Low Cost Simulator for Cardiopulmonary Resuscitation in Infants: a Proof-of-Concept Study.

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Brief Research Report

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Abstract

Background: Realistic simulation methodology is used in various learning scenarios, allowing students to participate directly in problematic situations that require immediate professional action. The objective of this proof-of-concept study was to develop a low-cost simulator for cardiopulmonary resuscitation procedures in infants.

Findings: The prototype was developed successfully with accessories to simulate cardiopulmonary resuscitation maneuvers. The data collection instrument was a questionnaire based on the Basic Life Support guidelines of the American Heart Association to test the instrument. The prototype was used as a learning object for the teaching-learning process as a low-cost resource.

Conclusion: A low-cost prototype was developed, and its application was obtained from the simulation of the training activity in Basic Life Support and from the performance of procedures in the positioning and simulation of cardiopulmonary resuscitation.

Introduction

The use of realistic simulation methodology has been offered in various learning scenarios in the United States and Europe. This strategy allows students to directly participate in challenging situations that require professional action and, consequently, the students seek solutions to the actual problem [1,2].

Medical Simulation is the modern-day methodology for training healthcare professionals through the use of advanced educational technology. Professional training to help a newborn suffering from cardiac arrest or asphyxiation can reduce the risk of death. In several North American and European countries, several educational institutions are encouraged to develop their own simulators to allow training and knowledge acquisition at an affordable cost [3-10].

Basic Life Support (BLS) training develops specific skills that help to identify cardiorespiratory arrest and contribute to interventions in this sudden event. Studies indicate that educating the population to intervene in cases of cardiopulmonary arrest increases the survival rate of victims 2 to 3 times compared to those who do not receive cardiopulmonary resuscitation [11-13].

The production of low-cost simulators for training enables and encourages teachers and coordinators to actively participate and develop new measures to assess the performance of the use of these resources14. Studies indicate that, compared to traditional lecture teaching, simulation is a more enjoyable learning strategy to provide technical skills [1,15].

Some current physical models have a high commercial value, which limits institutions' access to the equipment. This increases the risk of an institution having simulators in its inventory, but not being able to use them due to the high cost of maintenance. These obstacles are the main motivators for the development of accessible models with low maintenance costs [15-17].

Thus, the objective of this proof-of-concept study was to develop a low-cost simulator for cardiopulmonary resuscitation procedures in infants.

Methods

In this proof-of-concept study, an experimental prototype for basic life support training was developed and, its performance in cardiopulmonary resuscitation maneuvers in infants was evaluated. The research was approved by the institution's Ethics Committee (number: 1728913).

The study population for the simulation consisted of undergraduate nursing students at a Brazilian university. A pre-test was carried out to evaluate the prototype. , Then a class on Basic Life Support in infants was carried out using the prototypes of children's simulators for 30 minutes, followed by renewal of the pre-test. The test was developed by Tavares et al and consists of 16 objective questions with four alternatives each, and only one correct alternative. In addition, students were asked about previous training in Basic Life Support.

In the simulation, choking maneuvers and cardiopulmonary resuscitation in infants were demonstrated.

The model consists of a child simulator composed of rubber members and a body made of biodegradable ecological fabric (Nonwoven), plastic plates for the chest and scapular region, mesh flaps, 20cm rubber tube coupled to a 10/10 cm air reservoir (Figure 1)

The statistical analysis compared the proportions of correct answers before and after training, wrong answers before and after training, correct answers followed by wrong answers after the training, and wrong pre-training responses followed by correct ones after training. Two normality tests were applied to distribute correct and erroneous answers in the pre- and post-training questionnaire with the simulator, using the Kolmogorov-Smirnov and Shapiro-Wilk test with a 5% significance. Subsequently, non-parametric tests were used: signal test of related samples and Wilcoxon test, to compare medians of two related samples. In addition, McNemar's binomial probability distribution, suitable for dichotomous nominal variables, was tested. The McNemar test was two-tailed, that is, the p-value takes into account both the modification of responses in one direction and in the opposite direction [18].

