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Anatomical models and simulated instances for learning surgical skills in undergraduate and postgraduate medical students. A systematic review.

Modelos anatómicos e instancias simuladas para el aprendizaje de competencias quirúrgicas de los estudiantes de medicina de pre y postgrado. Una revisión sistemática.

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Abstract: Background: Modern medical education has highlighted the role of simulation-based learning as an essential component in the development of clinical-surgical skills in medical students. Many universities nationwide have implemented simulation in their educational programs, so it is essential to investigate how to optimize its application in the surgery curriculum. The objective of this study is to identify and analyze the main findings reported in the literature on the use of anatomical models and simulated instances for teaching surgical skills in undergraduate and graduate medical students. Methods: A review was conducted following the guidelines of the PRISMA-ScR protocol in the Scopus and PubMed databases, ending with a total of 10 papers for review. Results: The implementation of simulation in medical education in its various forms improves student performance and achievement in clinical-surgical skills and theoretical learning, and also improves student satisfaction with learning. Discussion: The results of this review confirm the relevance of simulation as a teaching tool in surgical training. Its integration into curricula has shown improvements in technical skills, academic performance, and confidence in decision making. These findings suggest that its integration into surgical curricula would facilitate student learning. Conclusions: The need to prioritize the integration of simulation technologies and anatomical models in surgical training programs is highlighted. This could improve the quality of clinical training and has the potential to reduce medical errors and promote safe and quality care. However, these effects still require validation through longitudinal studies.

Keywords: Anatomical models; Simulated instances; Clinical competence; Surgical skills learning; Surgery; Medical students, Surgical skills.

Resumen: Antecedentes: la educación médica moderna ha resaltado el rol del aprendizaje basado en simulación como componente esencial en la formación de competencias clínico-quirúrgicas en estudiantes de medicina. A nivel nacional muchas universidades han implementado ésta en sus programas educativos, por lo que resulta fundamental investigar en cómo optimizar su aplicación en el currículo de cirugía. El objetivo de este estudio es identificar y analizar los principales hallazgos reportados en la literatura sobre el uso de modelos anatómicos e instancias simuladas para la enseñanza de competencias quirúrgicas en estudiantes de medicina de pre y postgrado. Métodos: Se realizó una revisión siguiendo las directrices del protocolo PRISMA-ScR, en las bases de datos Scopus y PubMed, finalizando con un total de 10 trabajos para revisión. Resultados: La implementación de simulación en la educación médica en sus diversas formas, mejora el rendimiento y desempeño de los estudiantes en habilidades clínico-quirúrgicas y aprendizaje teórico, además mejora la satisfacción de los estudiantes con el aprendizaje. Discusión: Los resultados de esta revisión confirman la relevancia de la simulación como herramienta de enseñanza en la formación quirúrgica, su integración en los currículos ha demostrado mejoras en habilidades técnicas, desempeño académico y confianza en la toma de decisiones, estos hallazgos sugieren que su integración en los currículos de cirugía, facilitaría el aprendizaje de los estudiantes. Conclusiones: Se destaca la necesidad de priorizar la integración de tecnologías de simulaciones y modelos anatómicos en los programas de formación quirúrgica, esto podría mejorar la calidad de la formación clínica y tiene el potencial de reducir errores médicos y fomentar una atención segura y de calidad; sin embargo, estos efectos aún requieren validación mediante estudios longitudinales.

Palabras clave: Modelos Anatómicos; Instancias simuladas; Competencia clínica; Aprendizaje de competencias quirúrgicas; Cirugía; Estudiantes de medicina, Habilidades quirúrgicas.

1. Introduction

Modern medical education has highlighted the crucial role of simulations as an essential component in the formation of clinical and surgical skills, with a direct impact on patient safety (1). Various international studies have shown that the use of simulations not only facilitates the performance of students in real clinical situations (2), but also improves their surgical skills, demonstrating the effectiveness of these educational interventions, even in relatively short training periods (3).

These simulated practices allow tutors to observe significant improvements in fundamental competencies, such as effective communication, medical interview, physical examination and execution of clinical procedures (4). In Chile, many universities have formalized the use of anatomical models and simulations, reflecting a growing trend in their incorporation into curricular programs (5), which promotes not only the development of technical skills, but also interprofessional collaboration in a safe environment, where students can learn from their mistakes without clinical repercussions (6).

