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Original Article

# Effectiveness of realistic simulation for teaching pulmonary physical examination: randomized clinical trial

## Eficácia da simulação realística para o ensino do exame físico pulmonar: ensaio clínico randomizado

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**ABSTRACT**
**Objective:** to evaluate effectiveness of realistic clinical simulation for teaching pulmonary physical examination to undergraduate nursing students. **Methods:** experimental study of pre-test and post-test type applied to randomized intervention and control groups. The sample consisted of 30 students, randomly divided. The analysis was performed using descriptive and inferential statistics, through Kolmogorov-Smirnov test and t-test for independent samples, considering statistical significance p≤0.05. A satisfaction scale validated with the intervention group was applied. **Results:** we identified increased correct answers in post-test in the intervention group, which was submitted to realistic simulation. In this group, the mean number of errors varied from 4.87 in the pre-test to 2.13 in the post-test. In the control group, students either decreased or maintained the number of correct answers in the post-test, and mean errors increased, from 3.87 in the pre-test to 4.0 in post-test. The difference in correct answers between intervention and control groups was significant (p=0.000). **Conclusion:** from realistic simulation, students obtained a lower average error rate on post-test. **Contributions to practice:** results of this research favor the curricular insertion of simulation for teaching pulmonary physical examination in undergraduate nursing.
**Descriptors:** Nursing; Simulation Exercise; Physical Examination; Clinical Trial; Learning.

**RESUMO**
**Objetivo:** avaliar a eficácia da simulação clínica realística para o ensino do exame físico pulmonar em discentes de graduação em Enfermagem. **Métodos:** estudo experimental do tipo pré-teste e pós-teste aplicado a grupo intervenção e controle aleatórios. A amostra foi de 30 discentes, divididos aleatoriamente. A análise foi realizada a partir de estatística descritiva e inferencial, por meio do teste de Kolmogorov-Smirnov e do Teste *t* para amostras independentes, considerando significativamente estatístico p≤0,05. Aplicou-se escala de satisfação validada com o grupo intervenção. **Resultados:** identificou-se aumento de acertos no pós-teste do grupo intervenção, submetido à simulação realística. Nesse grupo, a média de erros variou de 4,87 no pré-teste para 2,13 no pós-teste. No grupo controle, os discentes diminuíram ou mantiveram o número de acertos das questões no pós-teste, e a média de erros aumentou, no pré-teste foi de 3,87 e no pós-teste foi de 4,0. A diferença de acertos entre o grupo intervenção e o grupo controle foram significativos (p=0,000). **Conclusão:** a partir da simulação realística, os alunos obtiveram uma menor média de erros no pós-teste. **Contribuições para a prática:** os resultados desta pesquisa favorecem a inserção curricular da simulação para o ensino do exame físico pulmonar na graduação de enfermagem.
**Descritores:** Enfermagem; Exercício de Simulação; Exame Físico; Ensaio Clínico; Aprendizagem.

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## Introduction

The undergraduate nursing course aims to train ethical, reflective, critical, and autonomous individuals, through the development of knowledge, skills, and attitudes in students. Supervised practical activities are one of the main training methods, in which technical skills and procedures are improved, developing the student's professional identity, and consolidating theories learned in the classroom[1-2].

The period of supervised practical activity is marked by intense emotional stress[3]. Among the students' fears, the performance of the pulmonary physical examination stands out. In this examination, the propaedeutic methods of inspection, palpation, percussion, and auscultation are used[4]. The auscultation phase is referred to as one of the most error-prone, corroborated by the feeling of insecurity resulting from the few opportunities to develop technical ability in the laboratory[5].

This situation was exacerbated during the pandemic context of COVID-19, and the need to train qualified professionals to act against respiratory diseases was identified. A growing educational strategy, during this problematic issue, was the introduction of realistic simulation in the undergraduate context. Realistic simulation is considered to favor the evolution of diagnostic reasoning and effective decision making, leading to safe and holistic nursing care in emergency health care[2,6].

