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Low cost peripheral venipuncture simulator: from confection to evaluation

Simulador de baixo custo para punção venosa periférica: da confecção à avaliação

Simulador de venopunción periférica de bajo costo: desde la confección hasta la evaluación

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ABSTRACT

Objective: to present and evaluate a low cost simulator for peripheral venipuncture. **Method:** a descriptive study with a qualitative approach. The work comprised two phases - development of the low cost simulator and evaluation of the teacher perception about the use of the simulator. Six low-cost simulators were built and made available for use in the discipline for two academic semesters. The data were collected through the online questionnaire. This research was approved by the Ethics Committee. **Results:** the documents pointed out as potentialities in the use of the simulator in the possibility of effective training of the skill in a safe and low cost. Among the weaknesses of this resource or document highlighted and reduced and lost by the simulator. **Conclusion:** the perception of teachers, the use of the low-cost simulator was positive, as it improves learning, safety and the development of the peripheral venipuncture technique by students.
Descriptors: Simulation; simulation training; education, nursing; nursing.

RESUMO

Objetivo: apresentar e avaliar um simulador de baixo custo para punção venosa periférica, segundo a percepção docente. **Método:** estudo descritivo de abordagem qualitativa realizada com sete docentes universitários do sul do Brasil, em 2019. O trabalho compreendeu duas fases - desenvolvimento do simulador de baixo custo, e avaliação da percepção docente sobre seu uso. Foram construídos e disponibilizados seis simuladores de baixo custo para o uso no ensino por dois semestres letivos. Os dados foram coletados através de questionário *online*. O projeto teve aprovação de Comitê de Ética em Pesquisa. **Resultados:** os docentes apontaram como potencialidades no uso do simulador a possibilidade do treinamento efetivo da habilidade de forma segura e com baixo custo. Dentre as fragilidades deste recurso os docentes destacaram a reduzida durabilidade e manutenção recorrente do simulador. **Conclusão:** a utilização do simulador de baixo custo foi positiva, pois os docentes perceberam melhora no aprendizado, na segurança e no desenvolvimento da técnica de punção venosa periférica pelos estudantes.
Descritores: Simulação; treinamento por simulação; educação em enfermagem; enfermagem.

RESUMEN

Objetivo: presentar y evaluar un simulador de bajo costo para la punción venosa periférica. **Método:** estudio descriptivo com enfoque cualitativo. El trabajo constaba de dos fases: desarrollo del simulador de bajo costo y evaluación de la percepción del profesor sobre el uso del simulador. Seis simuladores de bajo costo fueron construidos y puestos a disposición para uso en la disciplina durante dos semestres académicos. Los datos fueron recolectados a través del cuestionario en línea. Esta investigación fue aprobada por el Comité de Ética. **Resultados:** los documentos señalaron como potencialidades del simulador la posibilidad de entrenamiento efectivo de la habilidad de manera segura y bajo costo. Entre las debilidades de este recurso documento resaltado y reducido y perdido por el simulador. **Conclusión:** la percepción de los docentes, el uso del simulador de bajo costo fue positivo, mejora el aprendizaje, seguridad y desarrollo de técnica de venopunción periférica por parte de los estudiantes.
Descriptores: Simulación; entrenamiento simulado; educación en enfermería; enfermería.

INTRODUCTION

Venipuncture is an important technique developed by nursing students during their professional training. It is a common procedure performed under the context of nursing work, which requires knowledge, skill and dexterity, since it offers potential risks, such as exposing patients to infection, phlebitis, bruising, infiltration and bleeding[1].

The failures to perform this procedure can be responsible for these complications. A study that sought to identify deviations related to scientific evidence, with regard to the prevention of phlebitis, found failures in the selection of the catheter insertion site and its caliber, evaluation of the insertion site for inflammatory signs, dressing on insertion, disinfection of accessories, hand hygiene and patient participation in the cares[1].

