

ORIGINAL ARTICLE

Low cost simulator for cardiopulmonary unobstructed and reunion procedures in infants

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Abstract

Introduction: The use of realistic simulation methodology is used in several learning scenarios, allowing students to participate directly in the problematization of situations that require immediate professional action.

Objective: To develop, validate and validate a low cost simulator for cardiopulmonary resuscitation and resuscitation procedures in infants.

Methods: An experimental study carried out with undergraduate students of the 1st year of the Nursing course at a higher education institution in the State of Paraíba, developed a simulator model with dimensions similar to an infant with low cost materials and made possible the use as a prototype for Basic Life Support training. The prototype was developed with the accessories for disengagement and cardiopulmonary resuscitation maneuvers. The data collection instrument was a questionnaire based on the American Heart Association Basic Life Support guideline to enable and validate the Basic Life Support training instrument.

Results: The low-cost prototype for Basic Life Support training was used as a learning object adequately and enabled the teaching-learning process as an accessible resource at low cost. Based on the questionnaire applied, we observed that there was an increase in the median number of correct answers and a reduction in the median of errors, which indicated an improvement in the acquisition of information and improvement in learning, observed through the test of Signal of Related Samples and the test of the Signs of Wilcoxon, (MA) and errors (ME), before and after training where it was found that there was an increase in MA and a reduction in ME with 5% significance ($p < 0.001$). The frequencies of response modifications after training with the simulator were also studied by means of the two-tailed McNemar test where Q1, Q2, Q3, Q4, Q8, Q9, Q13 and Q15 questions showed significant changes ($p < 0, 05$).

Conclusion: A prototype was developed that simulated the training activity in Basic Life Support, which made it possible to carry out the procedures appropriately in positioning and simulation of cardiac resuscitation, mouth / nose ventilation, and tapping in the scapular region. Which allowed the validation of disengagement and resuscitation training as a low cost alternative for health education.

Keywords: high fidelity simulation training, medical education, cardiopulmonary resuscitation, choking.

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Authors summary

Why was this study done?

Due to the lack of economic resources and the high value of practice training products in the medical clinic, we are looking for viable alternatives for the development of low cost resources in teaching and research.

What did the researchers do and find?

We developed a low-cost cardiopulmonary reissue training resource and applied the device to the training of higher education students in the nursing course to validate the concept of the device and its applicability

What do these findings mean?

the development of a low-cost device for the training of students in higher education in nursing proved to be viable and effective in its applicability and in the criteria for retaining the concept and transferring information to academic and clinical practice.

INTRODUCTION

The use of realistic simulation methodology has been offered in several learning scenarios in the United States and Europe, this strategy allows students to participate directly in the problematization of situations that require professional action and consequently the student to search for solutions to the problem presented^{1,2}.

In 1960, researchers at Harvard University built the “Sim One” model that reproduced heart and lung sounds. As a result of this fact there was an impulse for other models of high technology supported mannequins to be developed, for example those used for delivery care and videolaparoscopic surgery³.

Simulation can be defined as “the technique that mimics the behavior of a situation or process by means of an analogous situation or device, specifically dedicated to personal study or training”^{4,5}; may also be simply referred to as a “technique that uses a simulator as the object of partial or total representation of a test to be replicated”⁶.

In the United States, more than 500,000 children and adults have a cardiac arrest event and less than 15% survive^{7,8}. The incidence of cardiac arrest outside the hospital setting ranges from 20 to 140 per 100 000 inhabitants and the survival rate varies from 2 to 11%⁹. In comparison, the mean survival rates of in-hospital cardiac arrest are 18% for adults and 36% for children¹⁰.

A cardiac arrest event is one of the major lethality factors in the United States, recognized as a public health problem¹⁰.

Professional training to assist an individual suffering cardiac arrest may reduce the risk of death, another important condition is an infant choking, a recurrent condition that affects newborns and can be avoided with the correct training for immediate disengagement and cardiac resuscitation with ventilation, a procedure that can be performed at any location. In several countries, such as North America and Europe, a number of educational institutions are encouraged to develop their own simulators to enable training and knowledge acquisition at an affordable cost¹¹.

Rapid and effective cardiopulmonary resuscitation by trained individuals may be associated with successful return of spontaneous circulation (ROSC) and neurologically intact survival of children after out-of-hospital cardiac arrest^{7,12–14}.

