

# The use of simulators for health education of people with diabetes: a scoping review

## Uso de simuladores para educação em saúde de pessoas com diabetes: uma revisão de escopo

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### ABSTRACT

**Objective:** To map the simulators used as a health education strategy for people with diabetes mellitus. **Method:** This is a scoping review based on the recommendations of the Joanna Briggs Institute, conducted through a literature search strategy in PubMed Central, Web of Science, Scopus, ERIC, BDTD, and RCAAP databases. The analysis of the identified studies was performed by two independent review authors. Data were analyzed descriptively, resulting in the preparation of tables and statistics of absolute and relative frequencies.

**Results:** A total of 226 studies were identified, of which nine formed the final sample. The use of the Human Patient Simulator was identified in 78% of the studies, followed by low-cost simulators and simulation tools (11% each). All strategies showed positive results. **Conclusions:** The simulators used include the Human Patient Simulator, the low-cost simulator, and the simulation tool, all of which show equally satisfactory results.

**Descriptors:** Diabetes Mellitus; Simulation Training; Health Education.

### RESUMO

**Objetivo:** Mapear os simuladores usados como estratégia de educação em saúde para pessoas que vivem com diabetes mellitus. **Método:** Trata-se de uma revisão de escopo direcionada pelas recomendações do Instituto Joanna Briggs, realizada por meio de uma estratégia de pesquisa na literatura disponível nos bancos de dados PubMed Central, *Web of Science*, Scopus, ERIC, BDTD e RCAAP. A análise dos estudos identificados deu-se por dois revisores independentes. Os dados foram analisados de forma descritiva, levando à elaboração de quadros e estatísticas com frequência absoluta e relativa. **Resultados:** Foram identificados 226 estudos, dos quais nove compuseram a amostra final, levando à identificação do uso do *Human Patient Simulator* em 78% dos estudos, seguido por simulador de baixo custo e ferramenta de simulação (11% cada). Todas as estratégias apresentaram resultados positivos. **Conclusão:** Os simuladores produzidos são o *Human Patient Simulator*, simulador de baixo custo e ferramenta de simulação, com resultados igualmente satisfatórios.

**Descritores:** Diabetes Mellitus; Treinamento por Simulação; Educação em Saúde.

### INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic syndrome of multiple etiologies characterized by a cluster of endocrine disorders driven by hyperglycemia that can lead to microvascular and macrovascular complications<sup>(1)</sup>. DM is recognized as a significant and growing public health problem affecting a significant portion of the population<sup>(2)</sup>.

An effective treatment of DM is necessary and can only be achieved when individuals recognize their true health status and, based on this knowledge, reflect on and change their unhealthy behaviors. The more a person knows about their disease, the more likely they are to accept treatment<sup>(3)</sup>.

Health education interventions emerge as a proposal to improve the empowerment of individuals by promoting knowledge production, improving decision-making, and modifying behaviors to contribute to ensuring effective care for their health<sup>(4-5)</sup>.

Thus, teaching and learning strategies should be chosen correctly, as this choice determines the success or failure of learning and, consequently, treatment adherence. Considering the applicability in health education, researchers suggest the use of simulations in educational activities and training<sup>(6-8)</sup>.

Simulation supports the consolidation of knowledge, the development of techniques, relational skills (e.g., thinking and reflection), and more effective and safe decision-making<sup>(6)</sup>. In addition, it is an important strategy for recreating and anticipating a real situation through a simulated scenario in a safe and controlled context<sup>(9)</sup>.

Overall, simulations can be categorized as high, medium, or low fidelity based on the reality of the practice rather than the robotics used. Teaching, learning, and practicing simple procedures (e.g., insulin administration in people with DM) can already be covered by low-fidelity simulations<sup>(10)</sup>. Several studies have presented positive results regarding the use of simulation. However, this strategy is still underused in the training of people with DM because of difficulties in access, lack of awareness among professionals, and even the high cost of simulators<sup>(11)</sup>.

A preliminary search was conducted in the following databases: Joanna Briggs Institute Clinical Online Network of Evidence for Care and Therapeutics (JBI CONNECT+), Center for Reviews and Dissemination (CRD), and The Cochrane Library. No scoping reviews on similar topics were identified. Therefore, this scoping review is justified by the need to collect different study designs and to acknowledge the evidence produced, as simulations are often not used as a health education strategy for people with DM. Therefore, data collection can be used to understand the use of simulations to implement this strategy. We aim to map the use of simulations as a health educa-

tion strategy for people with DM.