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In addition to the procedure failures due to lack of knowledge or ability, there are factors that make peripheral venipuncture more difficult, such as sex, age, comorbidities, nutritional status, visibility and palpability of the venous network, gauge and model of the device[2].

Simulation models emerge as a way to combine theoretical and practical knowledge and offer an appropriate environment to students, which minimizes the risks to patients. Thus, simulation models, as a teaching-learning strategy in nursing, enable students to experience and practice different skills closer to reality that they will find in the health service in a safe and systematic way[3].

There are different types of simulators for health training that are available in the market, from parts for the training of single procedures to high-tech full body simulators, capable of reproducing various physiological responses controlled by computer. However, the high cost to acquire and maintain laboratories equipped with simulators can be a hindering factor in the use of this resource in teaching[4].

The use of low-cost simulators has been adopted in different realities around the world and has contributed to the teaching-learning process of students in the health field. It is an alternative with financial viability, which expands the opportunity to train not only students, but also the technical improvement of workers, in a safe and controlled environment[5-9].

After the IV Latin American Simulation Congress that took place in Chile in 2015, a low cost simulator was developed for the training of peripheral venipuncture, based on the adaptation of a model presented at the Congress mentioned by the *Centro de Simulación del* Hospital de Pediatría Juan P. Garrahan[9].(Argentina). This resource was adopted in the Fundamentals for Professional Nursing Care discipline at a federal university in southern Brazil, whose development and evaluation are the focus of this article.

It is believed that using this resource greatly contributes to the training of skills of nursing students, especially in the beginning of clinical practice. Thus, this study aimed to submit and evaluate a low cost simulator for peripheral venipuncture, according to the teaching perception.

LITERATURE REVIEW

Simulation is a very important resource in training people whose profession may put their safety at risk or that of others. Its meaning is the imitation or representation of an act by another.

In nursing, this resource has been used over the years, often in an improvised way, as in the use of oranges for injectables. However, from the report *To err is human* there was an incentive to use simulation as a training resource to reduce errors made by the health team. Since then, the use of this pedagogical resource, which is not necessarily expensive, has been strongly encouraged for its execution[10].

The simulators can be classified according to their fidelity, that is, how close to reality it looks. Low-fidelity simulators are static full body mannequins or parts used for training basic skills, they have no interaction with the learner. The medium fidelity simulators have some interaction and are pre-programmed, like the simulators for identifying respiratory or cardiac sounds, however it is not possible to change the parameters during the simulation. High-fidelity simulators, on the other hand, are those controlled by computer, in which the parameters can be changed according to the conduct of the participant in the simulation, for example the simulator starts with a high heart rate and can evolve to a cardiorespiratory arrest or to improve the vital signs depending on the performance of the team. High-fidelity simulators show respiratory movements, sweating, seizures, cyanosis, among other physiological changes[11]. Low-cost simulators are tools made with easily accessible materials and seek to reproduce the anatomy necessary for the training at issue.

Some studies have shown prototypes for training in ostomy care and insulin application, among others[12,13].

The advantage of using these simulators, in addition to the low cost, is the possibility of producing them on a larger scale, which favors students' access and extends the training time with them.

METHODOLOGY

This is a descriptive study with a qualitative approach, developed together with the discipline of Fundamentals for Professional Nursing Care of the Undergraduate Nursing Course at the Federal University of Santa Catarina. The work comprised two phases: The first, the construction of the low-cost simulator and availability for use in the discipline; and the second, evaluating the simulator by the teachers of the discipline.

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In the first phase, six simulators were built and made available for use in the Fundamentals of Professional Nursing Care Discipline for two semesters, 2017/02 and 2018/01.

In the second phase, the inclusion criteria were used - having worked as a teacher in that discipline in 2017-2 and/or 2018-1 and having used the low cost simulator for venipuncture in teaching activities with nursing students. As an exclusion criterion, the teachers who conducted the study did not participate in the research. The 11 teachers who met the inclusion criteria were invited to participate in the study.

