Moderate

Clinical Requirements of Future Patient Monitoring in the Intensive Care Unit: Qualitative Study	Poncette et al., 2019 Germany	The aim of this study was to evaluate ICU staff statements about current patient monitoring systems and their expectations for future technological developments, in order to investigate the clinical requirements and barriers to the implementation of future patient monitoring.	Cross-sectional study	For a future system, the importance of high usability was re-emphasized; wireless, non-invasive and interoperable monitoring sensors were desired; cell phones were needed for remote patient monitoring and optimizing alarm management; and AI-based clinical decision support systems were needed. Barriers to implementation included lack of confidence, fear of losing clinical skills, fear of increasing workload and lack of knowledge of available digital technologies.	Bass
Artificial Intelligence Applications for COVID-19 in Intensive Care and Emergency Settings: A Systematic Review	Chee, M.L. et al., 2021 Singapore	Our aim was to review and critically appraise the current evidence on AI applications for COVID-19 in intensive care and emergency settings.	Review Study	Current AI applications were limited in both range of applications and clinical applicability. Several significant problems in the development, validation and reporting of AI applications hinder the safe and effective implementation of these systems in intensive care units.	Bass
Patients' Perceptions Toward Human-Artificial Intelligence Interaction in Health Care: Experimental Study	Esmaeilzadeh et al., 2021 USA	The main objective of this study was to examine how potential users (patients) perceive the benefits, risks and use of of clinical applications of AI for their health purposes and how their perceptions might be different if confronted with three service meeting scenarios.	Cross-sectional study	We found no significant differences between the scenarios with regard to perceptions of performance risk and social bias.	High

Innovative Assisted Living Tools, Remote Monitoring Technologies, Artificial Intelligence-Driven Solutions, and Robotic Systems for Aging Societies: Systematic Review	Sapci & Sapci, 2019 USA	The main objective of this review was to identify advances in assistive technology devices for the elderly and aging-in-place technology and to determine the level of evidence for research into remote patient monitoring, smart homes, telecare and artificially intelligent monitoring systems.	Review Study	The results revealed that most studies had poor reference standards without explicit critical evaluation.	Moderate
Prediction of central venous catheter-associated deep venous thrombosis in pediatric critical care settings	Li, H. et al., 2021 China	Monitor the incidence of deep vein thrombosis associated with the central venous catheter (CVC) before it occurs.	Experimental study	These findings demonstrate that artificial intelligence (AI) can provide measures for thromboprophylaxis in a pediatric intensive care setting. It achieved 77% accuracy and 90% recall within 24 hours before the discovery of CADVT.	Very low
External validation of a novel signature of illness in continuous cardiorespiratory monitoring to detect early respiratory deterioration of ICU patients	Callcut, R. A., 2021 USA	The aim of this study is to monitor predictive analytics for the early detection of patients at high risk of potentially catastrophic sub-acute illnesses	Experimental study	Previously, we identified signatures of this disease in continuous cardiorespiratory monitoring data from intensive care unit (ICU) patients and developed algorithms to identify patients at increased risk. Here, we externally validate three logistic regression models for estimating the risk of emergency intubation developed in Medical and Surgical ICUs at the University of Virginia.	Very low
Prediction of hypotension events with physiologic vital signs in the intensive care unit	Yoon, J.H., et al., 2020 USA	We developed a machine learning model to predict the initial event of hypotension among intensive care unit (ICU) patients and designed an alert system for implementation at the bedside.	Experimental study	Clinically significant hypotensive events in the ICU can be predicted at least 1 hour before the initial hypotensive episode. With a highly sensitive and reliable practical alert system, a large majority of future hypotension can be captured, suggesting potential usefulness in real life.	High

There are numerous opportunities in the hospital environment to apply AI such as: Detection of abnormal chest X-ray findings, support for radiological diagnosis, data analysis to accelerate diagnosis, predictive analysis, robots, among others. In their research, Rong et al. (2020) state that unsupervised instructional techniques have been used to exploit large amounts of data encoded in electronic medical records. Models have been developed to obtain important information from medical records and identify high-cost patients.[31]