The Basic Life Support (SBV) training develops specific skills that help the identification

of cardiorespiratory arrest (CRP) by spectators and contributes to the interventions of this sudden event. Studies indicate that educating the population to intervene in cases of CRP increases 2 to 3 times the survival rate of the victims compared to those who do not receive cardiopulmonary resuscitation (CPR)¹².

In health education, local production of simulators for training in clinical procedures empowers and encourages teachers and coordinators to participate actively and develop new measures to evaluate the performance of the use of these resources¹⁵. Studies indicate that, in comparison with traditional teaching of lectures, simulation is a more enjoyable and enjoyable learning strategy, than providing more technical skills training for all students and preserving patients from the risks of this learning stage^{1,16}.

Some current physical models have a high commercial value, which limits the institutions’ access to such equipment. This raises the risk of an institution having simulators in their inventory, but not being able to use them because of the high cost of maintenance. These obstacles are the major motivators for the development of accessible models, easy to make and replenish¹⁷.

During academic training, health professionals often perform procedures, be they ambulatory or surgical, without prior training. Therefore, it is common that, due to lack of practice and the influence of psychological factors, failures occur in the execution of these procedures^{1,2,12,16,18}.

Thus, the objective of this work was to develop, validate and validate a prototype prototype infant of low cost for educational purposes in procedures of desengasgo and cardiopulmonary resuscitation.

METHODS

This is a cross-sectional study with the evaluation of an experimental prototype developed for basic life support training, as well as its feasibility and validation in the activities of disengagement maneuvers and cardiopulmonary resuscitation in infants.

The study population was made up of undergraduate nursing students from the Faculdades Integradas de Patos, Sertão Paraibano located in the city of Patos, State of Paraíba, Brazil.

The research was approved by the Ethics Committee of the Integrated Colleges of Patos-PB, opinion number: 1,728,913, in Patos, September 15, 2016.

Experiment evaluation

The prototype evaluation tests were carried out with first year undergraduate students of the Nursing course, an initial pre-test was carried out, followed by a practical theoretical class on how to perform the Basic Life Support in infants, with the training procedure of (TH) in the simulant prototype infants for 30 minutes, after the HT a post-test was performed.

Procedures were observed regarding the disengagement of the infant, followed by cardiopulmonary resuscitation (CPR) in infants.

Technical Parameters

The model consists of a human infant simulator (infant) composed of rubber members and body of biodegradable ecological fabric known as TNT, plastic plates for the thorax and scapular region, knitted fabric flaps, rubber tube with 20cm coupled to an air reservoir 10 / 10cm (Figure 1).



Figure 1: A. Infant head view. B. TNT body coupled to limbs. C. Patchwork of knitted fabric and the body. D. Mounted simulator.

Data collect

We applied a questionnaire composed of sixteen objective questions with four alternatives each, there was only one correct alternative and answer questions open in the section on populating the demographic data about the student having already undergone some previous training in Basic Life Support. In the case of a positive answer, the student should respond to the length of time he / she participated in this training, thirty tests were applied in a questionnaire model with objective questions, with a template and the free informed consent.

Statistical analysis

When evaluating the effect of the use of the simulator in training, the null hypothesis was stipulated and tested: "There were no significant changes in responses to the post-training questionnaire in relation to the pre-training questionnaire, using the infant simulator". By the statistical analysis we observe:

- (i) Compare the proportions of right answers before and after training;
- (ii) Compare the proportions of wrong answers before and after training;
- (iii) Compare the proportions of the right answers before the training and which became wrong after the training and;
- (iv) Compare the proportions of wrong pre-training responses that have become correct after training.

For the comparisons indicated in items i. and ii., two normal tests were applied for the distribution of correct and incorrect answers in the pre and post training questionnaire with the simulator. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used with significance of $\alpha = 5\%$.

Subsequently, the non-parametric tests were used: Signal test of related samples and the Wilcoxon signaled test, in order to compare medians of two related samples, are: null hypothesis- "The medians of the frequencies of correct questions before and after training with simulator are not different" and the other null hypothesis: The medians of frequencies of erroneous questions before and after training with simulator are not different, both with significance of 0.05.

