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REVIEW

Transformation in the education of surgical nursing staff: impact of new emerging technologies

Transformación en la educación del personal quirúrgico enfermero: impacto de las nuevas tecnologías emergentes

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ABSTRACT

Introduction: The transformation of the educational field is a reality, given the demand for highly competent professionals to face current challenges in different healthcare contexts. Therefore, we sought to analyze how the incorporation of new technologies is transforming the education of surgical personnel, as well as the challenges for their application and impact on the development of professional skills. Methods: A literature review was conducted to analyze articles obtained from indexed databases such as SCOPUS, PUBMED, Scielo, and Latindex, integrating Boolean operators (AND and OR) with keywords in Spanish, English, and Portuguese. These were recorded in a matrix for analysis by meeting the inclusion and exclusion eligibility criteria, as well as the CASPe method. Results: Its application has structural, organizational, pedagogical, and ethical limitations that condition its impact and sustainability in surgical training systems. However, they offer a controlled and repeatable environment where students can develop, integrate, and refine skills to address current healthcare challenges in surgical contexts. Conclusions: The current technological revolution is transforming the landscape of human development, with health and education being among the areas influenced. Therefore, the incorporation of technologies has proven to be a significant advance in the training of competent, confident, and humanized professionals.

Keywords: Surgical center; Professional education; Artificial intelligence; Virtual reality; Simulation.

RESUMEN

Introducción: La transformación del campo educativo es una realidad, teniendo en cuenta la demanda de profesionales altamente competentes para afrontar los retos y desafíos actuales en los diferentes contextos sanitarios; es por ello, que se buscó analizar como la incorporación de las nuevas tecnologías están transformando la educación del personal quirúrgico, así como los retos para su aplicación e impacto en el desarrollo de competencias profesionales. Métodos: Se realizó una revisión bibliográfica que facilitó analizar artículos obtenidos en bases de datos indexadas como SCOPUS, PUBMED, Scielo y Latindex, integrando operadores booleanos (AND y OR) con palabras clave en español, inglés y portugués. Estos fueron registrados en una matriz para su análisis mediante el cumplimiento de los criterios de elegibilidad de inclusión y exclusión, así como el método CASPe. Resultados: Su aplicación presenta limitaciones estructurales, organizativas, pedagógicas y éticas que condicionan su impacto y sostenibilidad en los sistemas de formación quirúrgica. No obstante, Estas ofrecen un entorno controlado y repetible donde los estudiantes pueden desarrollar, integrar y perfeccionar competencias para afrontar los actuales desafíos sanitarios en los contextos quirúrgicos. Conclusiones: La actual revolución tecnológica es un presente que está transformando los escenarios del desarrollo humano, siendo la salud y la educación una de las influenciadas; por lo tanto, la incorporación de tecnologías ha demostrado ser un avance significativo en la formación de profesionales competentes, seguros y humanizados.

Palabras clave: Centro quirúrgico; Educación profesional; Inteligencia artificial; Realidad virtual; Simulación.

INTRODUCTION

The transformation of the educational field is a reality, considering the demand for highly competent professionals to face current challenges and demands in different healthcare settings, ensuring a response to the needs of individuals, families, and communities, focused on dignity, quality, and safety; this under an approach of content and technological innovation. (1)

In this sense, health sciences education presents a profound paradigm shift driven by the accelerated development of new technologies such as artificial intelligence (AI), virtual reality (VR), and advanced clinical simulation, emerging tools that are not only modernizing learning environments but are redefining the way in which health professionals acquire, consolidate, and apply high-complexity clinical and surgical competencies. (2,3)

It should be noted that the incorporation of these technologies in surgical training enables improvements in diagnostic accuracy, automated feedback, and personalization of professional training; furthermore, they facilitate the identification of errors through simulated processes, which avoids complications through the development of competence and skills, without compromising the integrity and safety of individuals. (4,5)

Similarly, technological tools in formative processes and professional development foster active teaching-learning, transforming the reality of education in health sciences careers, enabling greater autonomy in decision-making through critical-reflective thinking, as well as assertive communication, teamwork, and the use of scenarios that allow students to face dynamic and realistic cases, which enhances the capacity to respond to critical clinical situations. (6,7)

However, these advances face implementation challenges, considering that the impact depends on the pedagogical quality of their incorporation at the curricular level, as well as the resistance of higher education institutions to adapt and invest in scenarios, technology integration, equitable access, and faculty preparation. (8) In this context, it becomes necessary to adapt curricula to the new digital and technological paradigm, as well as the ethical application of these tools in the learning process that allows future healthcare professionals to acquire competencies in the face of such a variable state of health. (9)

Therefore, the use of emerging technologies in surgical education is not only a technical innovation, but also a transformative process of professional development in health. This new educational model requires an integrative, reflective, and evidence-based approach, capable of responding to current clinical demands, as well as preparing healthcare personnel for an increasingly automated, interconnected, and patient-safety-centered surgical environment. (10) For this reason, we sought to analyze how the incorporation of new technologies is transforming the education of surgical personnel, as well as the challenges for their application and impact on the development of professional competencies.

METHODS

One study was conducted with a qualitative approach, descriptive design of a bibliographic review type, which facilitated exhaustively examining the literature on the research object, as well as organizing and detailing the findings of the articles, which allowed answering the proposed themes.

The population consisted of scientific publications, with one sample of 25 selected studies, taking into account the fulfillment of the previously established inclusion and exclusion criteria, as well as the time and access to complete information.

Inclusion criteria:

- Quantitative, qualitative, or mixed studies.
- Research in Spanish, English, or Portuguese.
- Articles that examine the application of new technologies in the training process of competency development in the surgical team, during the period from January 2021 to June 2025.