## METHOD

This is a scoping review, a type of review that aims to map the basic concepts of a field, explore its scope and developments, and identify existing research gaps<sup>(12)</sup>. The research protocol was registered with the Open Science Framework on March 13, 2023, and is available at <https://osf.io/zgqcp/>.

We followed the basic methodological structure proposed by Askey & O'Malley<sup>(12)</sup> along with the enhancements suggested by Levac, Colquhoun, and O'Brien<sup>(13)</sup> and the recommendations of the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis (2020 version)<sup>(14)</sup>. The following five stages were followed throughout the review:

- i. Identification of the review question;
- ii. Identification of relevant studies;
- iii. Selection of studies;
- iv. Mapping of information;
- v. Grouping, summarizing, and reporting results.

The acronym PCC (composed of population, concept, and context) was used to define the research question, as it is the most appropriate for the aims of this review. We defined the following determinants of study interest:

- Population (P): people living with diabetes mellitus;
- Concept (C): use of simulators;
- Context (C): health education<sup>(13)</sup>.

The population also included family members and professionals, as they also use simulators for health education in DM. We formulated the following review question: "Which simulators are used as a health education strategy for people with DM?". Initially, an initial survey was conducted on the SCOPUS and LILACS (Latin American and Caribbean Health Sciences) databases. We used the following combinations of Portuguese and English keywords: "diabetes mellitus" (related to the population), "simulação" or "simulation" (related to the concept), and "educação em saúde" or "health education" (related to the context).

The words contained in the titles and abstracts of the articles and their keywords were analyzed. On this basis, keywords appropriate to the databases searched (Medical Subject Headings [MeSH] and Descritores em Ciências da Saúde [DeCS]) were selected and similar ones were chosen to extend the textual search.

After selecting the keywords and equivalents, the following databases were searched:

PubMed Central, Web of Science, Scopus, Education Resources Information Center (ERIC), Biblioteca Digital de Teses e Dissertações (BDTD), and Repositórios Científicos de Acesso Aberto de Portugal (RCAAP).

Searches were performed using DeCS and MeSH terms combined with the Boolean operators "AND" and "OR", following the specific truncation techniques of each database. The final search strategies are shown in Figure 1.

Database	Search strategy
PubMed Central	Search (((("Diabetes Mellitus"[MeSH Terms]) AND Simulation[MeSH Terms]) OR "Simulation exercise"[MeSH Terms]) OR "Simulation training"[MeSH Terms]) AND "Health education"[MeSH Terms]) OR "Education of Patients"[MeSH Terms] Filters: Publication date from 2012/01/01 to 2023/03/01
Web of Science	(((((AK=("Diabetes Mellitus")) AND AK=(Simulation)) OR AK=("Simulation exercise"))) OR AK=("Simulation training")) AND AK=("Health education")) OR AK=("Education of patients")
SCOPUS	( KEY ( "diabetes mellitus" ) AND KEY ( simulation ) OR KEY ( "simulation exercise" ) OR KEY ( "simulation training" ) OR KEY ( "interactive learning" ) OR KEY ( "education technology" ) AND KEY ( "health education" ) OR KEY ( "community education" ) OR KEY ( "patient education as topic" ) OR KEY ( "education of patients" ) ) AND ( LIMIT-TO ( PUBYEAR , 2022 ) OR LIMIT-TO ( PUBYEAR , 2021 ) OR LIMIT-TO ( PUBYEAR , 2020 ) OR LIMIT-TO ( PUBYEAR , 2019 ) OR LIMIT-TO ( PUBYEAR , 2017 ) OR LIMIT-TO ( PUBYEAR , 2016 ) OR LIMIT-TO ( PUBYEAR , 2015 ) OR LIMIT-TO ( PUBYEAR , 2014 ) OR LIMIT-TO ( PUBYEAR , 2013 ) OR LIMIT-TO ( PUBYEAR , 2012 ) )
Education Resources Information Center (ERIC)	"diabetes mellitus" AND simulation simulation OR "simulation exercise" OR "simulation training" OR "interactive learning" OR "education technology"
Biblioteca Digital de Teses e Dissertações (BDTD)	(Todos os campos:"diabetes mellitus" E Todos os campos: simulação OR "exercício de simulação" OR "treinamento por simulação" OR "tecnologia educacional" E Todos os campos:"educação em saúde" OR "educação de pacientes como assunto")
Study defense time: 2012 to 2023	(Assunto:"Diabetes mellitus" E Assunto: "Educação em saúde") Data: de 2012 até 2023
Repositórios Científicos de Acesso Aberto de Portugal (RCAAP)	(Assunto:"Diabetes mellitus" E Assunto: "Educação em saúde") Data: de 2012 até 2023