The comparisons of items iii. and iv., the non-parametric test was applied, it is expected that the frequencies of the correct answers for each question will generally be distributed according to a binomial probability distribution of McNemar, well suited for dichotomous nominal variables when searching for changes in people's scores, that is, compares the numbers of people who have modified their responses in a given direction with the number of those who have modified their responses in the opposite direction as a process effect. This test was also performed with significance, $\alpha = 5\%$. For the McNemar test, the null hypothesis, H_0 , is 50% of the responses occur in one direction and the other 50% occur in the opposite

direction. In this work, McNemar's test was two-tailed, that is, the p-value takes into account both the modification of responses in a direction and in the opposite direction¹⁹.

RESULTS

Development of the prototype

The simulator respecting the respective dimensions of an infant (Figure 2), has the cephalic perimeter 43 cm, cephalo-caudal length equal to 55 cm, thoracic diameter equal to 44 cm, has air passages in the oral and nasal region of the simulator which allows ventilation of the mouth and nose simultaneously, for the purpose of thoracic expandability (Figure 1A). Body of TNT coupled to limbs (Figure 1B), body filling was performed with knitted tissue flaps, shaped to simulate the body of an infant (Figure 1C). Then the arms and legs were attached to the TNT and the head was then attached to the silicone tube and the air reservoir to the body. In this way, a simulator with a low relative cost of US \$ 15.00 (Figure 1D) was constructed, compared to other similar resources found in the market whose cost varies between US \$ 300 and US \$ 500 (dollars)²⁰.



Figure 2: A. Tapping technique of the scapular region of the infant simulator. B. technique for holding the infant's head. C. visualization technique of the mouth of the infant simulator. D. Technique of realistic complacency in the thorax of the infant simulator.

In the disengagement procedure it is possible to perform the tapotagens in the scapular region of the simulator (Figure 2A), technique to hold the infant's head (Figure 2B), checking the airway in case the foreign body has left the mouth (2C), and thoracic compression procedure in a rigid and flat location (Figure 2D).

Enabling the use of the prototype

The pre-test was performed for 40 minutes and collected at the end of the period, after which a training was carried out with the prototype of the infant simulator (Figure 3), with presentation of the simulator positioning technique for the group of students (figure 3A).

The groups were separated in stations to perform the tapotagens disengagement in the scapular region of the simulator (Figure 3B), then compressions in the intermamillary region (Figure 3C), the procedures were performed on a rigid and flat surface for cardiac resuscitation with the fingers (Figure 3D), the test circuit was performed in 30 minutes, with an additional 30 minutes to clear doubts supported with practical training in the simulator.

At the end of the steps a post-test was performed for 40 minutes with the same questions of the pre-test.



Figure 3: A. Tapping technique of the scapular region of the infant simulator. B. technique for holding the infant's head. C. Visualization technique of the mouth of the infant simulator. D. Technique of realistic complacency in the thorax of the infant simulator.

Validation of the prototype

The simulation and training of abilities in disengagement and CPR in infants participated 30 nursing students of the first period. The model proved to be practical in the skills proposed in cardiopulmonary resuscitation and resuscitation, facilitated skill training and provided a realistic test.

Table 1 presents the results of the comparisons between the medians of correct answers, before and after the training and; in the same way, of the comparisons between the medians of errors, before and after the training with the simulator, for the group of 30 students.

Table 1: Errors and correct answers the questionnaire, before (A) and after (D) of the training, for all students (30) using the simulator.

	A	D	p*	p**
Correct ^{MA}	6	10	< 0.001	< 0.001
Error ^{ME}	10	6	< 0.001	< 0.001

*TSAR: Signal Test for Related Samples; **TW: Wilcoxon Signal Testing of Related Samples Significance, $\alpha = 0,05$; MA: median answers correct; ME: median answer error.

Two different hypothesis tests were used as confirmation mechanisms, in all cases the p-value was <0.001, smaller than the significance $\alpha = 0.05$. Thus, we reject the null hypothesis, where the same median, before and after simulator training, are not different.

In order to study the frequency of modification of students' responses to one or more questions in the questionnaire after training with the simulator, the McNemar two-tailed test was performed, the results are presented in table 2 and the 16 questions of the questionnaire to Q16) and their respective frequencies of modified responses. Note that the p-value is smaller than the significance 0.05 for the questions Q1, Q2, Q3, Q4,

Q8, Q9, Q13 and Q15, so the null hypothesis is rejected, that is, there was a significant modification of the answers to these questions after simulator training.

The simulated teaching proposal, based on the principles of Basic Life Support in infants, based on

training with the simulator made with low cost material, reached its objective of assisting and orienting the students in how to proceed in an emergency situation and emergency.

