Impact of virtual simulators on clinical decision-making improvement: integrative review

impacto dos simuladores virtuais nas decisões clínicas: revisão integrativa

Impacto de simuladores virtuales en las decisiones clínicas: revisión integradora

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Abstract
Objective: This work aimed to conduct an integrative literature review to assess the impact of using virtual digital simulators (SV) for clinical cases on the enhancement and facilitation of clinical decision-making by students and healthcare professionals. **Methods**: The review was conducted based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations. A total of 362 articles were obtained from the established databases, of which 6 were included in the review. **Results**: As a result, it can be highlighted that such tools promote theoretical/practical applicability, increase awareness of individual skills, reduce anxiety, allowing for more confident practice, and consequently improve clinical decision-making. **Conclusions**: In conclusion, the use of SV appears as a promising alternative for the training of students and healthcare professionals.
Keywords: Clinical Case Simulator; Health Professionals; Clinical Decision Support Systems.
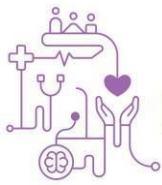
Resumo
Objetivo: Realizar uma revisão integrativa da literatura objetivando avaliar o impacto do emprego de simuladores digitais virtuais (SV) de casos clínicos no aprimoramento e na facilitação das tomadas de decisão clínica por parte de estudantes e profissionais da saúde. **Método:** A mesma foi elaborada tendo como base as recomendações do PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes). A partir da busca nas bases de dados estabelecidas obtiveram-se um total de 362 artigos dos quais 6 entraram na revisão. **Resultados**: pode-se destacar que tais ferramentas promovem aplicabilidade teórica/prática, aumentam a consciência das habilidades individuais, reduzem a ansiedade, permitindo uma prática mais confiante, por consequência melhoram as tomadas de decisões clínicas. **Conclusão**: Conclui-se que a utilização de SV, aparece como uma alternativa promissora para treinamento de estudantes e profissionais da saúde.
Descritores: Simulador de Caso Clínico; Profissionais da Saúde, Suporte de decisão clínica.

Resumem
Objetivo: realizar una revisión integradora de la literatura con el fin de evaluar el impacto del uso de simuladores digitales virtuales (SV) de casos clínicos en la mejora y facilitación de la toma de decisiones clínicas por parte de estudiantes y profesionales de la salud. **Métodos**: Se elaboró siguiendo las recomendaciones del PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). A través de la búsqueda en las bases de datos establecidas, se obtuvo un total de 362 artículos, de los cuales 6 fueron incluidos en la revisión. **Resultados**: se destaca que tales herramientas promueven la aplicabilidad teórica/práctica, aumentan la conciencia de las habilidades individuales, reducen la ansiedad, permitiendo una práctica más confiada y, en consecuencia, mejoran la toma de decisiones clínicas. **Conclusión**: Se concluye que la utilización de SV se presenta como una alternativa prometedora para la formación de estudiantes y profesionales de la salud.
Descriptores: Simulador de Caso Clínico; Profesionales de la Salud; Soporte de Decisión Clínica.

INTRODUCTION

During the COVID-19 pandemic, coupled with a steep rise in disease cases, a disruption in traditional education, previously emphasized in colleges, led to an adaptation to virtual teaching methods. Consequently, the use of virtual simulators and digital simulation in the clinical practice of healthcare students and professionals has become more prevalent. Virtual simulators are devices capable of accurately reproducing real-life scenarios on a computer screen/virtual environment, allowing healthcare students and professionals to enhance their clinical and surgical skills [1-2].

In the United States, data from 1999 indicate that approximately 98,000 patients annually die due to medical errors, defined as "an action or omission in planning or execution that contributes or may contribute to an unintended result." This underscores

a continuous challenge for healthcare professionals, regardless of advancements in the medical field. Medical errors not only have profound implications for patients and their families but also result in significant costs to medical treatment, emphasizing the urgent need to address this issue. This highlights that virtual simulators play an educational and protective role for patients and users, aiming to limit the possibilities of errors in healthcare decision-making [3-4].

