Almulihi et al. Saudi J Er Med. 2022;3(2):151-160
https://doi.org/10.24911/SJEMed/72-1646523518

REVIEW ARTICLE

Do departmental simulation and team training program reduce medical error and improve quality of patient care? A systemic review

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ABSTRACT

Aim: Simulation-based learning programs have become increasingly popular over the past 20 years to improve healthcare professionals' knowledge, skills, and attitudes while protecting patients from unnecessary risks and errors. However, recommended practices for simulations in healthcare are still unknown; hence this systematic review aimed to assess whether human simulations or machine stimulations programs would help prevent medical errors and improve patient safety.

Methods: We searched for all the publications in the Medline, Web of Science, and Google Scholar databases from January 2000 (when the idea of simulation in healthcare to prevent Medical Errors (ME) was employed for the first time by the Institute of Medicine) to Feb 2022 with only English language-based literature. The risk of bias from A randomized controlled trial (RCTs) was assessed through Cochrane's collaboration tool. The Newcastle-Ottawa Scale was used to evaluate the quality of the cohort studies. The main outcome of this review was the improvement in professional skills among healthcare professionals and reduction in medical errors by employing simulation-based training.

Results: Overall, the participants who received simulation-based training for the management of different clinical conditions and for the performance of various diagnostic, therapeutic, and surgical procedures showed better learning than those who were given traditional education and training. Moreover, the studies showed that simulation-based training can improve self-efficacy, confidence, and perceptions among medical professionals. Different simulated adult and pediatric scenarios were created to assess the errors and delays during drug infusion-preparation and administration. The simulation was demonstrated to be an effective way of reducing medical errors.

Conclusions: By incorporating simulation-based training into medical education curricula, the acquisition of knowledge and professional skills can be improved. Moreover, this can help improve patient outcomes and reduce medical errors. Based on our findings, we suggest that simulation can be best used as a complement to the other methods of healthcare professionals' teaching and training.

Keywords: Education, medication error, simulation-based learning, systematic review.

Introduction

The term "simulation" refers to the application of technologies to recreate the environments where specific tasks can be imitated for education or training purposes. From the simple mannequins and screen simulators, all the way to the contemporary computer-controlled, high-fidelity simulators, simulation technology has continued to flourish [1].

A medical simulation session is characterized by the presence of four core components (Figure 1). The first

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Received: 05 March 2022 | **Accepted:** 17 April 2022

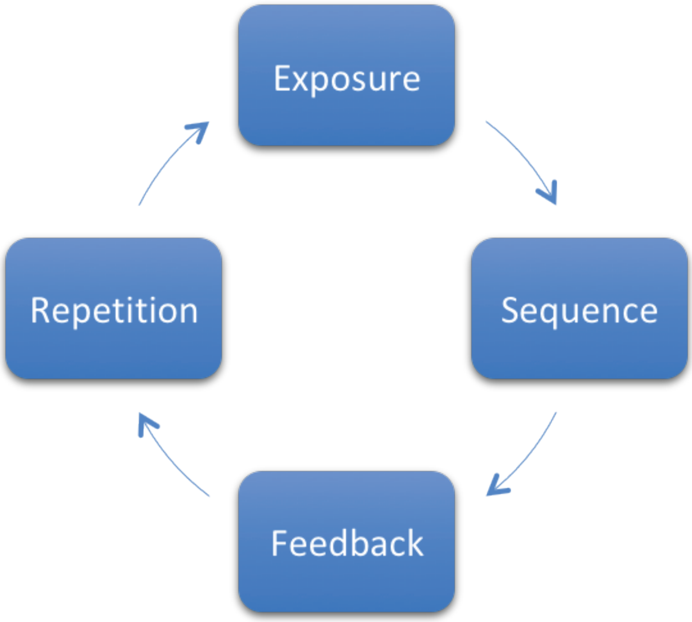

***Figure 1.** Core components of medical simulation.*

component is "exposure" or "briefing," which prepares and orientates participants before the start of the simulation. The second element is "sequence", defined by a progressively escalating complexity during the session; the third one "feedback", which refers to the continuous providing of negative and positive reflections between trainer and trainee. The last component is "repetition", which provides improved retaining of knowledge learned during a session [2].