Given the proven effectiveness of simulation in learning surgical skills, it is essential to investigate how to optimize its implementation in the surgery curriculum, facilitating effective integration between theoretical and practical learning (7).

This is especially important to improve students' knowledge of surgical techniques and their ability to make decisions under pressure, manage stress and uncertainty, critical aspects to reduce medical errors and raise safety standards in patient care (7). The present study aims to identify and analyze the main findings reported in the literature on the use of anatomical models and simulated instances for teaching surgical skills in undergraduate and graduate medical students.

2. Methods

2.1 Review Protocol

This scoping review was conducted following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) protocol (8).

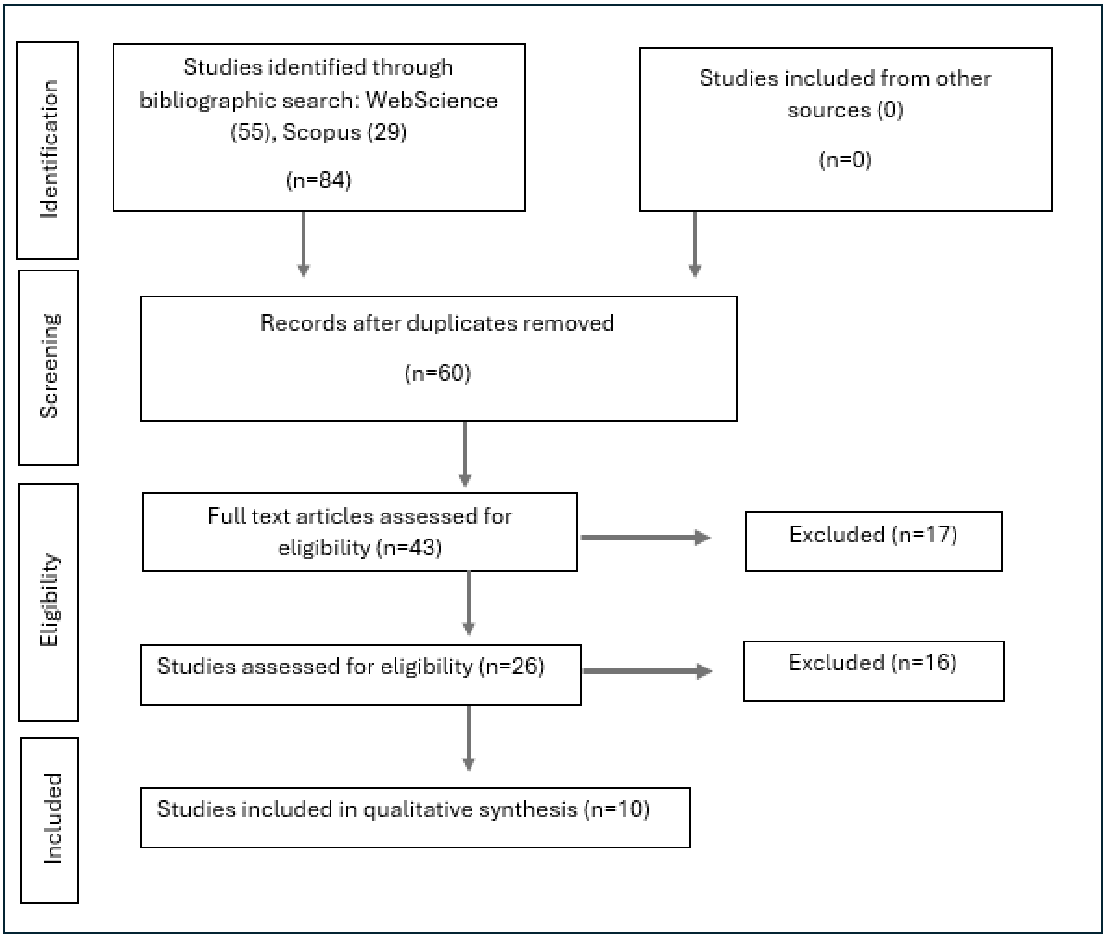

Figure 1. Search flowchart according to the PRISMA-ScR protocol.