Simulators have been widely used in surgical skills training, assisting residents in simulating and practicing operations in a manner that does not harm the patient. During practice, professionals are exposed to different situations that may occur, particularly in a hospital setting, reducing the shock when they enter clinical practice [3,4,5].

Virtual simulation (VS) enhances access to practice and encourages healthcare students and professionals to train their clinical skills. Within VS, standardized patients (SPs) may also be present, community members who play the role of patients for the training of students and professionals. These SPs are highly useful for students to practice not only clinical issues but also communication skills and cultural competence [6,7,8].

In this context, the aim of this work is to conduct a comprehensive review on how the use of virtual simulators affects learning and clinical decision-making in healthcare students and professionals. Additionally, we aim to highlight the absence of similar review studies on this topic, largely due to its recent emergence in healthcare practice. Therefore, this study aims to not only elucidate the current scientific evidence but also bridge this gap by contributing to future research in this developing area.

METHODOLOGY

This study is an integrative literature review aimed at answering the question: "What are the Impacts of Utilizing Digital Virtual Clinical Case Simulators on improving and Facilitating Clinical Decision-Making among Healthcare Students and Professionals?". This research question was formulated based on the recommendations of the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses).

The integrative literature review (ILR) consists of the following steps (9): Identification of the study's need; Definition of the review protocol, including research questions, keywords, synonyms, search strategy, and criteria for inclusion and exclusion of studies; Review execution, involving searches and selection of works; Quality analysis of selected works; Extraction and analysis of selected works.

English descriptors were employed, forming the following search string: ('Clinical Decision Support Systems' OR 'Clinical Competence') AND ('Case Simulation' OR 'Clinical Case Simulator') AND ('Physicians' OR 'health professionals'). It is noteworthy that these research databases were chosen for their consolidation in both health and computer science and informatics.

Boolean expressions AND and OR were utilized in the search to obtain the maximum number of studies on the reviewed topic.

The searches in the selected databases (PubMed/Medline and Scopus) occurred between December 2023 and January 2024.

Inclusion criteria comprised original research published within the last 10 years, in English, fully accessible, and presenting guidelines and development interfaces of virtual clinical case simulators related to health and their impact on clinical use. Exclusion criteria included articles that did not describe or address the research objective, lacked abstract and title, were not scientific articles, represented an older version of another considered, population overlap, publication date exceeding 10 years, inaccessible full text, and duplications.

The studies were analyzed, and data were transcribed and organized in a file and a computer software called Rayyan, extracting the following information from the search databases: publication year, study location, country, and target audience.

RESULTS

From the search in the established databases, such as PubMed and Scopus, a total of 362 articles were obtained. In the PUBMED database, we identified three relevant articles, while in the Scopus database, three relevant works were identified. Figure 1 outlines the steps for the selection of articles for this systematic literature review based on the PRISMA methodology.
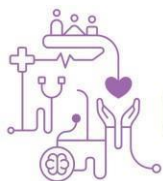
Figure 1. Flowchart of study selection - PRISMA. Belo Horizonte - MG, Brazil, 2024
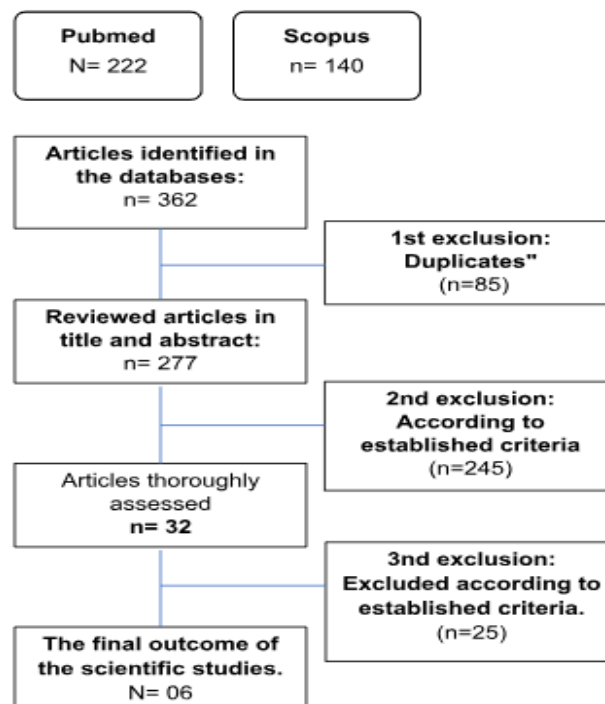
The sample consisted of 6 articles, published between 2010 and 2023, with 1 in 2010, 2 in 2014, 1 in 2017, 1 in 2021, and 1 in 2023, all in the English language. Further characteristics of the studies are detailed in Table 1.