Beginning in the late 1960s, the development of human patient simulators notably accelerated during the 1980s and 1990s. With the emergence of automatically controlled physiological and pharmacological features, the present-day simulators have got a remarkable magnitude of realism and are extensively used in healthcare professionals' education and training [3].

During the medical education and training, trainees deal with real-life clinical scenarios; often before the time, they become fully competent in doing so. Although this is necessary for transforming acquired knowledge into skills, this compromises patient safety and results in malpractice [4].

Preventable errors that often lead to adverse patient outcomes and sometimes even the death of patients are substantially attributable to system failures and inadequate situation handling. Such errors persist despite ongoing efforts to ensure patient safety [5]. Simulation-based training allows unhazardous exposure of healthcare providers of any level of experience to a standardized learning environment with the hope of improving physician performance without risking patient safety [5]. It has been demonstrated that various simulation methods can be employed for reducing medical errors and increasing patient safety [6].

In the traditional system of bedside teaching, patients often seem bothered about residents and students "practicing" on them, and students also feel that they are not adequately trained. Medical simulation is a good technique to bridge this gap [7]. When used appropriately and efficiently, simulation provides benefits for learners as well as for patients. It helps in reducing medical errors and improving patient safety, in addition to enhancing learners' confidence and competence [8]. With the advantage of providing students with the opportunity to learn and practice skills in realistic scenarios without compromising patient safety, simulation technology has emerged as a safe method of overcoming many of the drawbacks associated with patient-based training [9].

The techniques involved in healthcare simulation make use of considerable human, logistical, and financial investments, and this might be a potential barrier to their spread in developing countries. Despite this fact, healthcare simulation seems feasible and encouraging in developing countries as well [10]. Our current state of knowledge recognizes simulation programs employed in the hospital environment as a prevention tool, focusing on medical errors related to decision-making at each step of the medication process. This systematic review aimed to assess whether human simulations or machine stimulations programs would help to prevent medical errors and improve patient safety.

Material and Methods

Eligibility criteria

We used PICOS to help formulate our inclusion criteria: P (Population): healthcare professionals, nurses, medical interns, and students; I (Intervention) simulations; C (Control): traditional teaching or other stimulations scenarios; O (Outcome): medical errors, patient safety, and professional performance; and S (Studies): clinical trials and cohort studies published in English. The eligibility criteria for inclusion in the review required original articles in English (we excluded letters, case reports, abstracts, conference papers, and reviews); we included studies that have the main outcome focused on medical error, patient safety, and improved clinical skills by simulation-based learning programs such as prescribing, dispensing, and administering medication. We included only those studies conducted in hospitals or universities. Also, we had all the articles on technical and electronic simulation, surgery, intubation or students or nursing, or technology (serious games, virtual reality, and 3D environments).

Search strategy

This systematic review was conducted according to the Preferred Reporting Items for Systematic Review and Meta-analyses (PRISMA) guidelines [11]. We used three targeted Medical Subject Headings (MeSH) terms that are particularly useful in finding articles related to improving patient safety and error prevention by medical simulation: (1) risk management; (2) patient safety; (3) medical errors; and (4) medical simulation. We combined these terms, “Risk Management” [Mesh] OR “Patient Safety” [Mesh] OR “Medical Errors” [Mesh] AND“Medical Simulation” [Mesh], to be as specific and selective as possible. We searched for all the publications in the Medline database, Web of Science, Cochrane Database, Embase, and Google Scholar from 2000 (when the idea of simulation in healthcare to prevent ME was employed for the first time by the Institute of Medicine) to Feb 2022 with only English language-based literature.

Study selection and data extraction

The reviewers searched electronic databases and registers. Studies searched were exported to the EndNote Reference Library software version 20.0.1 (Clarivate Analytics) and duplicates were screened and removed.

We extracted data by entering them into a computer spreadsheet. Discrepancies were resolved through consensus discussions among investigators. The following data were tried to extract from each eligible study: first author’s name, year of publication, location of study, date of study, and sample size. This was performed by one investigator Qasem Ahmed Almulihi (QAA) and checked by another Duaa Abdulkadir Al Muslim (DAA) and Aminah Raad Alturki (ARA) blindly.