2.2 Search strategy

A search was conducted on different platforms such as WebScience, Scopus, PubMed, for original articles related to the implementation of simulations and surgical skills in medical students, using keywords in the search strategy (Table 1), and then proceeding with the selection of articles.

2.3 Inclusion and exclusion criteria and relevance screening

The inclusion criteria were that the document belonged to the article type. No exclusion criteria were used for publication date, language or other applicable filters. For the subsequent screening, the inclusion of undergraduate and graduate medical students in the study and the use of methodologies that include simulated learning were used as relevance criteria. Articles and studies not focused on medical students and systematic reviews were excluded.

Table 1. Search concepts and formulas.

Search 1 : Expansion of the concept "Simulation" (Web of Science) Thesaurus: " anatomical models" OR "anatomical simulators" OR "simulated instances" OR "simulation-based learning" Free search: Impact
Search 2 : Expansion of the concept "Surgical skills" (Web of Science) Thesaurus: "surgical skills learning" OR "surgical training" OR "surgical competence" OR "medical education" OR "surgical education" Free search: No
Search 3 : Expansion of the concept "Medical students" (Web of Science) Thesaurus: "medical students" OR "surgical students" OR "surgery trainees" Free search: No
Search 4 : Searches 1, 2 and 3 combined using AND, full text delimiters and document type article, medical education. (Web of Science and Scopus) Thesaurus: "Anatomical simulators") AND ("Surgical competence" OR "Surgical skills") AND ("Medical students") AND ("Surgery") AND ("Impact") AND (LIMIT-TO (DOCTYPE , "ar"))"

2.4 Selection process

Subsequently, once duplicate studies had been eliminated, the results of the search formulas were tabulated in Excel to facilitate screening. The titles and abstracts of the documents were reviewed by two reviewers, selecting those that met the criteria previously set out. If any questions arose about the relevance of the study, the entire text was reviewed by four reviewers.

2.5 Data collection

Significant information was extracted from the articles selected in the previous step by reading the entire document by four reviewers. This was done by identifying information that corresponded to results of any type, secondary to the implementation of some simulated learning methodology. In addition, data such as the study methodology, assessment instrument or the study population were obtained.

2.6 Classification of information

Finally, relevant results were classified based on recurring themes among the different articles and key aspects of simulation in medical-surgical education. These categories are: 1) Results reported with the use of 3D printed anatomical models, 2) Results reported in high-fidelity and mixed reality simulation, 3) Results reported in in vivo and ex vivo simulations, 4) Results reported in simulations of specific surgical tasks.

3. Results

3.1 Selection of studies

In this review, an initial universe of 84 articles was identified. After excluding duplicate articles, performing the initial screening and complete review of the works, and applying inclusion and exclusion criteria, the total number of articles was reduced to 10. The main findings of these are found in Table 2.

3.2 Characteristics of the studies

Considering the studies used in this review, it is observed that the publication date range of the documents spans from 2009 to 2023, with a marked increase in the density of studies since 2015, possibly secondary to the increase in the implementation of simulation-based learning within the curricular planning of the Medicine degree. In addition, it is evident that most of the works used questionnaires and surveys as a data collection method, also adding direct observation of the practical skills of the students. A summary of the studies used is presented in Table 2.

3.3 Common themes found in the studies

For this study, various sources of information were reviewed, and the results and findings were classified according to their relationship to the research question. Thus, it is possible to identify 4 main categories: 1) Results reported with the use of 3D printed anatomical models, 2) Results reported in high-fidelity and mixed reality simulation, 3) Results reported in in vivo and ex vivo simulations, 4) Results reported in simulations of specific surgical tasks . These categories and their respective findings are illustrated in Table 3.

3.3.1 Results reported using 3D printed anatomical models

3D printed anatomical models have emerged as a highly effective tool in teaching surgical skills. These models offer a tactile and spatial experience that facilitates the understanding of complex anatomical structures, surpassing the effectiveness of traditional or digital models in terms of retention and spatial perception (12, 17). In the context of surgical teaching, Bao et al. (13) observed that 3D models improve accuracy in interventional radiology procedures, promoting tactile feedback essential for the formation of technical skills. On the other hand, Silvero et al. (16) reported that 3D models of vasculature allow students to safely visualize and manipulate anatomy, increasing their confidence and satisfaction in learning .