Results

Development of the prototype

The prototype was built successfully. The child represented by the simulator (Figure 2) had a head circumference of 43 cm, head-length measure of 55 cm, and chest diameter of 44 cm. In addition, the simulator had air passages in the oral and nasal region allowing ventilation of the mouth and nose simultaneously (chest expansion) (Figure 1A).

The body was filled with fabric scraps, modeled to simulate a child's body (Figures 1B and 1C). Then, the arms and legs were attached to the fabric and the head, and a silicone tube and an air reservoir were added. Thus, the simulator was built at a cost of US$ 15.00 (Figure 1D). The cost of other similar resources found in the market varies between US$ 300 and 500 [19].

In the prototype, it is possible to perform the Heimlich maneuver, (Figure 2A), to maintain good head position for the infant (head tilt - chin lift) to maintain a patent airway (Figure 2B) and check the airways (foreign body aspiration) (Figure 2C and 2D).

A 40-minute training session was carried out with the prototype (Figures 3 and 3A). The groups were separated into stations to perform BLS techniques (Figure 3B, 3C and 3D).

Thirty nursing students from the first period participated. The prototype proved to be practical in cardiopulmonary resuscitation, facilitating skill training. Table 1 shows the results of the comparisons between the medians of the correct answers, before and after training, and the comparisons between the median of errors, before and after simulator training, 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, a = 0,05; MA: median answers correct; ME: median answer error.

To study the frequency of modification of students' responses after training with the simulator, McNemar's two-tailed test was performed, the results are shown in table 2.

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

	Answers (before ® after)		
Question	0 ® 1	1 ® 0	p- value
Q_1	17	0	< 0,001
Q_2	20	0	< 0,001
Q_3	12	0	< 0,001
Q_4	11	0	0,001
Q_5	6	1	0,125
Q_6	4	1	0,375
Q_7	6	1	0,125
Q_8	6	0	0,031
Q_9	7	0	0,016
Q_{10}	1	0	1,000
Q_{11}	8	2	0,109
Q_{12}	7	1	0,070
Q_{13}	16	1	< 0,001
Q_{14}	5	1	0,219

Q_{15}	15	0	< 0,001
Q_{16}	4	0	0,125
Using the McNemar test, bicauldal, with significance, a = 0.05 1: correct answer and 0: wrong answer			

Discussion

The simulator model that was developed allows easy reproduction, since the materials used in the manufacture are easily accessible. The simulated teaching proposal, based on a prototype made with low-cost material, reached its objective of helping and guiding students on how to proceed in an emergency situation.

A variety of models with similar purposes were presented in the contemporary medical literature; the models differ in relation to the level of fidelity when compared to a human body [20,21,22]. Working on low-cost models favors the training of basic skills during undergraduate training in health sciences, a way to partially reduce costs, especially in developing countries [23,24].

According to the BLS course (American Heart Association) [13], an individual, who reaches 84% of correct answers in a similar questionnaire, is considered qualified. Of the 30 participants in this study, only three (10%) achieved performance above 84%. According to students' reports, the use of the simulator helped in the completion of the questionnaire after training (post-test). Researches show that courses that combine simulation with mannequins allow for better knowledge retention compared to a traditional class [25,26].

In general, students commented that the simplicity of the equipment provided the goal of learning easily. Thus, our study showed that skill training with low fidelity equipment in simulation is a valuable educational approach to learning complex processes. Regarding the cost, the prototype proved to be significantly cheaper compared to the market average. Simulators for the same purpose range from 160 to 290$ [19,26]. In a study by Drummond et al (2016) [25], the authors concluded that knowledge retention was better among students who participated in the simulation than among those who participated in the traditional lecture. The course produced variable results in terms of skills - the transfer of knowledge to practice is a difficulty reported by doctors, and simulation can help in the learning process.