Quality assessment of studies

The investigators assessed the quality of each of the included studies. The risk of bias from RCTs was assessed through Cochrane’s collaboration tool in seven domains: adequate sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and free of other bias. The individual domains and overall risk of bias judgment were expressed on one of three levels: low risk of bias, unclear risk of bias, and high risk of bias. Based on these factors, the overall quality of evidence was deemed low, moderate, or high risk of bias (details of quality assessment is provided in Table 1). The Newcastle-Ottawa Scale (NOS) was used to assess the quality of the cohort studies. NOS score 1-5 were considered as high risk for bias, 6-7 was moderate and a score >7 was considered low risk of bias (details of scoring are provided in Table 2).

Table 1. *Quality assessment of randomized controlled trial using Cochrane’s collaboration tool.*

Author and year	Adequate sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of out-come assessment	Incomplete outcome data	Selective outcome reporting	Other sources of bias	Net risk
Neelankavil et al. (2012) [12]	Low risk	Unclear risk	Unclear risk	Low risk	Low risk	Low risk	Low risk	Low risk
Bruppacher et al. (2010) [13]	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk	High risk	Low risk
Jayaraman et al. (2014) [14]	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Smith et al. (2014) [15]	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Kory et al. (2007) [16]	Unclear risk	Low risk	Low risk	High risk	Low risk	Low risk	Low risk	Low risk
Wheeler et al. (2008) [17]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Adapa et al. (2012) [18]	Low risk	High risk	High risk	Low risk	Low risk	Unclear risk	High risk	Moderate risk
Estock et al. (2018) [19]	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Fisher et al. (2010) [20]	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Faulkner et al. (2020) [21]	Low risk	High risk	High risk	Unclear risk	Low risk	Unclear risk	High risk	Moderate risk
Diaz and Dawson (2020) [22]	Unclear risk	High risk	High risk	High risk	Low risk	Low risk	Low risk	Moderate risk
Ford et al. (2010) [23]	High risk	Unclear risk	High risk	Low risk	Low risk	High risk	Low risk	Moderate risk
Dean et al. (2021a) [24]	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Dean et al. (2021b) [25]	Low risk	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk

Table 2. Quality assessment of a cohort study using the NOS.

	Representativeness of the exposed cohort	Selection of the nonexposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up risk long enough for outcomes to occur	Adequacy of follow-up risk of cohorts	Net score
Yan et al. (2021) [26]	1	1	1	1	1	1	1	1	8

Statistical analysis

The results were analyzed using narrative analysis. A textual approach was used to combine and summarize the findings from different studies and subsequently explain the synthesized findings. It was selected as it systematically evaluates and incorporates the results from across the studies and explores the similarities and dissimilarities between the study findings. Since the included studies demonstrated heterogeneity regarding their evaluation criteria and study results, performing a meta-analysis was not considered appropriate, as it would have yielded potentially insignificant and misleading results [27].

Results

Literature search results

The initial search of the databases and registers yielded 1,322 potential studies. After exclusions based on titles and abstracts, the full text of 70 studies was read for possible inclusion. A total of 15 studies remained for qualitative and quantitative analysis. Figure 2 summarizes the results of our literature search.

Study characteristics

Table 3 provides the basic characteristics of the included studies [12-25].

Result of the quality assessment

The risk of bias from RCTs was assessed through Cochrane's collaboration tool. NOS was used to assess the quality of the cohort studies.

Out of the 15 included studies, 11 studies had a low risk of bias [12-17,19,20,24,25,26] and 4 had a moderate risk of bias [18,21,22,23].

Preventing errors by simulation for healthcare professionals

Five studies [17-19,22,23] employed simulations to evaluate medical errors. In these studies, different simulated adult and pediatric scenarios were created to assess the errors and delays during drug infusion-preparation and administration. The studies also evaluated the effect of different ampule labeling on drug dosing errors, the impact of label design on medication safety, and the impact of CLC on medical errors.