3.3.2. Results reported in high fidelity simulation and mixed reality

High-fidelity simulation and mixed reality (XR) technologies have shown remarkable effectiveness in advanced surgical learning, where students can experience realistic clinical scenarios and receive immediate feedback. The Essential Skills in the Management of Surgical Cases (ESMSC) model, evaluated by Sideris et al. (11), is a successful example of high-fidelity simulation that increases both technical skills and understanding of complex surgical procedures. Likewise, Silvero et al. (16) highlighted the use of virtual reality (VR) and augmented reality (AR) in neurosurgery, facilitating the understanding of complex anatomical relationships and the practice of high-precision techniques. These advanced simulations allow students to practice in a safe environment, where they can make and correct errors without clinical repercussions (15).

Table 2. Summary of the results found.

Author (Year, Country)	Objective of the study	Study design	Participants	Information gathering	Findings
Nara et al. (2009, Japan) (4)	To contribute to the reform of the medical education system in Japan, we visited medical schools abroad and observed the methods used in medical education.	Qualitative, descriptive observational	Medical students from 28 medical schools and five institutes	Direct observation	Simulation-based learning is used to improve communication skills, medical interviews, physical examinations, and basic clinical procedures in medical students. Both students and tutors acknowledge its effectiveness in medical education, indicating that these tools can have a positive impact on the development of surgical competencies.
Sideris et al. (2016) (9)	Evaluating the effectiveness of high-fidelity in vivo simulation-based learning for undergraduate students - comparing the skill-based performance of senior students to those at the more basic level	Quantitative, experimental cohort	40 medical students	Questionnaires and direct observation	Simulation in surgical education has improved the quality of training and has been integrated into the surgical curriculum. Low-fidelity models improve technical skills at low cost, while high-fidelity models facilitate a better understanding of the anatomy and abdominal space, resulting in improved scores on assessments and a more efficient transition from open to laparoscopic techniques.
Dhaif et al. (2017, European Union) (10)	Comparing students' skill and ability-based performance with demographic and educational parameters	Quantitative, experimental	112 medical students	Direct observation. Westside Anxiety Scale. O'Connor pincer grasp test.	Our results demonstrate that more advanced medical students, in their second or third clinical year, with greater clinical experience, do not show an improvement in their surgical skills in low- and high-fidelity open osteosynthesis and internal reduction (ORIF) simulations compared to students in their first clinical year.

Sideris et al. (2018, European Union) (11)	Reporting on our experience in creating ESMSC (Essential Skills in the Management of Surgical Cases) during the global financial crisis	Quantitative, descriptive and longitudinal	311 medical students	Direct observation	Simulation-based learning (SBL) is fundamental for early surgical education, improving performance and transferring skills to clinical practice. It offers cost-effective alternatives to traditional teaching, using dry laboratory models to replace high-fidelity simulations. Although it has limitations for junior students, it provides important motivational and educational benefits, bringing students closer to a real surgical environment.
Pandya et al. (2021, UK) (12)	To assess differences in undergraduate students' attitudes towards tactile learning via non-tactile distance learning and review their acceptability among this cohort	Mixed, cohort	1280 medical students	Likert scale and qualitative evaluation	Tactile learning with physical anatomical models was superior to non-tactile learning in terms of improving anatomical knowledge, as reported by students. Physical 3D models supported spatial retention and understanding better than computer models or textbook images. These results suggest that physical models are more effective for teaching surgical skills, facilitating better understanding and retention of anatomy through tactile manipulation.
Sideris et al. (2016, United Kingdom) (13)	To critically evaluate feedback from the Essential Skills in the Management of Surgical Cases (ESMSC) programme using a scaled questionnaire, and compare these findings with a review of the current literature on undergraduate surgical education.	Mixed, observational	49 medical students	Likert scale	Simulation-based training (SBT) is essential in surgical education, with emphasis on advanced training. The ESMSC model has been shown to be effective in improving surgical skills and understanding of surgical approaches in students, with strong support from students in assessments. Students highly value the inclusion of SBT in the undergraduate curriculum, indicating a need for early, structured integration of SBT into surgical training.