Exclusion criteria:

- Works of grey literature.
- Repository studies.

For this purpose, specific search equations were constructed in indexed databases such as SCOPUS, PUBMED, Scielo, and Latindex, integrating Boolean operators (AND and OR) with keywords in Spanish, English, and Portuguese related to artificial intelligence, virtual reality, clinical simulation, continuing education, surgical team, competencies, health education, technologies, and innovation.

It should be noted that the selection of articles was carried out independently by three researchers, subsequently supervised by an additional team that was responsible for validating compliance with the criteria and resolving conflicts about them. The information was incorporated into a matrix developed in Microsoft Excel, data such as: a) article characteristics (year of publication, URL, database); b) limitations (organizational, resources, infrastructure, regulatory, pedagogical); and c) application and impact (clinical simulation, virtual reality, artificial intelligence; development of cognitive, attitudinal, and procedural competencies). It was analyzed using the CASPe method.

DEVELOPMENT

Limitations in the incorporation of technological tools in the academic training process of professionals in surgical centers.

Technological tools are transforming professional training environments, fostering autonomy among healthcare personnel to develop the various competencies needed to address new health challenges within the framework of surgical care. In this regard, a lack of institutional leadership and strategic planning hinders the implementation of innovative methods such as clinical simulation in vascular surgery, which could enable training of the multidisciplinary team to reduce error margins during this procedure (11).

Furthermore, professionals' resistance to change is centered on the safety and quality of procedures, given that most of these procedures are invasive in the operative setting (12). This resistance is exacerbated by limited infrastructure and resources for its application in health teaching institutions, as well as in higher education institutions; consequently, its effectiveness in developing skills and acquiring competencies would be limited (13,14).

On the other hand, its implementation entails investment and maintenance costs, including the acquisition of technology for simulated scenarios, the use of virtual reality, and the application of AI (15). Furthermore, the lack of protocols and norms established in educational, legal, and ethical aspects poses challenges for its implementation in strengthening the competencies of surgical team professionals, given that these are high-complexity scenarios within the framework of safety and quality of care for people (16,17).

On the other hand, pedagogical competencies within health teaching institutions are limited because of the need for continuous instructor training to effectively use these technological tools, interprofessional barriers, and difficulties in structuring collaborative learning experiences (18,19). Likewise, the lack of integration of these methodologies and their application in undergraduate and postgraduate training curricula has reduced their impact, unless they are adequately integrated with pedagogical objectives and real clinical-surgical competencies (20,21).

In turn, the risk of technological dependence in the absence of reasoning and clinical-reflective judgment can undermine autonomy and safety in surgical settings, where precision in care and interventions is required to ensure the quality and survival of people and the well-being of families (22,23).

Application and impact of emerging technologies on the development of competencies among surgical professionals.

New technological tools are transforming training and care scenarios, fostering the development of competencies in professionals to address current global health challenges. At the cognitive level, clinical simulation allows surgical professionals to face realistic situations, as well as high-fidelity ones centered on high pressure, in a controlled environment, enabling them to train in reacting and making decisions without putting patients at risk (24).

These realistic scenarios allow professionals in training to make mistakes without consequences, which better stimulates analysis and reflective critical thinking and strengthens clinical judgment, focused on the ability to perform differential diagnoses in urgent surgical situations, preparing trainees to respond in contexts of high clinical uncertainty (25).

On the other hand, technologies such as virtual reality enable cognitive immersion in scenarios that not only allow the practice of techniques but also the development of skills such as surgical planning, complex anatomical interpretation, and problem solving; this fosters the professional's autonomy to explore surgical alternatives, observe the consequences of their decisions, and reflect on their errors (26,27).

Furthermore, artificial intelligence-based complementary tools provide immediate, perso-

nalized, and quantifiable feedback, helping students make more informed and safer clinical decisions. Likewise, the algorithms analyze decisions made during a surgical simulation and generate recommendations to improve clinical judgment. This makes it possible to observe not only which decisions were correct or incorrect, but also why they were, thereby promoting critical thinking and continuous improvement (28,29).

It should be noted that these tools improve effective communication within collaborative work frameworks, enabling high-pressure scenarios to be addressed by promoting early error identification, collaborative work, and surgical leadership (30,31). Similarly, they foster empathy and clinical humanism, as students face situations of suffering, grief management, ethical conflicts, or informed consent through the representation of real-time surgical situations that require ethical and communicative responses and a proactive approach centered on the multi- and interdisciplinary team (32).

On the other hand, these innovative approaches within the continuous training process provide students with the opportunity to practice techniques such as incisions, dissections, and sutures under remote supervision, achieving an efficient transfer of skills to the real context. This reduces errors, shortens surgical times, improves coordination through training at different levels of difficulty, and allows learning to be adjusted to each student's learning curve (33, 34). Likewise, they allow real-time monitoring of surgical performance, which improves procedural skills and consequently leads to better postoperative outcomes (35).

CONCLUSIONS

The current technological revolution is transforming the scenarios of human development, with health and education among those influenced. The incorporation of technologies has therefore proven to be a significant advance in the training of competent, confident, and humanized professionals. These technologies offer a controlled and repeatable environment where students can develop, integrate, and refine competencies to face current health challenges in surgical contexts. However, their application is not exempt from structural, organizational, pedagogical, and ethical limitations that condition their impact and sustainability in surgical training systems.

Therefore, these technologies should not be viewed as substitutes for traditional clinical learning, but rather as strategic and transformative complements that, when integrated in an ethical, planned, and pedagogically sound manner, enrich the comprehensive training of the surgical professional, improving their technical preparation, clinical judgment, teamwork ability, commitment to safety, and the well-being of patients and families, centered on the ontological dignity of persons.

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CONFLICT OF INTEREST

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