In the simulated pediatric anaphylaxis scenario [17], providers using mass concentration labels administered the dose more accurately and in a shorter time. The simulated scenario of septic shock [18] demonstrated that the availability of prefilled syringes for drug infusions can prevent medication errors and treatment delays. In the simulated scenario of vascular injury [19], participants who used redesigned labels selected and administered correct medications more frequently. Implementation of a CLC simulation training curriculum [22] was found to be associated with a significant reduction in medical errors. Simulation-based training for CCU nurses [23] led to a reduction in medication administration errors.

The results can help healthcare professionals minimize medical errors while dealing with real patients.

Improving patient safety and professionals' skills by simulation for healthcare professional

Ten studies [12-16,20,21,24,25,26] demonstrated the positive impact that simulation-based training can have on the acquisition of professional knowledge and skills required for optimal management of various clinical conditions and for ensuring appropriate patient care. Overall, the participants who received simulation-based training for the management of different clinical conditions and for the performance of various diagnostic, therapeutic, and surgical procedures showed better learning than those who were given traditional education and training. Moreover, the studies showed that simulation-based training can improve self-efficacy, confidence, and perceptions among medical professionals.

Residents who received simulation training for TTE [12] were able to obtain better quality imaging and more efficient interpretations of the acquired views. Residents receiving the simulation-based cardiac training [13] performed better CPB weaning. Similarly, simulation-based training of invasive diagnostic procedures, such as nasolaryngoscopy [15] and airway management skills [16], resulted in better clinical performance. The improved performance was also seen in simulation-based training of surgical skills in cricothyroidotomy [14], cataract surgery [24], and glaucoma surgery [25].

Discussion

Our systematic review demonstrates that simulation-based training proves to be beneficial in all aspects of healthcare performance, i.e., diagnostic procedures, surgical interventions, and emergency management of

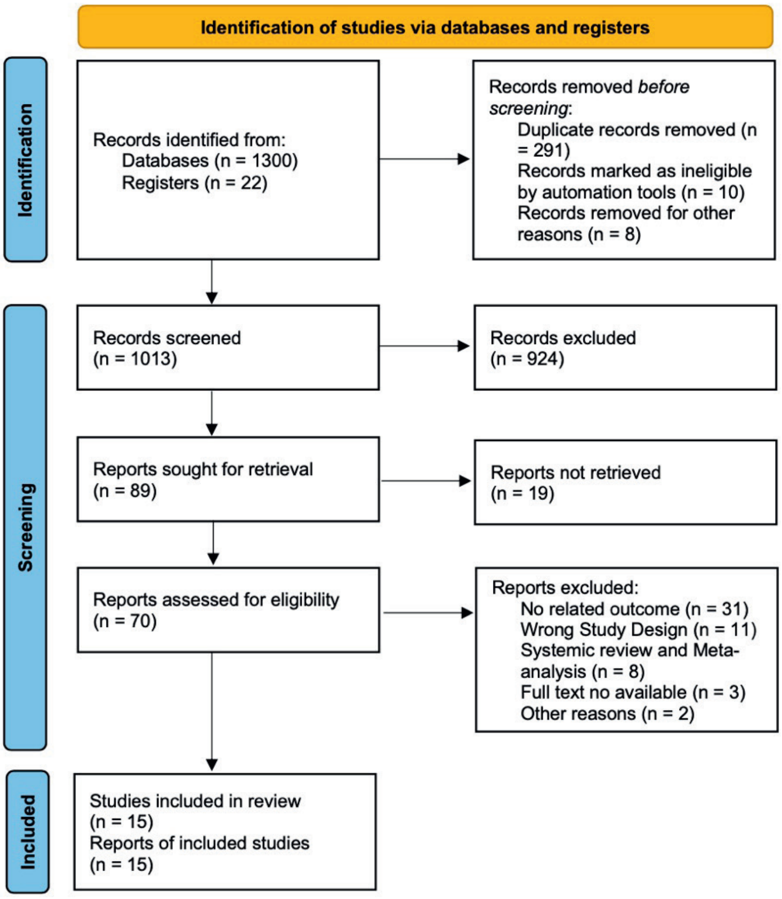

Figure 2. *PRISMA flowchart.*

various clinical conditions. Moreover, it is an efficient tool for addressing medical errors to ensure patient safety.