Bao et al. (2023, China) (14)	To evaluate the educational benefits that residents receive from the use of new 3DP liver models, taking into account the experience and gender of residents	Quantitative, analytical cross-sectional	30 medical students	Objective structured clinical examination (OSCE) and Likert scales	Simulation-based medical education (SBME) has been shown to be more effective than traditional methods, improving understanding and satisfaction in surgical training. The integration of 3D printed (3DP) anatomical models with 2D scans has optimized tumor assignment and increased performance and participant satisfaction in surgical training. The results indicate that 3DP models may offer an effective alternative to traditional methods, especially for more experienced students, although more evidence is required to confirm their superiority over cadavers in anatomical teaching.
Haji et al. (2015, Canada) (15)	We investigated the sensitivity of these measures to expected differences in intrinsic load arising from variations in task complexity and learner experience during simulation-based surgical skills training.	Quantitative, observational	28 medical students	Skills test, subjective rating of mental effort and reaction time	Simulation-based education has been shown to be effective in optimizing the learning of surgical skills and facilitating the transfer of these skills to the clinical setting, reducing the learning curve for novices. According to Cognitive Load Theory (CLT), simulation helps to decrease the intrinsic cognitive load associated with complex tasks, allowing for more effective practice and the formation of cognitive schemas in trainees. Research results show that simulation improves both performance on primary and secondary tasks by reducing cognitive load and increasing learning efficiency. To assess the impact of simulation, it is useful to combine subjective assessments with performance on primary and secondary tasks.

Silvero et al. (2023, Germany) (16)	To identify whether a neurosurgical MRI simulation module in the setting of an undergraduate neurosurgery practical course could improve medical students' satisfaction.	Quantitative, experimental	223 medical students	Visual analogue scale and Likert scale	Extended reality (XR) technology, which includes virtual reality (VR), augmented reality (AR) and mixed reality (MR), has shown promise as an educational tool in medical education. This technology allows for interactive and dynamic simulation, combining physical and virtual environments, and has been used effectively in neurosurgery to develop technical competencies and understand complex anatomical relationships. Simulation-based medical education (SBME) has shown remarkable effectiveness in teaching basic surgical skills and general medical scenarios, outperforming traditional methods in many ways. Recent systematic reviews confirm that SBME improves knowledge transfer and long-term retention when integrated into current curricula. This methodology provides a controlled learning environment, ideal for immediate feedback and reflective practice outside of the hospital setting. MR students reported high levels of satisfaction, finding this technology entertaining and beneficial, suggesting a significant positive impact on medical education.
Goudie et al. (2019, Canada) (17)	To describe the development and application of 3D printed vasculature models within a radiology interest group to determine their effectiveness as complementary learning tools to traditional lecture-based teaching.	Quantitative, experimental	30 medical students	Survey	3D printed anatomical models are a cost-effective and advanced tool that enhances the teaching of procedural skills when used alongside traditional methods. They offer benefits in spatial perception and tactile feedback, and students are eager to integrate them into their continuing education, suggesting a potential benefit for learning in interventional radiology.

Table 3. Classification of the main results reported with the implementation of simulation-based medical education.

1. Results reported in 3D printed anatomical models • Better performance in terms of exam scores and in responses to questionnaires that evaluate theoretical learning and surgical techniques (3). • Improvement in the level of student satisfaction with teaching methods when using 3D models, evidenced in the results of different satisfaction scales applied (3). • The simulation-based approach provides greater opportunities for testing high complexity and low frequency procedures (1). • Statistically significant improvement in anatomical knowledge in the groups that used 3D models compared to those that did not (p=0.017) (1).
2. Results reported in high fidelity simulation and mixed reality • Mixed reality was experienced as pleasant, beneficial and novel by students (1). • Positive impact of immersive technology in high fidelity simulations resulting in high satisfaction in learning demonstrated in results of different satisfaction scales applied (3). • Participants showed significant improvement in practical and theoretical surgical skills (3).
3. Results reported in in vivo and ex vivo simulations • Increase in the results of practical tests showing improvements in quality and speed of procedures in students who performed in vivo and ex vivo simulations (2). • The students highly valued the course, as evidenced by different satisfaction scales applied to the students (4). • Increased confidence and ability to approach surgical patients (1).
4. Results reported in simulation of specific surgical tasks • Significant improvement in surgical skills, reducing the time and movements required (2). • Decreased cognitive load and increased performance of secondary tasks, reflected in better reaction times and self-assessments of mental effort (1). • Negative association between anxiety and performance in low-fidelity simulations, indicating that high-fidelity scenarios are better representations of the actual procedure (1).