Table 1 - Characterization of studies according to authorship, year of publication, journal, sample, study objective, and results. Belo Horizonte, MG, Brazil, 2024.

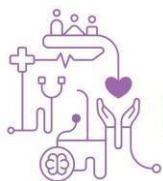| N	Authorship/Year of publication	Journal/Paper	Sample	Objective	Results
01[9]	J.F. Knight et.al. / 2010	Resuscitation	During the Medical Support and Management of Severe Incidents Courses, 91 students were randomly assigned to one of two training groups: 44 participants practiced the triage sieve protocol using a card sorting exercise, while the remaining 47 participants engaged in a serious game.	Evaluate the effectiveness of a serious game in teaching severe incident triage, comparing it with traditional training methods.	The accuracy in precision by participants undergoing serious game training was significantly higher compared to those who performed the card sorting exercise. Additionally, a higher precision was observed in the steps, specifically among participants who properly followed the protocol in triaging all eight victims. No statistically significant differences were identified in the time spent completing the victim triage.
02[10]	F. W. Kron et.al. / 2017	Patient Education and Counseling	A blinded, randomized, multicenter clinical trial was conducted, involving 210 participants in the MPathic-VR group and 211 in the	The study aimed to assess advanced communication skills in second-year medical students exposed to a computer simulation (MPathic-VR)	Students who underwent training with MPathic-VR demonstrated improvement in their intercultural and interprofessional communication skills in each scenario.

			computer-based learning group.	with virtual humans or a computer-based multimedia learning module.	Additionally, they achieved significantly higher scores in the Objective Structured Clinical Examination (OSCE) compared to students who received computer-based learning. The attitudes and experiences of students trained with MPathic-VR were more positive, emphasizing appreciation for immediate feedback, teaching of non-verbal communication skills, and preparation for emotionally charged clinical situations.
03 (11)	J.T.C Fung et.al. / 2023	Nurse Education Today	A total of 61 students participated in the study, with the majority being female (87%) and nursing undergraduate students (72.1%). Participants were randomly assigned to receive virtual simulation (Group A) or Problem-Based Learning (PBL - Group B). Data collection included the	To compare the effectiveness of virtual simulation and Problem-Based Learning (PBL) in the perception of clinical and cultural competence among nursing students.	The results demonstrated statistically significant improvements in the overall scores of the Clinical Competence Questionnaire (CCQ) for both groups, in nursing professional behavior, and advanced nursing skills after two interventions. Additionally, both groups showed significant improvements in the overall scores of the Inventory