The increasing adoption of this methodology of medical training for teaching basic, as well as advanced, clinical skills across the globe reflects the benefits of simulation [3]. A meta-analysis by Beal et al. [28] showed that simulation-based learning resulted in the better acquisition of skills but was not superior to other teaching methods in terms of knowledge acquisition. They also demonstrated greater effectiveness of high-fidelity simulations as compared to low-fidelity simulations.

With simulations becoming more realistic, simulation-based surgical training allows better integration of knowledge and practical skills [29]. A systematic review of surgical simulation training showed that participants who received simulation-based training prior to undergoing patient-based assessment showed improved performance than their counterparts who did not get prior simulation training [29]. Simulation not only provides a safe environment for hands-on experience, but it also provides an opportunity for reflection and improvement of mental models [30]. The challenge point framework [31] and the cognitive load theory [32] reinforce the idea that simulation has a distinctive impact on the learning process.

Although high-fidelity and low-fidelity simulations can provide notable improvements in performance, low-fidelity simulation can provide this benefit at considerably lower costs [33]. Low-cost simulation can be a good economical alternative to high-fidelity simulation [34]. These findings are important for the healthcare education and training institutes that strive to ensure quality learning in the face of finite resources and budgets.

Despite being an efficient tool for medical training, simulation is associated with certain weaknesses and limitations which cannot be neglected. It has been demonstrated that simulation may not accurately recreate the stress that is encountered in the real environment [35]. Moreover, the financial costs and resource utilization associated with simulation-based teaching are high, and this may limit its implementation into the medical school curriculum [36]. Potential barriers to the development of effective simulation programs include inadequate financial resources and a lack of sufficiently experienced faculty to maintain the simulation programs [37]. This systematic review provides ample evidence that simulation is an effective method for teaching and training healthcare professionals. It is particularly effective in augmenting the practical skills of healthcare professionals, improving patient care, and preventing iatrogenic risk related to ME, if the program is well designed. Furthermore, simulation programs offer an encouraging advantage over other methods of teaching and training [38].

Table 3. Basic Characteristics of included studies

Author and year	Type of the study	Purpose of the program	Simulation scenario	Comparator	Outcomes measured	Result	Perception evaluation (Debriefing)	Notes
Neelankavil et al. (2012) [12]	Randomized controlled trial	Transthoracic echocardiography (TTE) training	First session TTE on simulator Second session Observed TTE on simulator + volunteer subject	First session Lecture-based video Second session Observed TTE on standardized patient + volunteer subject	TTE skills acquired after training (written posttest + performance)	Simulator group scored higher at posttests after the training sessions	The examinations were graded on the ability to acquire the correct image, image quality, anatomy identification, and time required to attain proper imaging by two blinded experts	Residents trained with simulation acquired better skills
Bruppacher et al. (2010) [13]	Randomized controlled trial	Cardiopulmonary bypass (CPB) weaning training	Simulation-based cardiac training	Expert interactive seminars	Clinical performance on CPB patients (Posttest + retention test)	The simulation group scored significantly higher than the seminar group at both the posttest and the retention test	All sessions were videotaped to facilitate debriefing At the end of each session, trainees were debriefed with regard to their performance in nontechnical and technical skills.	Compared with traditional interactive seminars, simulation-based training leads to improved performance in patient care
Jayaraman et al. (2014) [14]	Randomized controlled trial	Cricothyroidotomy teaching	Standard education (lecture and video) plus low-fidelity simulation	Standard education (lecture and video)	Performance of cricothyroidotomy Pre- and posttests of self-efficacy and knowledge	Time to complete cricothyroidotomy was significantly less, and performance scores were significantly higher in the simulation group.	Scores for each item were summed. Time to complete the procedure and complications were recorded The faculty member completing the evaluation recorded his or her belief of whether the resident had received simulation training	Low-fidelity simulation can improve time and skill to perform cricothyroidotomy.
Smith et al. (2014) [15]	Randomized controlled trial	Flexible nasolaryngoscopy training	Lecture and video presentation + mannequin training + video feedback	Lecture and video presentation	Flexible nasolaryngoscopy performance on volunteers	Simulation + video feedback group produced significant performance improvement	Structured video feedback Blinded observers scored the trainees Volunteers also scored the comfort of the procedure	Simulation + video-assisted feedback is an effective way to improve endoscopy skills prior to starting flexible nasolaryngoscopy on patients.
Kory et al. (2007) [16]	Randomized controlled trial	Airway management skills	Scenario-based training with computerized patient simulator	Traditional residency training	Initial airway management skills tested using a standardized respiratory arrest scenario	The simulation group performed significantly better than the traditional training group in 8 of the 11 steps of the respiratory arrest scenario.	Immediately after testing, the two researchers independently completed a standardized scoring sheet based on their observations	Simulation training is more effective in training medical residents than the traditional method.
Wheeler et al. (2008) [17]	Randomized controlled trial	Assessing the effect of ampule labeling on drug dosing errors.	Simulated pediatric acute anaphylaxis scenario (using mass concentration labels)	Simulated pediatric acute anaphylaxis scenario (using ratio labels)	The amount of epinephrine given and the time taken to administer it	providers using ratio labels gave more epinephrine (above target) and took longer to do so	Audiovisual recordings of the scenarios were made. Investigators recorded the dose of epinephrine administered and the time taken for it to be given.	Patient safety might be improved by expressing drug concentrations exclusively as mass concentration

