











REVIEW

Artificial intelligence-mediated surgical center management: limitations, application, and opportunities

Gestión de centros quirúrgicos mediada por inteligencia artificial: limitaciones, aplicación y oportunidades

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ABSTRACT

Introduction: the technological revolution is currently transforming healthcare services. Therefore, we set out to analyze how the application of artificial intelligence improves management processes in surgical centers, as well as the limitations and opportunities of its incorporation into healthcare services.

Method: a literature review study was conducted to comprehensively analyze articles obtained from indexed databases such as SCOPUS, PUBMED, Scielo, and Latindex, using a combination of Boolean operators (AND and OR) with keywords in Spanish, English, and Portuguese. which was classified and organized in an Excel matrix for analysis according to the CASPe rubric guidelines, which facilitated the assessment of their scientific and academic quality.

Results: the healthcare system faces several challenges that hinder the incorporation of new technologies into its administrative, care, teaching, and research processes, considering investment, ethical dilemmas, lack of digital skills, and economic investment. However, their integration shows opportunities in terms of resource optimization, decision-making, lower margin of error in surgical interventions, and continuous postoperative follow-up.

Conclusions: technological transformation enables effective management with the incorporation of artificial intelligence, which improves administrative and care processes in surgical centers. However, its use presents challenges in terms of the ethical, training, and operational gaps in AI, considering the variety of types available in the technology market, which requires more scientific evidence on the impact of these technologies on healthcare systems, professionals, families, and patients.

Keywords: Surgery; Health Management; Artificial Intelligence.

RESUMEN

Introducción: la revolución tecnológica actualmente está transformando los servicios de salud; por lo que, se propuso analizar como la aplicación de la inteligencia artificial mejora los procesos de gestión de los centros quirúrgicos, así como las limitaciones y oportunidades de su incorporación en los servicios de salud.

Método: estudio de revisión bibliográfica que permitió analizar de manera exhaustiva los artículos obtenidos de bases indexadas como SCOPUS, PUBMED, Scielo y Latindex; mediante la combinación de operadores booleanos (AND y OR) con palabras claves en español, ingles y portugués; esta fue clasificada y organizada en una matriz en Excel para su análisis según los lineamientos de la rúbrica CASPe que facilito evidenciar la

calidad científica-académica de estos.

Resultados: el sistema sanitario enfrenta varios desafíos que dificultan la incorporación de nuevas tecnologías en sus procesos administrativos, asistenciales, docentes e investigativas; teniendo en cuenta la inversión, los dilemas éticos, la carencia de competencias digitales y la inversión económica; sin embargo, su integración evidencia oportunidades a nivel de optimización de recursos, toma de decisiones, menor margen error en intervenciones quirúrgicas y seguimiento continuo postoperatorio.

Conclusiones: la transformación tecnológica posibilita una gestión efectiva con la incorporación de la inteligencia artificial, esto mejora los procesos administrativos-asistenciales en los centros quirúrgicos; no obstante, su uso evidencia retos frente al vacío ético, formativo y operativo de la IA, considerando su variedad de tipos en el mercado tecnológico, que requiere mayor evidencia científica sobre el impacto de estas tecnologías en los sistemas de salud, profesionales, familias y pacientes.

Palabras clave: Cirugía; Gestión en Salud; Inteligencia Artificial.

INTRODUCTION

The technological revolution is currently transforming society and the different areas of its development, being the health sector one of the most innovated; in this context new technologies such as artificial intelligence (AI) emerge, which according to the World Health Organization (WHO) recognizes that the efficient use significantly optimizes the available resources, improves response times and streamlines administrative processes in hospital environments.⁽¹⁾

In this sense, AI facilitates more accurate diagnoses, predicting complications in healthcare, as well as in decision making, contributes to inventory and medication management. Therefore, this technological tool not only improves the quality of diagnosis and the localization of pathologies, but also allows greater patient autonomy over their medical process, thus strengthening the efficiency of care protocols and the planning of interventions.⁽²⁾

However, its integration into healthcare systems faces structural challenges for institutions, including the high demand for procedures, the shortage of specialized personnel and the complexity of supply management, as well as the violation of data confidentiality and possible technological dependence in clinical decision making.⁽³⁾

On the other hand, its incorporation makes it possible to provide potential solutions to critical problems in the organization of services, considering the capacity to process and analyze information, as well as to synthesize and represent the administrative-care processes that facilitate the management work of areas and institutions in the face of the demand for documents, guidelines, protocols and standards that are applied in care.^(4,5)

In the same way, the growing demand of citizens for a more transparent, equitable and efficient care. In this new paradigm, technologies such as AI and robotics challenge traditional work structures, raising ethical questions about the possible replacement of human functions, which requires a thorough reflection on their integration without violating labor rights or principles of equity, respecting patient dignity and conforming to quality and safety standards.⁽⁶⁾