Table 2: Frequencies of modified responses in the questionnaire after simulator training for each question for the 30 students

Question	Answers (before → after)		p- value
	0 → 1	1 → 0	
Q1	17	0	< 0.001
Q2	20	0	< 0.001
Q3	12	0	< 0.001
Q4	11	0	0.001
Q5	6	1	0.125
Q6	4	1	0.375
Q7	6	1	0.125
Q8	6	0	0.031
Q9	7	0	0.016
Q10	1	0	1.000
Q11	8	2	0.109
Q12	7	1	0.070
Q13	16	1	< 0.001
Q14	5	1	0.219
Q15	15	0	< 0.001
Q16	4	0	0.125

Using the McNemar test. bicaudal. with significance. $\alpha = 0.05$
1: correct answer and 0: wrong answer

DISCUSSION

The present work was structured for the development of disengagement and CPR skills in infants. Therefore, this simulator presents a knowledge and skills cut that must be acquired by nursing students in training, which should include the acquisition of other skills.

The extensive training of practical skills aims to simulate the same steps applied in the approach to the patient and to minimize the most frequent errors. The description of this model allows its easy reproduction, since the materials used in the confection are easily accessible. It should be emphasized, however, that the model serves as an initial practical instrument, where it becomes fundamental in the execution of the technique when the fact occurs in a real patient.

The role of educators in academic formation is constantly changing and challenges, in the process of learning is present the error and failure of a certain activity, where it is necessary the intervention of the educator as facilitator of learning, a mediator for acquisition and retention of knowledge by students, a challenge that is constantly discussed in the literature in the search for new strategies and reflections on the training of students in the area of health, providing new alternatives to teaching the educator offers greater chances and options of transmission of concepts and techniques, thus access to new tools is very important to boost professional development².

For DeNadai et al., (2014)²¹, low-fidelity bench models for training basic surgical skills, simulating sutures is a complementary alternative to the arsenal of existing programs and simulators, to prepare students before contact with patients.

A wide variety of bench models with similar purposes are presented in the contemporary medical literature, the models differ in relation to the level of fidelity when compared to a human body for study, some simulators have high fidelity (pig and chicken skins, ox tongue and surgical specimens discarded in surgical procedures) and others of low fidelity as EVA plates and rubberized^{22,23}. The work on low-cost and low-cost bench models favors the training of basic surgical skills during medical graduation, a way to partially reduce costs, especially in underdeveloped and developing countries^{21,23-25}.

The students had little knowledge in Basic Life Support, observed the need to provide and improve information on this topic during graduation, and through continuing education, training was provided at different moments that will help in the retention of knowledge and encouraging the intervention of the students in the face of cardiac arrest¹².

According to the SBV course of the American Heart Association¹⁴, the individual who achieves 84% achievement in a similar questionnaire is considered

qualified. Of the 30 participants in this study, only three (10%) achieved a performance above 84%. According to the students' reports, the use of the simulator helped in the performance of the questionnaire after the training (post-test). Some participants reported that they watched videos about the procedure, but they had not participated in simulator training.

Drummond (2016)²⁶, showed that a course combining video and simulation with high fidelity mannequins to teach pediatric CPR to medical students allows better retention of knowledge compared to a traditional lecture and in terms of skills there is an increase in the potential for execution from resuscitation guidelines after the practical course²⁶.

Compared to what was observed in our tests, participants reported that they were curious about the device, "an" infant "baby doll. Noted with greater intensity in the girls, possibly inherent to the maternal instinct, the welcome, the affection, words of praise and protection. There were comments where the terms applied to humans arose, which aroused in their colleagues the desire to take the doll and hold with care as if to breastfeed. The male students also felt at ease and allowed themselves to be taught by the girls how to hold the simulator, helping the interaction and collaboration for the activity.

In general, students commented that the simplicity of the equipment provided the goal of learning easily. Thus we observe that skill training with equipment with low fidelity in simulation is a valuable educational approach to the learning of complex processes.

In relation to cost, the proved to be significantly cheaper compared to the market average. Simulators with the same purpose, found in the active search for medical equipment sites, range from approximately US \$ 161.66 to US \$ 289.54. Although they represent an increase in education expenditures, these technologies meet the expectations of new generations of students in the health area, besides the ease in transportation^{20,27}. The low weight, approximate size and appearance of an infant, the good resistance to shocks and environmental phenomena, consequent, low maintenance of the simulator favors the use in the environment to retrain the training at any time.