Continued

Author and year	Type of the study	Purpose of the program	Simulation scenario	Comparator	Outcomes measured	Result	Perception evaluation (Debriefing)	Notes
Adapa et al. (2012) [18]	Randomized controlled trial	Assessing errors during drug infusion-preparation	Simulated patient with septic shock (prefilled syringes provided)	Simulated patient with septic shock (drug infusions prepared by participants)	Time taken for the infusion to be started final concentration of the drugs	Early infusion and less medication error when pre-filled syringes were used	Audiovisual recordings of the scenarios were made with integrated time displayed	Providing drug infusions in prefilled syringes would reduce medication errors and treatment delays
Estock et al. (2018) [19]	Randomized controlled trial	Assessing the impact of label design on medication safety	Simulated scenario of an unexpected vascular injury (using redesigned labels)	Simulated scenario of an unexpected vascular injury (using current labels)	Medication safety frequency of correct medication selections from the cart Frequency of correct medication administrations to the simulated patient.	The percentage of participants who correctly selected hetastarch from the cart was significantly higher for the redesigned labels than the current labels	Medication administration was recorded in real time during the simulation by investigators in the observation room and confirmed by the confederates in the simulation.	The redesigned labels helped participants correctly select hetastarch from the cart, thus preventing some potentially catastrophic medication errors
Fisher et al. (2010) [20]	Randomized controlled trial	Eclampsia and magnesium toxicity management training	Simulation simulation + lecture	Traditional lecture	Maternal, fetal, eclampsia management, and magnesium toxicity scores	Postintervention maternal and eclampsia scores were significantly better in simulation-based groups	Postintervention simulations were performed for all and scored using standardized lists	Simulation training is superior to traditional lecture alone for teaching crucial skills for the optimal management of both eclampsia and magnesium toxicity
Faulkner et al. (2020) [21]	Cluster randomized controlled trial	Assessing the impact of simulation-based training on health service board members' perceptions of their skills	Simulation-based training session	Control waitlist	Perceived skills and confidence in communicating in health service board meetings Self-reported perceptions of the relevance and utility of the training.	Board members' skills and confidence, and perceptions of board meeting processes were improved after training	Statements about the utility of the training suggested a generally positive response. Participants also described being more mindful about the ways in which they frame questions and the styles of questions that they use.	Simulation-based training appeared to improve board members' skills and confidence, and perceptions of board meeting processes.
Diaz and Dawson (2020) [22]	Non-randomized trial	Assessing the impact of simulation-based closed-loop communication (CLC) training on medical errors	Hands-on CLC simulations (postimplementation of the training curriculum.)	Preimplementation of CLC simulation training curriculum	Number of medical errors	Staff perceptions of CLC ability improved and were sustained after one month	Using a 1-10 Likert scale, staff rated their perceptions about their own and their team's CLC ability	Simulation-based CLC training curriculum improved staff perceptions of their CLC ability and was associated with a significant decrease in the number of medical errors in ESI 1 patients.
Yan et al. (2021) [26]	Prospective cohort study	Evaluating the impact of rapid cycle deliberate practice (RCDP) on primary and secondary survey skill retention.	RCDP trauma resuscitation (received the RCDP trauma resuscitation curriculum.)	RCDP trauma resuscitation (did not received the curriculum)	Completion of key components within the trauma primary and secondary survey	Significant improvement in primary and secondary survey performance between study group and control groups	Videos of trauma care were reviewed and scored	The RCDP curriculum led to significant improvement in surgical residents' trauma survey performance and had clinical impact on actual patients
Ford et al. (2010) [23]	Randomized controlled trial	Critical care unit (CCU) and medical intensive care unit (MICU) training	Simulation-based training for CCU nurses	Didactic lecture for MICU nurses	Medication administration error rates	After the simulation-based educational intervention in the CCU, medication administration error rates decreased and were sustained	Direct observation method and quizzes were completed for evaluation	Simulation-based learning provides a significant advantage to patient care through the reduction of medication administration errors compared to lecture style education.