3.3.3 Results reported in in vivo and ex vivo simulations

In vivo and ex vivo simulations represent a valuable alternative for teaching surgical skills in a controlled environment, where practice can be performed on real tissues or anatomical models that closely mimic human structures. In their study, Nara et al. (4) highlighted how in vivo and ex vivo simulations can significantly improve basic clinical skills, such as physical examination and medical interviewing, by offering students an immersive and hands-on learning experience. Dhaif et al. (10) found that these simulations allow students to advance their surgical training without the associated risks to the patient, increasing their skills in specific tasks such as osteosynthesis. Although ex vivo models have certain limitations, their use in combination with other types of simulation has proven effective for comprehensive surgical training.

3.3.4 Results reported in simulations of specific surgical tasks

Simulation of specific surgical tasks allows students to practice and improve specific skills within a surgical procedure, and has been particularly effective in highly complex procedures. Sideris et al. (13) documented improvements in student dexterity in laparoscopic simulations, where high-fidelity models facilitated the transition from open to laparoscopic techniques. On the other hand, Pandya et al. (12) reported that students prefer tactile models, such as those used in laparoscopic surgery simulations, for their ability to realistically reproduce anatomy and surgical instrument handling. Assessment of skills in specific simulations, such as the use of the Westside Anxiety Scale and the O'Connor Forceps Dexterity Test, has shown that task-specific simulations can significantly improve both technical accuracy and student self-confidence when performing complex surgical procedures (10).

3.4 Undergraduate

In undergraduate students, 3D printed anatomical models and high-fidelity simulations have been particularly effective in improving the understanding of anatomy and the acquisition of basic skills in a safe environment. Goudie et al. (17) found that 3D printed models facilitated the retention of anatomical knowledge and provided an interactive learning experience that complemented traditional lectures. Furthermore, studies such as that of Pandya et al. (12) highlight that undergraduate students value tactile learning, which is beneficial for the retention of anatomy and initial familiarization with surgical instruments. Simulation at these levels also promotes the development of basic competencies in physical examinations and clinical procedures (4).

3.5 Postgraduate

At the postgraduate level, where students typically have advanced clinical experience, simulation models focus on specific surgical skills and transition to more complex techniques. Sideris et al. (11) reported that high-fidelity simulation programs, such as ESMSC, significantly improve technical skill and decision making in surgical residents. Dhaif et al. (10) observed that simulations of specific procedures, such as open osteosynthesis and internal reduction, do not always show a proportional improvement in residents compared to less experienced students, suggesting that benefits at this stage may depend on task complexity and experience accumulated in other clinical settings. Postgraduate training benefits from advanced simulations such as virtual and mixed reality, which allow for the practice of high-precision procedures in areas such as neurosurgery and laparoscopy. Silvero et al. (16) demonstrated that these technologies not only improve surgical skill, but also increase residents' self-confidence and satisfaction, preparing future surgeons for highly complex interventions.

4. Discussion

The results of this review confirm the relevance of simulations as teaching tools in medical education, especially in surgical training. The integration of simulations into curricula has demonstrated significant improvements in technical skills, academic and clinical performance, and confidence in decision-making, which are essential elements for effective surgical practice.

Studies implementing 3D printed anatomical models highlight that these models facilitate the practice of procedures in a safe environment, reducing clinical risks and promoting a deeper understanding of anatomy. By providing a direct tactile and visual experience, these models improve spatial perception and support surgical planning, reinforcing students' confidence and performance. The implementation of these 3D models also resulted in positive feedback from students about their usefulness and effectiveness in learning (12, 18-19). These findings suggest that 3D printed anatomical models should be regularly integrated into medical education to facilitate the learning of surgical skills in an ethical and safe environment.