			completion of three self-assessment questionnaires: Clinical Competence Questionnaire (CCQ), Inventory for the Assessment of the Cultural Competence Process among Healthcare Professionals - Student Version (IAPCC-SV), and a demographic questionnaire.		for the Assessment of the Cultural Competence Process among Healthcare Professionals - Student Version (IAPCC-SV). No statistically significant differences were observed between the two groups. The findings indicate that both virtual simulation and Problem-Based Learning (PBL) were effective in promoting perceived clinical and cultural competence among the students.
04 (12)	O. Kostopoulou. et. al./ 2014	British Journal of General Practice	A total of 297 general practitioners (GPs), including 30 interns, were recruited in the United Kingdom. The sample had an average of 9 years of experience in general practice (standard deviation = 9, median = 5, range from 0 to 34) and included a higher proportion of women (54%) compared to the UK average (44%).	To determine whether providing general practitioners (GPs) with diagnoses to consider before they start testing hypotheses improves accuracy.	Considering a risk of incorrect diagnosis of 0.37 for the control group and an odds ratio of incorrect diagnosis with early support of 0.77 (95% CI = 0.60 to 0.97), the number needed to treat was 17 (95% CI = 9 to 146). In summary, early support demonstrated significant improvements in diagnostic accuracy, particularly in challenging cases, with a benefit for one out of every

					17 treated patients.
05 (13)	JA. Sperl-Hillen et.al. / 2014	Academia Médica	Nineteen primary care residency programs, involving 341 voluntary residents in all postgraduate years (PGY), were randomly assigned to participate in the SimDE intervention group or the control group (GC). The web-based interactive educational intervention utilized computerized virtual patients that responded to healthcare providers' actions through programmed simulation models.	To validate the primary hypothesis that the virtual intervention of Simulated Education on Diabetes (SimDE), grounded in cases, enhances the ability of primary care residents to appropriately and safely achieve evidence-based clinical goals for diabetes. Evaluated through a series of virtual patient case assessments.	Residents in the SimDE group, who partially completed 18 learning cases (L cases), showed improvement in A case outcomes compared to the control group, although they did not reach the overall performance of SimDE residents who completed all cases. The average time to complete an A case was 25.6 minutes, with no consistent pattern in the time dedicated to case assessment. The intervention had a notable impact on glycemic control and lipid management, with a lesser effect on blood pressure. A significantly higher frequency of appropriate and safe treatment was observed in the intervention group for specific cases.
6 (14)	R. Plackett et. al. / 2021	Journal of Medical Internet Research	A mixed methods design was employed to examine the impacts of eCREST on data collection across three medical schools in the UK (N=148). An	Identify data collection patterns among final-year medical students during the use of eCREST and assess how eCREST	The trial results indicated that students in the intervention group were more detailed in data collection compared to the control groups. Students

| | | | | eCREST trial was conducted to assess potential effects on data collection. Additionally, a qualitative study involving semi-structured interviews and think-aloud sessions was carried out with 16 medical students from one college. | influences these patterns. | highlighted that eCREST encouraged accuracy by promoting continuous reflection and providing opportunities to practice managing uncertainty. However, some participants found eCREST less helpful, leading to random information collection. Reanalysis of trial data revealed that the intervention group had a significantly higher probability of adopting a comprehensive data collection pattern compared to the control group (21/78, 27% vs. 6/70, 9%) and a lower probability of following a succinct pattern (13/78, 17% vs. 20/70, 29%; χ^2 3 = 9.9; P = 0.02). |

DISCUSSION

Virtual simulators have emerged as an influential tool in the training of healthcare professionals, serving as both a training and assessment method for both practitioners and students. Their primary goal is to enhance patient care, teamwork, and clinical reasoning, focusing on practical decision-making without jeopardizing patient lives [1,2,3,4,9].

In this way, they provide an affordable means to create clinically realistic scenarios in a safe environment, addressing various areas such as communication skills, clinical and cultural competence, diagnostic accuracy, primary care skills, patient data collection, among other utilities [9,10,12,13,14,15].

One of the advantages of SV is their versatility in applications, including a more playful approach through games, fostering a lighter learning experience for healthcare students and professionals [1,11,16,17,18].