Moreover, this technology not only automates operational processes, but also redefines planning, diagnostic accuracy, decision making and treatment personalization; taking into account that it allows the analysis of large volumes of clinical data with greater speed and accuracy, resulting in safer, more timely and efficient care.⁽⁷⁾

Likewise, AI enables the execution of operational tasks at lower cost and the optimization of resources. However, there are still risks associated with possible algorithmic failures and the vulnerability of sensitive clinical information, which makes it necessary to strengthen monitoring mechanisms and digital governance. Therefore, its effective integration requires an ethical, human and ontological approach that ensures the continuous improvement of care at all levels of the healthcare system.^(8,9) Therefore, we proposed to analyze how the application of artificial intelligence improves the management processes of surgical centers, as well as the limitations and opportunities of its incorporation in health services.

METHOD

A qualitative approach study, descriptive design of bibliographic review type that made it possible to interpret and examine the findings of the selected articles, as well as their organization and classification according to the object of research. In this sense, the population was made up of studies, obtaining a sample of 30 by convenience focused on their complete availability, temporality and compliance with eligibility criteria.^(10,11)

Inclusion criteria

- Studies of quantitative, qualitative and mixed character.

- Research in Spanish, English or Portuguese.
- Articles addressing the use of AI in surgery center management in the last 5 years.

Exclusion criteria

- Research from gray literature and found in repository.
- Clinical trials and theses.

For this purpose, search equations were performed in indexed databases such as SCOPUS, PUBMED, SciELO and Latindex; by combining Boolean operators (AND and OR) with keywords in Spanish (AI, artificial intelligence, health services, management, challenges, limitations, use, application, opportunities, dilemmas); English (AI, artificial intelligence, health services, management, challenges, limitations, use, application, opportunities, dilemmas); and Portuguese (IA, inteligência artificial, serviços de saúde, gestão, desafios, limitações, use, aplicação, opportunities, dilemmas).

In this sense, this process was performed independently by two authors, supervised by other researchers who oversaw the fulfillment of the criteria, as well as the resolution of conflicts in the validation of the findings; therefore, the information was recorded in a matrix in the Microsoft Excel program, where it is extracted information about: (a) article data (year, type of study, ID, Url, indexed base); (b) limitations (structural, financial, ethical, political, organizational); (c) applications (management, processing, planning, research, evaluation, resolution), and (d) opportunities (health services, patients, families, health professional). For the analysis, a reading process was applied using the CASPe reading application, which made it possible to visualize the academic scientific quality of the selected studies.

DEVELOPMENT

Limitations presented in the application of artificial intelligence in the management of healthcare services

The healthcare system faces several challenges that hinder the incorporation of new technologies in its administrative, assistance, teaching and research processes; in this sense. The hospital and surgical infrastructure faces substantial limitations to integrate emerging tools such as AI.⁽⁴⁾ In addition, many operating spaces lack technical platforms for its efficient adoption, as well as fragmented or outdated clinical information systems, which prevents an adequate data flow for the training and deployment of intelligent algorithms.⁽¹²⁾

Similarly, institutions with advances in physical and digital infrastructure are often not aligned with the requirements of strategic, data-driven surgical management. This gap limits real-time surgical planning and clinical risk assessment, which are fundamental for safe and efficient surgical care.⁽¹³⁾

On the other hand, the implementation of AI and intelligent systems in surgical centers requires considerable investments, which represents a barrier for public or low-budget institutions; taking into account acquisition, maintenance and upgrade costs.⁽¹⁴⁾ In turn, investments should not only focus on technology, but also on training surgical staff, hiring experts in AI and cybersecurity, as well as redesigning administrative and clinical processes.⁽¹⁵⁾

In another context, the use of AI in surgical contexts poses significant ethical challenges centered on reliance on automated clinical decisions that may jeopardize healthcare professional and patient autonomy. In the surgical setting, where decisions must be made accurately and quickly, over-reliance on intelligent systems may dilute medical responsibility.⁽¹⁶⁾ Similarly, the legal vacuum regarding liability in case of errors arising from AI-based systems, considering the absence of a clear ethical-legal framework that limits the safe and acceptable implementation of these technologies in care.⁽¹⁷⁾

Thus, the lack of updated public policies and specific regulatory frameworks for AI in healthcare generates uncertainty, considering that its application in several countries lacks clear regulations on certification, auditing or validation of algorithms in clinical contexts, which affects its integration in surgical services.⁽¹⁸⁾ It should be noted that digital divides accentuate inequities in access to quality surgical services, which has a direct impact on the sustainability of surgical management based on data and advanced technology.⁽¹⁹⁾