**Figure 1** – Search strategy used in databases. Cuité, PB, Brazil, 2023

Finally, as a third step, the reference lists of all articles included in the review were searched to identify studies of interest that were not retrieved from the databases searched.

The selection of studies included various sources of available evidence (e.g., grey literature) in repositories and academic articles published since 2012, considering that the United Nations

recognized DM as a major threat to global health and well-being in 2011. In addition, International Standards for Diabetes Education were published by the International Diabetes Federation at the end of 2013, which covered the period of interest. There were no language or geographical restrictions, as DM is recognized as a global health problem affecting people worldwide. Studies that did not meet the proposed objective or did not address the guiding question were excluded.

Searches were performed on the Portal of Journals of the Coordination for the Improvement of Higher Education Personnel (CAPES) via the Federated Academic Community (CAFe).

Upon selection, the studies were entered into the EndNote reference manager to remove duplicates. These studies were then imported into the Rayan Qatar Computing Research Institute (Rayan QCRI) platform. To minimize potential selection bias, studies were selected by two review authors. Each review author listed the productions individually and then compared the databases to check for discrepancies. A third review author was consulted to resolve conflicts. The detailed selection of documents is described in the flowchart in Figure 2, which was constructed according to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR).

To map the information, we used a structured tool developed in a Microsoft Office Excel Online spreadsheet based on the model provided in the JBI manual. The tool was designed to facilitate the synthesis of information and recommendations. We collected the following variables for extraction: study title; author(s), year of publication, origin/country of origin, objectives/purposes, study population, study type, main findings (i.e., types or strategies used as simulators and main issues in DM addressed with the use of simulators).

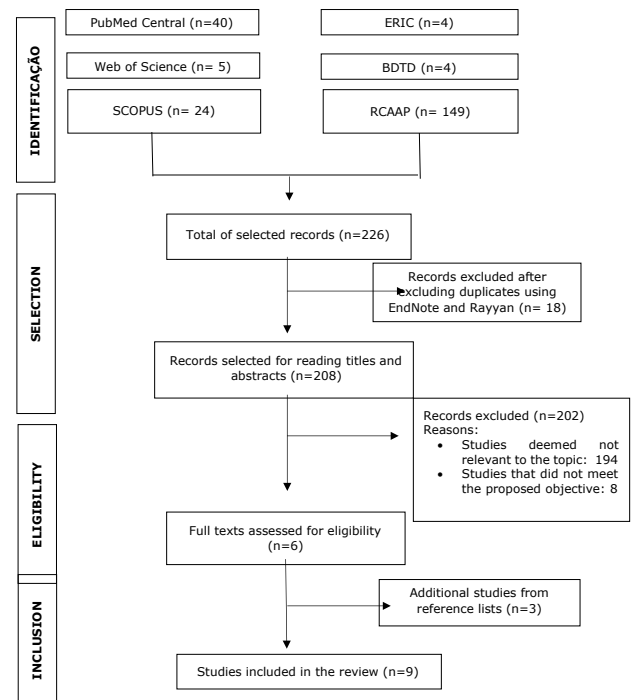
The extracted data were analyzed descriptively and presented in tables and statistics using absolute and relative frequencies. The study did not involve human subjects and therefore did not require ethics committee review.

## RESULTS

A total of 226 studies were selected according to the predefined criteria. After initial screening, we excluded 18 duplicate studies, leaving 208 studies for title and abstract reading. After this analysis, we excluded 202 studies,

leaving six for full-text analysis. The studies were read, and all were selected for analysis in this review. Three articles were analyzed after examining the reference lists of the selected articles. A total of 9 studies were selected for this review.

The results of the search are shown in Figure 2.