One study even observed better decision-making accuracy among participants compared to those using traditional methods, with equivalent time spent between the groups [9]. These findings were not unique to a single study but were consistent across the selected articles, demonstrating improved diagnostic efficiency in both severe and non-severe cases. Additionally, there was enhanced selection of appropriate treatments, increased accuracy in patient history-taking, and improved interprofessional skills. These aspects contribute to reducing patient waiting times and increasing survival chances in real-world scenarios [9,10,11,12,13,14].

Another aspect that can be inferred is that virtual simulators allow beginners and less experienced individuals to undergo training before facing real situations, providing greater safety for both them and the patients they will attend to. In this way, they become proficient after participating in effective simulations [6].

A noteworthy factor contributing to the growth of simulator users and their widespread adoption is the immediate feedback provided by virtual patients. This feature facilitates the identification of errors made during simulations, leveraging the more detailed memory of the moment and allowing for more accurate corrections later on. This aspect was praised by participants in one of the selected articles [9].

In light of this, the increased use of simulators across all stages of professional education is justified. One of the articles even draws a comparison with Problem-Based Learning (PBL), a method gaining global prominence for its efficiency and currently employed by many colleges, particularly those dedicated to healthcare professional education. This study confirmed that simulators demonstrated equivalent effectiveness in promoting clinical and cultural competencies among nursing professionals [10].

In this way, it can be asserted that Virtual Simulators (SV) have proven to be a promising teaching and learning tool by promoting theoretical and practical applicability. They demand prior knowledge and allow its application to assess skills in accordance with one's preparedness. The subsequent reflection aims to understand strengths and weaknesses, fostering the development of critical thinking associated with decision-making. This process enhances awareness of one's capabilities and boosts confidence in performing procedures and engaging with real patients [10,11,12,13,14].

Often, anxiety can bring drawbacks in real practice, causing a state of negative stress that increases insecurity, fear, and reduced focus, leading to difficulty in clinical reasoning, absorption of information, and difficulty in choosing the best course of action. In this way, the Virtual Simulator (SV) facilitates addressing these issues in all types of environments, whether under pressure or not, so that in real practice, the practitioner can feel comfortable and, consequently, have more clarity in their actions [11].

It is noteworthy that simulators facilitate the reassessment of previous outcomes through recordings and videos for clarification and resolution of details before the next simulation [11].

On the other hand, the simulators can have inherent limitations. Although they approximate reality, they cannot fully replicate the complexity and unpredictability of

real-life situations, such as the injuries and the deterioration of a patient's condition, as well as the triage challenges that may arise during actual patient care. Additionally, professionals tasked with preparing simulators for users face the constant need to create diverse scenarios for simulations, which can sometimes limit the range of activities available [8,9,10,11].

Considering the simulated nature of the interactions, it is possible that users may not demonstrate the same level of commitment as they would in real situations, which significantly compromises the learning potential offered by simulation and its relevance in the educational context.

And finally, simulators can also influence users to lean towards a premature conclusion, potentially leading to a misdiagnosis and limiting diagnostic hypotheses [12].

Therefore, the use of SV in the training of nurses and physicians should be considered a complement to the learning and training of healthcare professionals. This is because direct interaction with real patients is essential for refining clinical decisions and communication skills [5,6,9,16].

CONCLUSION

In conclusion, virtual simulators (SV) emerge as a powerful tool in the field of medical and health education, offering an innovative and effective approach in training professionals and students. The reviewed studies consistently demonstrate that SV contributes to significant improvements in various parameters, including communication skills, clinical and cultural competence, diagnostic accuracy, primary care skills, and patient data collection, all of which collectively lead to more precise clinical decision-making.

It is important to emphasize that SV should be a complement to real patient practice. Direct contact with patients is crucial for the practical development of clinical skills and communication, with simulators serving as a valuable tool to enhance theoretical and practical learning.

Continuous research and integration of these innovative technologies are essential to ensure ongoing advancements in medical education and to foster more qualified and prepared healthcare professionals to face the challenges of the real clinical environment.

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