On the other hand, organizations face resistance to cultural change, due to the scarce digital competencies and strategic vision to lead the digital transformation; this is due to the gap between technological development and organizational readiness to adopt it, having an impact on misaligned surgical processes, inflexible workflows and management models that do not prioritize innovation.⁽²⁰⁾

Current applications of the integration of artificial intelligence in the management of surgical services

Currently, AI has a substantial impact on the management of surgical flows and the automation of administrative processes, considering that algorithms can optimize patient flow in critical units, improving bed allocation, surgery scheduling and turnaround times. In surgical centers, this translates into shorter waiting times, better use of resources, increased operational efficiency, as well as the rapid identification of relevant patterns for surgical planning and risk management.^(21, 22)

On the other hand, this tool can predict postoperative complications, assess the patient's suitability for a specific procedure and help define optimal clinical trajectories through predictive models, which enables personalized and evidence-based surgical planning.⁽²³⁾ It should be noted that there is development of autonomous surgical assistance systems using deep learning algorithms, which actively participate in intraoperative decision making, suggesting cuts, trajectories or technical maneuvers, under medical supervision.⁽²⁴⁾

In another context, it facilitates applied clinical research processes in surgery, considering that machine learning algorithms are used in the development of new surgical protocols, the evaluation of biomarkers and the design of clinical trials, which improves the automated collection and analysis of surgical data, promoting a continuous learning environment based on real results.⁽²⁵⁾ Furthermore, it allows more accurate risk assessments and resolution strategies to be proposed.⁽²⁶⁾

In another context, it has provided remote post-surgical monitoring, considering the use of integrated sensors and intelligent algorithms that allow monitoring of vital signs, mobility and adherence to treatment, facilitating early intervention in the event of warning signs, as well as reducing the incidence of hospital readmissions.^(27,28) Likewise, it provides a personalized vision in medical care, this focused on integrating 3D images, clinical histories and intraoperative data to guide complex procedures such as neurosurgeries or minimally invasive surgeries, thus favoring the execution of autonomous maneuvers under human supervision, marking the beginning of robotic surgery with AI as an active co-protagonist of treatment.^(29,30)

Opportunities envisioned on the incorporation of artificial intelligence in the management of healthcare services

AI in the surgical area offers advantages considering that it increases efficiency, diagnostic and operative precision, considering that automatic learning algorithms make it possible to anticipate surgical risks, improve the scheduling of interventions and optimize the use of operating rooms.⁽³¹⁾ It should be noted that predictive models facilitate the evaluation of probabilities of complications, readmissions and clinical risk, this focused on the capacity to adapt to the safety and quality of care for people and families.^(32,33)

On the other hand, this tool offers with its incorporation a personalized attention focused on the real and potential needs of the users-patients, taking into account the efficient allocation of resources for follow-up and post-surgical monitoring, as well as the effective management of waiting lists that cause dissatisfaction.^(34,35) In addition, the advances of AI in surgery provide greater transparency and diagnostic accuracy, which provide peace of mind and confidence during the surgical process to families, enabling an active participation in the digital follow-up in the evolution and recovery of the patient, without moving to the areas in situations of restriction and distance.⁽³⁶⁾

It should be noted that this emerging AI technology in surgical environments represents both a clinical support in decision making and a tool for learning and continuous improvement, as well as assistance in complex procedures, improving the accuracy of interventions and reducing the margin of error; in turn, it facilitates the healthcare professional to optimize the development of the documentation of the clinical history.^(37,38)

Therefore, at the level of healthcare institutions, the integration of artificial intelligence systems strengthens the institutional capacity to respond to crises, due to dynamic planning based on data and simulation, as well as the promotion of new lines of research according to the clinical specialty, innovation and project development, as well as protocols and evidence-based guidelines; therefore, the effective and safe management of services.^(39,40)

CONCLUSIONS

The technological transformation in health care enables effective and quality management with the incorporation of artificial intelligence, which improves administrative-care processes in highly complex areas such as surgical centers, optimizing planning, clinical decision-making, postoperative follow-up, patient safety and operational efficiency of the service. Therefore, its integration should focus on a multidimensional approach under a framework of ethical and legal standards that enables the construction of modern, resilient and value-centered surgical systems.

However, its use evidences challenges facing the ethical, formative and operational vacuum of AI, considering its variety of types in the technological market, which requires more scientific evidence on the impact of these technologies on health systems, health professionals, families, patients and users; in addition, the collateral effects that could arise from the displacement of human competences, privacy and confidentiality of data; that is why, the need for governance models, technological interoperability, continuous training, and regulatory policies that allow a fair, safe and sustainable adoption in the long term.

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