Simulation is based on the active methodology of problem-based learning, which is conceptualized as a technique capable of creating a situation or environment that allows people to experience the representation of a real event, for the purpose of practice and learning about human systems or actions[2,7].

The use of this strategy allows improving cognitive performance, encouraging students' self-confidence and satisfaction in learning. Based on the conceptual model of Miller's Pyramid, the cognitive domain refers to the first and second levels of the pyramid ("knowing" and "knowing how to do"). The "knowing" refers to theoretical knowledge, while the "knowing how to do" refers to applied knowledge. In professional practice, the "doing" is based on "knowing" knowledge allied to "knowing how to do"[8-9].

The skills and competencies necessary for the development of these levels should be demonstrated by students during their academic training, which characterizes the "show how you do it". This level corresponds to practical assessments based on clinical activities, examples being the observation by the student of the care of real patients, and simulated patients and the use of realistic simulation[8-9].

Simulation has been a healthcare technique explored as a strategy in teaching laboratories to provide a reflective environment and develop theoretical and practical skills that are indispensable for future nurses[10-13]. However, none of these studies specifically addressed simulation in teaching pulmonary physical examination.

In this context, the present study assumes that students submitted to clinical simulation prior to hospital practice have greater knowledge about pulmonary physical examination. Therefore, to ratify this statement, this study aimed to evaluate the effectiveness of realistic clinical simulation in teaching pulmonary physical examination to undergraduate nursing students. The following question was posed: Is realistic simulation effective in the teaching-learning process of the pulmonary physical examination in undergraduate nursing students?

## Methods

This is an experimental study of the pre-test and post-test type, conducted at a Federal University located in the Northeast of Brazil during 2018. The research was developed in three stages: construction of the simulation script, validation by experts, and implementation of the educational intervention. The study followed the recommendations of the Consolidated Standards of Reporting Trials (CONSORT).

The simulation script was built based on sci-

entific literature and pertinent references and was composed of the following topics: title of the scenario, objectives, materials, participants, description of the clinical case, dialogue guidance, debriefing, and references. The clinical case contained the narrative of the patient's clinical history and his needs focused on the respiratory system. The design of the clinical simulation followed the National League for Nursing (NLN)/ Jeffries Simulation Framework[14] model, addressing the following steps: definition of the learning objectives; definition of the competencies to be developed; simulation duration; characters involved in the simulation; current history of the simulated client; additional information that comprise the medical record; directed speeches of the simulation characters, and the simulation objectives to be delivered to the student[15]. A checklist was also created about the activities expected from the student during the simulation, to subsidize the discussions during the debriefing.

In the second stage, the evaluation of the simulation script was performed with nine nurse specialists from a focus group. Regarding the number of specialists, the number was determined by the formula $n = Z^2 1\text{-}\alpha/2.\ P\ (1 - P) / e^2$, in which $Z1\text{-}\alpha/2$ refers to the confidence level adopted, P represents the expected proportion of experts indicating the adequacy of each item, and "e" represents the acceptable proportion difference in relation to what would be expected[16].

The inclusion criteria for the experts consisted of being a nurse; having at least a master's degree; being a professor of the discipline of Nursing Semiology and semiotechnology or developing research aimed at teaching; and having the availability to attend the face-to-face meeting to validate the intervention instrument. Those who did not attend the scheduled meeting were excluded.

The focus group evaluation started with a four-hour meeting with the experts, in which the study objectives and the realistic simulation script were discussed. Each topic was discussed, and the moderator/researcher reached consensus on the opinions expressed. All contributions were analyzed and added to the scenario.

In the third stage, the educational intervention was implemented with 30 fourth-year undergraduate nursing students in the skills laboratory of a federal institution, enrolled in the discipline of Semiology and Semiotechnics in Nursing. This number refers to the estimated number of students per semester in the undergraduate periods.

The students were randomly divided into control and intervention groups, upon availability to participate in the intervention. The first 15 students formed the intervention group and received the instructions about the simulation, who were invited to voluntarily apply for the roles of nurse and nursing student. The control group received only the traditional class.