This study has some major limitations. We were not able to study the effects of other methods of learning such as within-group learning, computer-assisted learning, and self-study learning. The assessment consisted of a questionnaire and thus, the effects of the model on the ability to correctly perform BLS maneuvers could not be assessed.

Conclusion

A prototype was developed that obtained its application in the simulation of the training activity in BLS, enabling proper performance of the procedures.

Abbreviations

BLS - Basic Life Support

Q - question

Declarations

Competing interests

The authors declare that they have no competing interests. No funds were received in the support of this study. No editorial or statistical assistance or rights were extended to or claimed by anyone other than the authors. All figures and tables are original work of the authors.

Authors' contributions

ANT designed the study and provided primary authorship. ANT and AGO organized data collection efforts. JOE and LCA provided statistical analysis, and provided editorial support services. ANT, RDR, JOE and LCA assisted in initial study design and review of the manuscript. RDR and APS provided data support and manuscript review services. All figures and tables are by APS and JOE. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

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

CONSENT FOR PUBLICATION

Attachment

AVAILABILITY OF DATA AND MATERIAL

Please contact author for data requests.

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References

1. FERREIRA C. Impacto da metodologia de simulação realística, enquanto tecnologia aplicada à educação nos cursos de saúde. Anais do Seminário Tecnologias Aplicadas a Educação e Saúde. 2015; 1(1): 32-40.
2. Page RL. Brief history of flight simulation. in *Proceedings of SimTecT 2000*. 2000; :11-17. doi:10.1.1.132.5428
3. Bradley P. The history of simulation in medical education and possible future directions. *Educ.* 2006; 40(3): 254–262. https://doi.org/10.1111/j.1365-2929.2006.02394.x
4. Ziv A, Wolpe PR., Small SD, Glick S. Simulation-based medical education: an ethical imperative. *Healthc.* 2006; 1(4): 252–256. doi: 10.1097/01.SIH.0000242724.08501.63
5. Pazin FA, Scarpelini S. Simulação: definição. Medicina (Ribeirao Preto. Online)[internet]. 2007June [Cited 2016 Apr 5], v. 40, n. 2, p. 162-66.
6. Go AS, *et al.* American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2013 update: a report from the American Heart Association. 2013; 3: 29-45. doi:10.1161/CIR.0b013e31828124ad
7. Nichol G. *et al.* Regional Variation in Out-of-Hospital Cardiac Arrest Incidence and Outcome. 2008;300 (12): 1423–1431. doi:10.1001/jama.300.12.1423
8. Berdowski J, Berg RA, Tijssen JGP, Koster RW. Global incidences of out-of-hospital cardiac arrest and survival rates: Systematic review of 67 prospective studies. 2010; 81(11): 1479–1487. https://doi.org/10.1016/j.resuscitation.2010.08.006
9. Christenson J, *et al.* Cardiopulmonary Resuscitation Quality: Improving Cardiac Resuscitation Outcomes Both Inside and Outside the Hospital. *Circulation* 2013; 128(4): 417–435. https://doi.org/10.1161/CIR.0b013e31829d8654
10. Al-Elq AH. Simulation-based medical teaching and learning. *Family Community Med.* 2010; 17 (1): 35–40. doi: 10.4103/1319-1683.68787
11. Tavares LFB, *et al.* Knowledge of health sciences undergraduate students in objective tests on basic life support. *Hum. Growth Dev.* 2015; 25(3): 297- 306. DOI: https://doi.org/10.7322/jhgd.106002
12. Kitamura T, et al. Implementation Working Group for the All-Japan Utstein Registry of the Fire and Disaster Management Agency. Nationwide public-access defibrillation in Japan. *N Engl J Med. 2010;* 367 (11): 994–1004. nejm.org/doi/pdf/10.1056/NEJMoa0906644
13. Circulation 2005;112;IV-1-IV-5; originally published online Nov 28, 2005; DOI: 10.1161/CIRCULATIONAHA.105.166550