Continued

Author and year	Type of the study	Purpose of the program	Simulation scenario	Comparator	Outcomes measured	Result	Perception evaluation (Debriefing)	Notes
Dean et al. (2021a) [24]	Rand-omized controlled trial	Surgical educa-tion for manual small-incision cataract surgery	Simula-tion-based cataract surgi-cal training + standard surgi-cal training	Standard training only	Overall surgi-cal compe-tency Outcomes of cataract surgical procedures performed	Participants in the inter-vention group scored higher Complications in surgeries performed were less in the interven-tion group	Masked assessments by independent experts Self-reported outcomes	Intense simu-lation-based cataract surgical education facil-itates the rapid acquisition of sur-gical competence and maximizes patient safety
Dean et al. (2021b) [25]	Rand-omized controlled trial	Surgical education for glaucoma	Intense simula-tion-based sur-gical training course	Standard training	Overall surgi-cal compe-tency	Greater increase in surgical com-petence after intervention Mean surgical competency score higher in intervention group at 1 year	Video record-ings graded by masked experts	Results support the pursuit of investments to es-tablish simulation surgery training units and courses

To maximize the cost-benefit impact of this resource-consuming education technique, it is necessary to define the optimal contexts in which simulators can be employed. Our systematic review can help meet this requisite.

Strength

To the best of our knowledge, our paper is one of the fewest systemic reviews that discusses the details of numerous studies that have medical stimulation for comprehensive and practical training, and safer patient care. Also, the strengths of the review include the exhaustive search, inclusion of multiple English articles encompassing a broad range of participants (doctors, nurses, interns, and students), outcomes (patient safety, medical errors, medical skills, and professional performance), and different study designs.

Limitations

Firstly, the variability of methods used in the studies limits the generalizability of our results. Each study employed a different clinical scenario and included participants from specific fields of the healthcare profession. On that account, inferences cannot be made regarding the specific field of the healthcare profession that can get the greatest benefit from simulation-based training.

Moreover, many of the included studies evaluated participants in simulated scenarios. Although the simulated scenarios closely resembled the real ones, they were not actually identical to the real scenarios. This may have altered the behaviors of the participants and they may have been less cautious while performing the assigned tasks.

Conclusion

By incorporating simulation-based training into medical education curricula, the acquisition of knowledge and professional skills can be improved. Moreover, this can help improve patient outcomes and reduce medical errors. Based on our findings, we suggest that simulation can be best used as a complement to the other methods of healthcare professionals' teaching and training.

List of Abbreviations

ME	Medical Errors
MeSH	Medical Subject Headings
NOS	The Newcastle-Ottawa Scale
RCT	A randomized controlled trial

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

None.

Consent to participate

Not applicable.

Ethical approval

Not applicable.

Protocol registration number

INPLASY202230006 at https://inplasy.com/.

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