Data were collected from January to March 2019, using an online form *online* and made available via *email*to the participants, with an invitation letter. The form was composed of two parts: The first to characterize the participants and the second to open questions regarding the use of the simulator. The data were organized in text format and treated according to the content analysis technique[14]. To assist in organizing the data, an identifier code was used for each form, using the letter D (teacher), followed by the number corresponding to the order in which the form was answered. For example: D1, D2, D3, etc.

It is worth noting that data saturation was obtained with the seventh form, reducing the number of participants to seven.

This research is part of the macro project entitled*Simulation as a teaching strategy for reflective nursing thinking*, approved by the Research Ethics Committee. The Free and Informed Consent Form (FICF) was submitted *online* to the participants before starting the data collection, through an explanation page about the study. The participant needed to click on the option *I agree to participate in the survey* to confirm their consent and be directed to the next screen with the questionnaire, which was available for download *download*.

RESULTS

Construction of the low-cost peripheral venipuncture simulator

For building up the simulator, one used the materials and costs as described in Table 1.

TABLE 1: Materials and costs for buiding up the peripheral venipuncture simulator, Florianópolis, SC, 2019.

Materiais	Quantity	Cost per simulation (R$)
Needle	1 un (30 mm x 0.7 mm)	0.06
Red liquid food pigment	3 ml	0.20
Equipament (simple orburette)	2 un	1.10
Stiletto	1 un	0.80
Large transparent adhesive tape	20 cm	0.10
Pool floater (macaroon)	30 cm	0.94
Serum flasks	2 un (100 ml)	2.30
Tourniquet	34 cm	1.00
Blackout fabric	40 cm x 20 cm	0.75
Schoolscissors	1 un	1.00
Syringe	1 un (3 ml)	0.21
Total		**8.46**

Some materials are disposable, however, others can be reused - such as the stylus, needle, syringe and scissors. In addition, the stylus can be replaced by other cutting materials of less cost, such as the scalpel blade No. 11 or a knife. It is noteworthy that the total cost of materials purchased for a simulator reached R$ 8.46, according to Table 1. If the purchase of materials is wholesale, the unit cost reduces, therefore, the average cost of the simulator can reach R$ 4.00 or U$ 1 (reference 2019).

The following steps were taken to build up the simulator: 1st step: Creating a base on the floater by cutting a thin layer in the longitudinal direction; 2nd step: Making a longitudinal cut at the top to accommodate the tourniquet; 3rd step: Accommodating the tourniquet in the opening made, fixing it with adhesive tape at the ends; 4th step: inserting the dye into the filled serum bottle, using the syringe and needle, and couple the equipment; 5th step: At

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one end of the tourniquet connect a device attached to an empty serum bottle and at the other end, the device connected to the bottle with pigmented serum, filling the circuit; 6th step: Covering the model with *blackout* type fabric in a coloring that mimics human skin, as can be seen in Figure 1. For use, hang the filled up serum bottle to ensure pressure within the circuit.