**Figure 2** – Flowchart of the study selection process adapted from PRISMA. Cuité PB, Brazil, 2023

Figure 3 shows the characteristics of the articles included in the review. Information is provided on authors, country of origin, year of publication, objectives, population/participants, and study type. The sample includes publications from 2012 to 2021, with one ( $\cong 11\%$ ) in 2012, three (34%) in 2015, two ( $\cong 22\%$ ) in 2016, and the remainder in 2017, 2018, and 2021, one ( $\cong 11\%$ ) each year. Of these, 7 ( $\cong 78\%$ ) will be conducted in the United States, 1 ( $\cong 11\%$ ) in China, and 1 ( $\cong 11\%$ ) in Brazil. Regarding the participants in the studies, the majority were parents of children with DM ( $\cong 63\%$ ). Regarding the study type, there were different study designs, the most common being a randomized controlled experimental study ( $\cong 44\%$ ).

<b>Study title - Author</b>	<b>Origin / Year of publication</b>	<b>Results</b>	<b>Study population</b>	<b>Study type</b>
E1 – Sullivan-Bolyai et al <sup>(15)</sup> .	US / 2012	To evaluate the use of a pediatric Human Patient Simulator (HPS) to teach parents how to control diabetes in their newly diagnosed children with type 1 diabetes.	Forty-five individuals participated in this study, including 41 parents of children with type 1 diabetes mellitus (DM1), one pediatric clinical nursing specialist, one simulator specialist, and one principal investigator.	Pilot study
E2 – Maguire, Crawford e Sullivan-Bolyai <sup>(16)</sup> .	US / 2015	Explore the feasibility of using HPS to teach DM1 management to grandparents of grandchildren with DM1.	Thirty grandparents (11 males, 19 females) of young grandchildren (12 years old or younger) with DM1.	Randomized, controlled experimental study
E3 – Sullivan-Bolyai et al <sup>(17)</sup> .	US / 2015	Evaluate the effectiveness of Parent Education Through Simulation - Diabetes (PETS-D) for parents of newly diagnosed children < 13 years old with DM1 with three parent education vignette sessions using HPS compared to formal sessions using vignettes only.	One hundred and ninety-one parents of newly diagnosed children with DM1.	Randomized, controlled experimental study
E4 – Hughes et al <sup>(18)</sup> .	US / 2015	Report the perspectives of the pre-adolescent and parent focus group with a feasibility intervention titled PREP-T1 (Preteen Reeducation with Parents-Type 1 Diabetes)	Eleven pre-adolescents and 11 parents	Qualitative study
E5 – Ramchandani et al <sup>(19)</sup> .	US / 2016	Describe the four perspectives of certified diabetes educators (CDEs) through Diabetes Education Simulation (PETS-D) to teach parents of newly diagnosed children with DM1 early diabetes management skills using formal vignettes and an HPS to enhance/improve the teaching-learning process.	Four certified diabetes educator nurses	Descriptive study with a qualitative approach
E6 – Ramchandani et al <sup>(20)</sup> .	US / 2016	Describe parents' perspectives on the use of HPS to enhance diabetes education	Forty-nine parents of children with recent-onset DM1 from 32 families participated in this study (31 mothers and 18 fathers)	Descriptive study with a qualitative approach



Study title - Author	Origin / Year of publication	Results	Study population	Study type
E7 – Bova et al <sup>(21)</sup> .	US / 2017	Describe the fidelity process of intervention with the human patient simulator	One hundred and ninety-one parents of newly diagnosed children with DM1	Randomized controlled experimental study
E8 – Silva <sup>(22)</sup> .	Brazil / 2018	Construct and validate educational methods for use in the education of patients with diabetes mellitus with an emphasis on insulin application: low-cost patient simulator, video, and booklet	Stage 1: nine experts in the study area. Stage 2: one professional with expertise in sound and image, one professional in advertising, and 10 experts for validation. Stage 3: Ninety patients with DM.	Stage 1: Phase 1 - action research, applied, exploratory, and qualitative approach. Phase 2 - methodological study of simulator validation. Stage 2: methodological study, descriptive in nature. Stage 3: quasi-experimental study, with a quantitative approach and descriptive character
E9 – Liang, Xie, Nie e Deng <sup>(23)</sup> .	China / 2021	Investigate the effect of standard training on the ability of diabetic patients to self-administer insulin injections	After follow-up, a total of 120 patients with diabetes mellitus were included, randomly divided into an intervention group (60 cases) and a control group (60 cases).	Randomized controlled experimental study

**Figure 3** – Characterization of the studies included in the scoping review. Cuité, PB, Brazil, 2023

Figure 4 shows the main data from the studies related to the review objective. Hypoglycemia, glucose monitoring, and insulin administration

are the main topics addressed by simulators, with the Human Patient Simulator (HPS) being the most commonly used simulator strategy.