Many works in the literature indicate that the compilation index is greater the lower the operator experience, thus requiring training standardization²⁷⁻²⁹. To meet the need for dexterity, several models of human simulation manikins have been developed for patient safety.

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In a study conducted by David Drummond and colleagues (2016)²⁶, a study with large numbers of medical students in CPR in pediatric allowed us to reveal that knowledge up to 12 months after courses was significantly better among students who participated in the course than those who participated in the traditional lecture. The course produced mixed results in terms of skills. The transfer of knowledge to practice is a difficulty reported by junior and senior doctors and the simulation can aid the learning process.

Without adequate understanding and information about SBV, lifeguards can provide assistance to victims incorrectly, with potential damage¹⁸. In this theoretical presupposition, knowledge is the result of a construction whose constitution occurs in sociocultural relations through the practical experience of phenomena. This construction is possible by the action itself supported by theoretical concepts sufficient to aid in the process of intellectual development. As well as preliminary results of this work discussed with other researchers, they could enrich and contribute in a relevant way to the improvement of the study³⁰. These conditions are indispensable for the advancement of knowledge as a construction¹⁶.

The results imply that efforts must be made to have the basic life support techniques introduced into the curriculum from the first year of graduation and the knowledge and skills are improved throughout the training. On the other hand, continuing education is important so that the good practices developed are implemented appropriately to the needs of individuals and society¹².

The importance of acquiring skills to support scientific knowledge ensures greater efficiency in a situation where good use of time is paramount. Thus, it is probable that a doctor who in his undergraduate studies has trained in basic life support techniques can naturally develop better basic skills in emergency situations^{22,31}.

■ CONCLUSION

It was developed a prototype that obtained its application in simulation of training activity in Basic Life Support, which made possible the accomplishment of the procedures in the proper way in positioning and simulation of cardiac resuscitation, mouth / nose ventilation and tapotagem in the scapular region, which allowed to validate disengagement and resuscitation training as a low-cost alternative to health education.

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Resumo

Introdução: O uso da metodologia de simulação realística é utilizado em diversos cenários de aprendizado, permitindo aos discentes a participação direta na problematização de situações que requerem ação profissional imediata.

Objetivo: Desenvolver, viabilizar e validar um simulador de baixo custo para procedimentos de desengasgo e reanimação cardiopulmonar em lactentes.

Método: Estudo experimental realizado com alunos de graduação do 1º ano do curso de Enfermagem em uma instituição de ensino superior do Estado da Paraíba, foi desenvolvido um modelo simulador com dimensões similares a um lactente com materiais de baixo custo e acessórios para manobras de desengasgo e reanimação cardiopulmonar, viabilizado o uso como protótipo para treinamento de Suporte Básico de Vida. O instrumento de coleta de dados foi o questionário baseado no guideline do Suporte Básico de Vida da American Heart Association.

Resultados: O protótipo para treinamento em Suporte Básico de Vida foi utilizado como adequadamente e viabiliza o processo ensino-aprendizagem como recurso acessível de baixo custo. O questionário aplicado observamos que houve incremento na mediana de acertos e redução na mediana de erros e indicou melhora na aquisição de informações e aprendizado, através do teste de Sinal de Amostras Relacionadas e o teste dos Postos Sinalizados de Wilcoxon, as medianas de acertos (MA) e erros (ME), antes e depois do treinamento, com o aumento de MA e redução em ME com 5% de significância ($p < 0,001$). As respostas as questões Q1, Q2, Q3, Q4, Q8, Q9, Q13 e Q15 mostraram modificações significativas ($p < 0,05$), após o treinamento com o simulador por meio do Jteste de McNemar bicaudal ao estudar as frequências de modificações de respostas.

Conclusão: O protótipo obteve sua aplicação em simulação de atividade de treinamento em Suporte Básico de Vida, viabilizou a realização dos procedimentos da forma adequada em posicionamento e simulação de reanimação cardíaca, ventilação boca/nariz e tapotagem na região escapular, permitiu validar o treinamento de desengasgo e reanimação como uma alternativa de baixo custo para educação em saúde.

Palavras-chave: treinamento com simulação de alta fidelidade, educação médica, reanimação cardiopulmonar, engasgo.

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