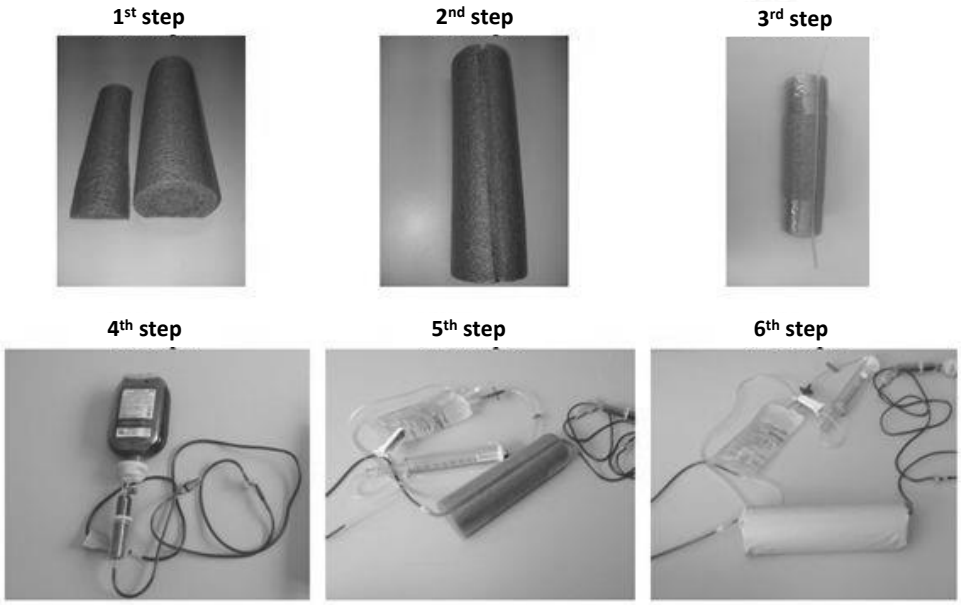

FIGURE 1: Steps for building up the low-cost simulator. Florianópolis, SC, 2019.

The simulator in its final format is shown in Figure 2.

FIGURE 2: Low-cost simulator for peripheral venipuncture, Florianópolis, SC, 2019.

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Simulation evaluation by teachers of the discipline

Seven professors took part in the research: Six female and one male, aged between 29 and 57 years old. Regarding the length of experience in the discipline, it ranged from 1.6 to 16 years, with an average of 9.6 years.

The professors mentioned that, in addition to the low cost simulator, they have already used as a resource for teaching peripheral venipuncture and fluid therapy: The commercial adult simulator arm (*part task trainer*), the demonstration of the *procedure in vivo* among teachers and/or students, and the practice of the procedure on a patient during theoretical-practical hospital activities.

Among the aforementioned resources, the teachers consider the use of a simulator to be more efficient and safer for this purpose, according to the following statements:

> *The low cost simulator, for giving the student a close notion of blood reflux and needle angulation in a safe way, without exposing the student or teacher to risks. (D3)*
>
> *Simulation, as it avoids inconvenience among students and contamination. (D4)*
>
> *The low-cost simulator, therefore, the student improves the technique well and then will be performing the procedure on the human being. (D5)*
>
> *Anatomical model, as it avoids risk exposure to infections and other complications resulting from unnecessary invasive procedures. (D7)*

The positive aspects, punctuated by the teachers in relation to the use of the simulator, include characteristics of the device itself and the learning provided by it.

> *The low-cost simulator helped to teach the choice of vein, touch the filling of the vein and even, its visualization [...]. Students felt more confident in practice after training in the simulator. (D1)*
>
> *[...] the students are happy when they realize that they were able to puncture (because the system requires that the vein be well visualized and that the insertion technique is correct); allows to evaluate students during the procedure concurrently; allows complete installation of the punching system. (D2)*
>
> *[...]I realized that students who had the opportunity to use the simulator entered the internship field more confident to perform peripheral venipuncture compared to students from previous classes when the technology was not yet available. (D3)*
>
> *[...]enabled the development of skills without the stress of exercising the practice on the colleagues themselves. (D6).*

As weaknesses of the low-cost simulator, the teachers identified some aspects that could be improved for a better efficiency of the device.

> *One of the weaknesses that I point out is the fact that it is not possible to simulate the tourniquet of the limb properly [5 to 7 cm from the puncture site] and the durability of the product (D1).*
>
> *Very light [...]you have to keep holding the simulator. (D4)*
>
> *Low reality regarding skin perfusion, feel of the venous network and limb manipulation. (D7)*

However, all teachers would recommend the use of the low cost simulator for teaching. Among the justifications presented, we highlight the practicality and effectiveness of the material, the possibility to learn without the *pressure* of clinical practice and the expansion of teaching possibilities, as can be seen in the following statements:

> *Yes, I recommend it, as it is a technology that helps in student education. The laboratory simulation allows the student to learn without the "pressure" of clinical practice and also allows the student to identify his weaknesses and potential in the face of the procedure. (D1)*
>
> *Yes, due to the practicality and effectiveness of the material.(D6)*
>
> *Yes, it helps to expand the didactic possibilities, it also helps in monitoring the technical development and recognition of the puncture steps, it allows the improvement of the ability to handle the fluid system and manipulate the catheter. (D7)*

DISCUSSION

Building up the simulator at issue is simple and inexpensive. It should be noted that simulators for the training of peripheral venipuncture are available on the market. They are arms that have anatomical similarity, so the skin can be replaced, as well as the veins. However, the cost of this simulator is close to R$ 1,000 or U$ 250 and the spare parts must be purchased separately. The skin, for example, costs R$ 240 or U$ 60[15].

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The participants in this study are teachers who, from their experiences, had the opportunity to have contact with several strategies for the technical teaching of venipuncture and evaluated the use of the low-cost simulator for student learning as positive and efficient. It is possible to find teaching alternatives in the context of health training, and in teaching praxis, reflect and choose good practices that ensure patient safety and take into account the ethical issue, accessible technologies and the demands of current training[16].

Teachers have ethical and moral responsibility for how students acquire and expand knowledge, skills and attitudes. Thus, with regard to practical teaching in nursing, it is possible to show over the years the development of technical procedures in students, teachers and even the own patient. This practice needs to be rethought, as there is no real justification for exposing students who are often training their skills for the first time with colleagues who do not need such intervention[16]. In addition, as previously explained, the simulators are inexpensive, provide an alternative close to the reality and are easy to manufacture.

The resource enabled students to develop the technique of peripheral venipuncture, contributing to the acquisition of skills in a safe environment with repeated exposure over time. The findings of this study corroborate the results of another study that also used a low-cost simulator for venipuncture training[17].

Another study that developed a low-cost simulator for the training of central venous catheterization, guided by ultrasound, identified that the device allowed the progressive acquisition of the basic hand-eye coordination skills necessary for the procedure to be carried out by medical residents[7]. Similarly, simulator skills training reduced risks to patients and expanded the learning opportunity.

Experiences that mimic reality enable students to build up and repeat skills training, preparing them better for the clinical practice. Through exposure to simulation experiences in a safe environment, students feel more confident and satisfied in developing the reasoning for executing a procedure.

Thus, students are able to fix the theoretical content more effectively before having contact with the real patient[18-20].

Product's durability was pointed out as a point to improve. It is known that the acquisition of procedural technical skill is conditioned to the repetition of the procedure and that this repetition reduces the useful life of the simulators, which requires constant maintenance and consequently a higher cost[9]. However, even so, the cost of the simulator manufactured in the present study is almost 250 times lower than the prototypes available on the market.

The low-cost simulators have many positive aspects that facilitate the learning process, among them, the low cost a for its construction, the possibility of performing the complete procedure, the satisfaction of students in being able to perform the technique countless times. Another fundamental issue is that the teacher is able to evaluate the student, giving the *feedback* while developing the technique, which can still be done in stages, giving the student the opportunity to train in the field where they are weak[21].

As limitations of this study, we highlight the non-inclusion of students, who could enrich the findings. Further studies are suggested to include student perception and improve the created device, based on the changes suggested by the teachers.

CONCLUSION

The teachers approved the use of the low-cost simulator. The highlighted potentialities were: Proximity to the reality, greater security regarding the risk of contamination and improvement of the technique.

The use of this simulator is important for teachers and students to strengthen skills based on intensive risk-free training, providing increased safety when performing the peripheral venipuncture technique.

The lightness of the low-cost simulator, durability, low reality regarding skin perfusion and visibility of the venous network, as well as a *loose* tourniquet for the device to work, were pointed out as weaknesses, using this simulator. These weaknesses can be corrected in the future development of more prototypes, always improving them.

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