Some studies have used large population datasets to predict length of stay, ICU readmission, and mortality rates, and the risks of developing medical complications or conditions such as sepsis, points out the study by Poncette et al. (2019), which is in line with the research of Esmaeilzadeh et al. (2021) who dealt with smaller sets of clinical and physiological data to assist in the monitoring of patients on ventilatory support.[32]

Early detection of sepsis allows for treatment with better results, say Chee et al. (2021) in their review study, but sepsis is usually not clear until the late stages[33]. Existing tools have low predictive accuracy and often rely on time-consuming laboratory results[33]. Sapci & Sapci (2019) found that in 22,853 ICU admissions, systemic inflammatory response syndrome (SIRS), the Simplified Acute Physiology Score II (SAPS II), and the Sequential Organ Failure Assessment (SOFA) had AUCs of 0.609, 0.700, and 0.725, respectively, to identify sepsis at the time of onset[34].

Regarding the resources used by the ICU team to monitor patients, alarm management was mentioned more frequently[35]. The study by Li et al. (2021) states that nurses and respiratory therapists would regularly adjust alarm thresholds to the patient's current conditions[36] in contrast to the idea of Callcut et al. (2021) who point to alarm fatigue as a major deficit in the current system, leading to patient and team stress and, potentially, reduced patient safety[18]. The reasons for this were stated as: difficulty distinguishing between false and critical alarm and susceptibility to ECG error, peripheral capillary oxygen saturation (SpO2), delirium-related movements, centralized circulation or high perspiration, inadequate alarm hygiene due to lack of staff training with patient monitoring, and lack of staff resources[18].

Privacy can also be a major concern for any system that uses video monitoring[37], data protection laws are the ones that provide regulatory standards and protect the rights of individuals and establish obligations for data controllers and processors[38]. Data protection laws also increasingly recognise that people have the right not to be subject to decisions guided solely by automated processes. However, a future operational version may rely on real-time and online vision analytics without storing any video data[19]. This approach can also reduce the need for extensive storage requirements.

Current AI applications were limited both in the range of applications and in clinical applicability[39]. Several significant issues in the development, validation, and reporting of AI applications hinder the safe and effective implementation of these systems in intensive care units. or emergency departments.[40] Integrating new AI-specific reporting guidelines, such as CONSORT-AI and SPIRIT-AI[41], into research and publication processes will be a vital step in creating future AI applications that are clinically acceptable in future pandemics and the broader care field[42]. We also emphasize the importance of closer interdisciplinary collaboration between AI experts and nurse practitioners[43].

Conclusion

We believe that AI will be an integral part of healthcare services soon and will be incorporated into various aspects of clinical care, such as prognosis, diagnosis, and care planning, including in intensive care units. As such, they are typically limited in scope to specific diseases or diagnoses or only applicable to a small subset of the patient population.

Perhaps the next big challenge for AI in healthcare is to develop approaches that can be applied to the entire patient population, monitoring vast amounts of data to automatically detect patient safety issues and threats, including suboptimal standards of care, as well as outbreaks of hospital-acquired disease, and uncover new patient care best practices.

A comprehensive assessment of the acceptability, usability, and effectiveness of this technology in healthcare is needed to gather the evidence so that future development can target areas of improvement and potential for sustainable adoption. While private and public sector investment in the development and deployment of AI is critical, the unregulated use of AI can subordinate the rights and interests of patients and communities to the powerful commercial interests of technology companies or the interests of governments in surveillance and security. In this sense, this research partially answered its guiding question, there are many gaps in this area that should be the object of new research. Our findings should motivate other researchers to conduct patient-centered qualitative research. One of the limitations of this study was the low number of articles published on the subject.

Acknowledgment

This study was funded by the authors themselves.

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