Studies	Main topics in DM addressed by simulators	Types or strategies used as simulators for health education of people with DM
E1 <sup>(15)</sup> .	Review of glucose monitoring, daytime, and nighttime hypoglycemia, preparation and administration of insulin and glucagon, and observation and treatment of tremor/seizure activity	Pediatric HPS
E2 <sup>(16)</sup> .	Hypoglycemia control	HPS
E3 <sup>(17)</sup> .	Hypoglycemia, hyperglycemia/disease management, and control of glucose level pattern, activity, and insulin requirement	Pediatric HPS

Studies	Main topics in DM addressed by simulators	Types or strategies used as simulators for health education of people with DM
E4 <sup>(18)</sup> .	Hypoglycemia, high blood sugar treatment, carbohydrate counting, healthy eating, and diabetes treatment around sports participation and practices with glucagon kits	HPS
E5 <sup>(19)</sup> .	Hypoglycemia, hyperglycemia, and standard management	HPS
E6 <sup>(20)</sup> .	Hypoglycemia, hyperglycemia, and standard management of blood glucose monitoring (BG)	HPS
E7 <sup>(21)</sup> .	Hypoglycemia, hyperglycemia/disease management, and control of glucose level pattern, activity, and insulin requirement	Pediatric HPS
E8 <sup>(22)</sup> .	Application of insulin and capillary glucose monitoring	Low-cost simulator made by the author (mannequin manufactured from rigid plastic, hollow, with iron support on the feet, with a cutout for insulin application according to the recommendations of the Brazilian Diabetes Society)
E9 <sup>(23)</sup> .	Insulin injection	Simulation tool (tool composed of artificial skin, sponge, and cloth bags used for insulin administration)

**Figure 4** – Data from studies related to the objectives of the scoping review. Cuité, PB, Brazil, 2023

## DISCUSSION

The use of simulators as a health education strategy has intensified since 1999, with the publication of the book "To Err is human: Building a safer health system" by the Institute of Medicine of the US. The publication recommended simulation as an effective method of multidisciplinary training. Since then, studies involving these tools have been developed<sup>(24)</sup>.

Among the countries that stand out for producing texts addressing the use of simulators as a health education strategy for people with diabetes, the United States stands out. According to the International Diabetes Federation<sup>(25)</sup>, it ranks 4<sup>th</sup> in the list of the top 10 countries with the highest number of people with diabetes, which justifies the need for studies directed towards these individuals. The other countries with studies included in this review (i.e., China and Brazil) ranked 1<sup>st</sup> and 6<sup>th</sup>, respectively, in the same list, but they had few studies, demonstrating a lack of research on the topic.

Furthermore, concerning the United States, the country ranks 2<sup>nd</sup> in the Global Innovation Index (GII). Innovative activities directly influence the scientific sector, which, in turn, leads to changes in healthcare practice, such as new

information, equipment, medications, and possibilities. Therefore, if a country invests in innovation, its prominence in scientific production using simulators is legitimate<sup>(26-27)</sup>.

Among the participants in the studies, parents stood out because they are responsible for all treatment, monitoring, encouragement to maintain care, and disease management until the child gains autonomy and can take a more active role in self-care. They are also responsible for providing all necessary social support<sup>(28)</sup>. Regarding the methodological designs used, the most prominent was the randomized controlled experimental study, which is a methodological approach designed to collect data precisely to answer a hypothesis and is also an excellent tool for evaluating the effectiveness of an intervention<sup>(29)</sup>.

Regarding the objectives of the review, the investigation, evaluation, and application of various simulators as a health education strategy for people with diabetes is highlighted.

As for the main topics in DM addressed by simulators, hypoglycemia, glucose monitoring, and insulin administration are highlighted. Hypoglycemia is common during insulin therapy and can lead to accidents and even death<sup>(30)</sup>. Glucose mo-

monitoring and insulin administration require specific techniques that can be difficult for some people to understand and perform, so these topics are more commonly covered in health education and demonstrated using simulators.