On the other hand, high-fidelity simulations and mixed reality have proven to be powerful tools in developing technical and confidence skills in both undergraduate and graduate students. High fidelity simulations provide realism that facilitates the transfer of skills to real clinical contexts and improves student satisfaction, who highly value the experience (20-21). This coincides with other research indicating that students from various careers in the health area show high levels of satisfaction with simulations based on realistic scenarios, especially in areas that demand technical precision and rapid decision making (22).

In relation to theoretical and practical skills, a significant improvement was observed in the results of theoretical questionnaires and practical tests in the groups that participated in simulated scenarios, which coincides with the studies of Dávila-Cervantes (23) that highlight advantages such as the lower stress load for students and its use as a high-quality assessment tool. This approach ensures the learning of specific techniques and a consistent assessment of the acquired skills.

In vivo and ex vivo simulations also offer favorable results, especially in the quality and speed with which students acquire theoretical knowledge and practical skills in surgery (13). The positive perception reported in the satisfaction scales reflects the usefulness of these practices in medical training (9-11). In addition, the increase in students' confidence to address surgical procedures reinforces the value of simulation in the development of technical skills and in strengthening self-efficacy and autonomy, essential aspects for success in the surgical context.

Although surgical simulations have been shown to be effective in improving the learning of surgical skills, there are factors such as cognitive load that must be considered. According to Haji et al. (15), tasks of greater difficulty can increase the initial cognitive load, which affects performance; however, over time, this load decreases, improving efficiency and technical skill. On the other hand, Dhaif et al. (10) found that anxiety impacts less on students who participate in high-fidelity simulations compared to those in low-fidelity simulations, which supports the recommendation to prioritize high fidelity in simulations for a positive impact on the development of surgical skills. These results coincide with previous studies, such as that of Aggarwal et al. (24), which demonstrated that simulation improves execution time in endovascular procedures, increasing efficiency in complex surgical skills.

Although the reviewed methods suggest a positive impact on student preparation, direct evidence on reduced medical errors and improved clinical outcomes remains limited. This aspect should be addressed in future research that measures long-term outcomes in professional practice.

4.1 Strengths and limitations

The systematization and classification of the results obtained in this review contribute to medical education in the area of surgery. However, a key limitation is that, by focusing on studies of a specific and eminently practical subject, these results may not be extrapolated to other areas of medicine or health sciences. Likewise, the variability in the methods and designs of the included studies, as well as the use of questionnaires, surveys and direct observation as assessment methods, may limit the direct comparability and generalization of the findings. Although these instruments are useful, they need to be complemented with objective measures that assess the impact on actual clinical performance. Another important limitation of this review is the pooling of results for undergraduate and graduate students. Since these groups have different levels of experience and training needs, this mixing could introduce variability in the findings regarding the effectiveness of the models. Future studies should explore these differences more specifically .

4.2 Future research

It is necessary to further investigate the impact of simulations on patient satisfaction and the development of soft skills. Investigating the use of simulations in the terminal phases of training, focusing on interaction with patients, would allow exploring the effects of these tools in the most transcendental phase of medical education. It is also relevant to examine the costs of implementing simulated activities, to facilitate their adoption in early phases of medical education.

4.3 Recommendations

The implementation of simulation-based learning is recommended from the early stages of medical studies. In the field of surgery, high-fidelity simulation is especially advisable for the development of practical and theoretical skills, providing effective and safe learning for future doctors.

5. Conclusions

- This review corroborates the relevance of anatomical models and simulations as essential components in contemporary surgical training. Anatomical models, both 3D printed and conventional, promote a more solid spatial understanding and facilitate surgical planning, reinforcing students' confidence and accuracy. High-fidelity simulations and mixed reality contribute to the development of technical and non-technical skills, such as decision-making and management of complex cases in a safe environment.
- In vivo and ex vivo simulations provide opportunities to practice procedures in a controlled environment, decreasing anxiety and promoting more realistic and safer practice. In addition, task-focused simulations allow for a progressive approach to cognitive load, optimizing the acquisition of technical skills.
- These approaches together highlight the need to prioritize the integration of simulation and anatomical modeling technologies in surgical training programs. The implementation of these resources in medical education allows for a balance between theory and practice, improving the quality of clinical training, and preparing students to effectively face the challenges of real practice.

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