14. Pugh CM. Low-cost, locally fabricated simulators: The wave of the future. Journal of Surgical Research. 2011; 168(1): 29-30. doi:10.1016/j.jss.2010.07.018
15. Varga CRR, et al. Relato de experiência: o uso de simulações no processo de ensino-aprendizagem em medicina. Bras. Educ. Med. 2009; 33(2): 291-297. doi:10.1590/s0100-55022009000200018
16. Mileder LP, et al. Compliance with guidelines recommending the use of simulation for neonatal and infant resuscitation training in Austria. Klinische Pädiatrie, 2014; 226 (01): 24-28. DOI: 10.1055/s-0033-1361106
17. Pergola AM, Araujo IEM. O leigo e o suporte básico de vida. Rev. da Esc. Enferm. da USP. 2009; 43 (2): 335–342. https://doi.org/10.1590/S0080-62342009000200012
18. Zangirolami-Raimundo J, Echeimberg JO, Leone C. Research methodology topics: Cross-sectional studies. J. Hum. Growth Dev. 2018; 28(3):356-360. doi:10.7322/jhgd.152198
19. Silva RR, Lourenção Jr A, Goncharov M, Jatene FB. Low Cost Simulator for Heart Surgery Training. Brazilian J. Cardiovasc. Surg. 2016; 31(6): 449–453. https://doi.org/10.5935/1678-9741.20160089
20. Denadai R., Saad-Hossne R., Todelo AP, Kirylko, L, Souto LRM. Low-fidelity bench models for basic surgical skills training during undergraduate medical education. *Col. Bras. Cir.* 2014; 41 (2): 137–145 (2014).
21. Vieira JE, Tamousauskas MRG. Avaliação das resistências de docentes a propostas de renovações em currículos de graduação em medicina. *Bras. Educ. Med.* 2013; 37(1): 32-38. doi:10.1590/s0100-55022013000100005
22. Denadai R., Oshiiwa M, Saad-Hossne R. Does bench model fidelity interfere in the acquisition of suture skills by novice medical students? *Assoc. Med. Bras.* 2012; 58(5): 600-606. doi:10.1590/s0104-42302012000500019
23. Denadai R, Kirylko L. Teaching basic plastic surgical skills on an alternative synthetic bench model. Aesthetic surgery jornal. 2013; 33: 458-461.
24. Denadai Rafael, Souto Luís Ricardo Martinhão. Organic bench model to complement the teaching and learning on basic surgical skills. Acta Cir. Bras. [Internet]. 2012 Jan [cited 2020 Apr 28] ; 27(1): 88-94. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-86502012000100015&lng=en. https://doi.org/10.1590/S0102-86502012000100015.
25. Drummond D, Arnaud C, Thouvenin G. *et al.*An innovative pedagogic course combining video and simulation to teach medical students about pediatric cardiopulmonary arrest: a prospective controlled study. *Eur J Pediatr*. 2016; 175: 767–774. https://doi.org/10.1007/s00431-016-2702-1
26. Wang C, Chen L, Mu D, Xin M, Luan J. A Low-Cost Simulator for Training in Endoscopic-Assisted Transaxillary Dual-Plane Breast Augmentation. *Plast. Surg.* 2017; 79: 525–528.
27. Vieira LJES, Carneiro RCMM, Frota MA, Gomes ALA, Ximenes LB. Ações e possibilidades de prevenção de acidentes com crianças em creches de Fortaleza, Ceará. *Saude Colet.* 2009; 14: 1687-1697. doi:10.1590/S1413-81232009000500010

Figures

Figure 1

(A) View of the baby's head; (B) Body attached to the limbs; (C) Fabric used for the body; (D) Assembled simulator.

Figure 2

(A and B) Maneuver positioning in the child simulator - choking maneuver; (C) visualization of the baby's mouth; (D) Chest compressions

Figure 3

(A, B and C) Simulation class B. technique to hold the baby's head; (D) Student performing Basic life support maneuver

Supplementary Files

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