Based on the results, the most commonly used strategy as a simulator is the HPS. It is a highly sophisticated and technologically advanced mannequin that is fully integrated with computer software, supports the development of pre-planned scenarios, and mimics a wide range of clinical situations. These simulators also produce sounds, may have pulses, and respond to medical and pharmacological interventions with expected physiological responses<sup>(31)</sup>. Thus, it is suggested that their widespread use is due to the presentation of a response closer to that of a real patient. In addition to using HPS, some researchers have chosen to build their health education simulators. After searching for resources to incorporate simulation into the patient and caregiver education process and finding the results costly and incompatible with the expected features, Silva<sup>(22)</sup> decided to develop and use a low-cost simulator similar to the HPS. In addition to this simulator, a simulation tool was also used to increase the opportunities for patients to practice their insulin administration skills<sup>(23)</sup>.

The development and use of a low-cost simulator, as well as simulation tools, aims to present a model at a lower cost without compromising quality, and with the advantage of being more accessible for maintenance. In addition, it can be produced on a larger scale, which improves accessibility<sup>(27)</sup>.

The use of simulators as a teaching strategy has been documented in the literature as a critical component of experiential learning, allowing theoretical and practical knowledge to be delivered in a safe environment with less exposure to unnecessary risk, and allowing various skills to be experienced more realistically<sup>(19,32)</sup>.

Because of its versatility and adaptability, this resource can be used in a variety of contexts and settings, ensuring high performance and contributing to individual engagement in therapy<sup>(20)</sup>. In addition, it provides skill development, longer-term retention of content, improved critical thinking, better decision making and problem solving, reduced fear and anxiety, and improved self-confidence, which is much more than just technical and technological<sup>(17,19-22)</sup>.

These tools can help maintain blood glucose levels at appropriate levels, prevent complications, increase productivity, and reduce diabe-

tes-related complications, especially insulin-induced hypoglycemia<sup>(22-33)</sup>.

Many people with diabetes use insulin therapy to manage their blood glucose levels. However, insulin administration requires specific skills that patients and their caregivers often do not possess. Therefore, to minimize complications resulting from incorrect use, health education and the use of simulators can identify critical points in skill performance and knowledge, provide training for patients and family members or caregivers, and help correct errors and clarify doubts<sup>(22-33)</sup>.

In addition, simulators allow users to practice beforehand (without using other people or themselves as guinea pigs), improve skills through repeated practice, master insulin injection skills in a short period, and overcome the fear of subcutaneous injection<sup>(20-23)</sup>.

Although the use of simulators offers many advantages, there are also deficiencies in their functioning that can be observed during their use. This may result in the need to replace the manikin to continue training activities<sup>(19-20)</sup>.

A study<sup>(34)</sup> that looked at the main educational technologies used in the care of people with DM did not present the HPS as a tool, demonstrating a possible weakness in the research by not presenting a resource with great educational potential that is widely used in educational interventions, which may discourage its dissemination. However, it highlights other strategies, namely online games, mobile applications, and printed educational materials, as they are related to entertainment and are popular.

The limitation of this scoping review is the small number of publications available on the topic. This draws attention to the need for further research to help disseminate and replicate this technology, overcome barriers to its use, and develop new models.

Understanding the use of simulators and the main models used is very useful, especially in the context of health education where these tools play such an important role. Simulators contribute to the teaching and learning process of relevant topics, making this teaching more versatile, dynamic, and safe. Therefore, health professionals, especially nurses, who excel in conducting educational activities, need to be aware of the possibility of incorporating these tools, considering their benefits and the models currently available.

## CONCLUSION

From the mapping of simulators used as a health education strategy for people with DM, it is clear



that the HPS is the most commonly used. In addition, a low-cost simulator and a simulation tool were also used with equally satisfactory results. With the rapid development of technology and the inclusion of simulators as a pedagogical tool, this study provides important insights into the use of these tools in educational interventions. In addition, it stimulates discussion in the scien-

tific and educational communities, contributes to the promotion of new research, and provides support for evidence-based decision making.

### CONFLICT OF INTERESTS

The authors have declared that there is no conflict of interests.

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