The participants of both groups initially answered the pre-test instrument composed of two steps: the first with the sociodemographic and academic characterization of the students and the second part composed of 10 questions about the pulmonary physical examination, including objective questions of multiple choices about the propaedeutic methods for evaluation of the pulmonary segment in the patient, assigning 01 point for each question of the instrument. The questions had the same value for believing in the holistic and interconnected character of the pulmonary physical examination.

The choice of this subject for the experiment provided more control to the study and reduced possible biases, since the students had no previous hospital experience. The sample inclusion criteria were previous access to a traditional theoretical class on pulmonary physical examination and no previous hospital experience. The students who had some previous hospital experiences were excluded. It is noteworthy that, among the participants, none had this situation.

The patient was represented by the Nursing

Anne Simulator mannequin, of the brand Laerdal Medical®, in which altered parameters of the pulmonary system were adjusted, from its computational system. The student-manikin communication occurred from a trained actor, in a simulated scenario previously tested by the responsible researcher.

The entire scene was filmed and, after its completion, passed to the rest of the group, to support the last stage, the debriefing. At this moment, all students of the intervention group reflected on the actions developed during the simulation and the care provided to the patient.

Finally, the students in the intervention and control groups answered the post-test, containing the same 10 questions about the pulmonary physical examination of the pre-test instrument. Similarly, to what was done previously, 01 point was attributed for each question, totaling 10 maximum points. The same questions were used for the pre-test and post-test, considering standardizing the level of difficulty, as well as evaluating the efficacy of the simulation in the learning of the students in the intervention group and comparing the results with the control group.

In addition, the intervention group also answered a satisfaction scale[17], which referred to the degree of satisfaction with the application of realistic simulation, in which three axes were addressed: practical, realism, and cognitive. The three simulation stages: briefing, debriefing, and post-test were performed in the Practical Skills Laboratory of that institution. The simulation took place during the morning shift.

The data were organized in Microsoft Office Excel® spreadsheets, version 2013. For statistical analysis, the statistical software IBM SPSS Statistic 21.0 for Windows was used. The relative and absolute frequencies of categorical variables were calculated, as well as the measures of central tendency and dispersion of quantitative data, which were tested for normality using the Shapiro-Wilk test. The analysis of the effectiveness of the intervention was verified using the t-test for independent samples, with $p \leq 0.05$.

The ethical precepts of research with human beings were respected. The Informed Consent Form was signed by all participants involved. This study was approved by the Research Ethics Committee of the Federal University of Rio Grande do Norte, under opinion number 2,057,709/2017.

## Results

The sample characterization is expressed in Table 1, in which the results show similarity between the sociodemographic and student characteristics among the nursing students of both groups, according to $p \leq 0.05$.

**Table 1** – Sociodemographic and student characterization of the sample (n=30). Natal, RN, Brazil, 2018

| Variables | Intervention | Control | p-value* |
|---|---|---|---|
| | n (%) | n (%) | |
| Gender | | | 0.510 |
| Female | 12 (40.0) | 12 (40.0) | |
| Male | 3 (10.0) | 3 (10.0) | |
| Marital Status | | | 1.000 |
| With partner | 4 (13.3) | 5 (16.7) | |
| Without partner | 11 (36.7) | 10 (33.3) | |
| Any disapproval | | | 1.000 |
| Yes | 5 (16.7) | 1 (3.3) | |
| No | 10 (33.3) | 14 (46.7) | |
| First degree | | | 0.130 |
| Yes | 9 (30.0) | 11 (36.7) | |
| No | 6 (20.0) | 4 (13.3) | |
| Completion of technical course | | | 1.000 |
| Yes | 2 (6.7) | 1 (3.3) | |
| No | 13 (43.3) | 14 (46.7) | |
| Participation in projects involving physical examination | | | 1.000 |
| Yes | 3 (10.0) | 5 (16.7) | |
| No | 12 (40.0) | 10 (33.3) | |

*Fisher's exact test

To better understand the conduct of the clinical trial, its validity, and the applicability of its conclusions, CONSORT was followed. The segment diagram or flow chart of the research is presented in Figure 1.

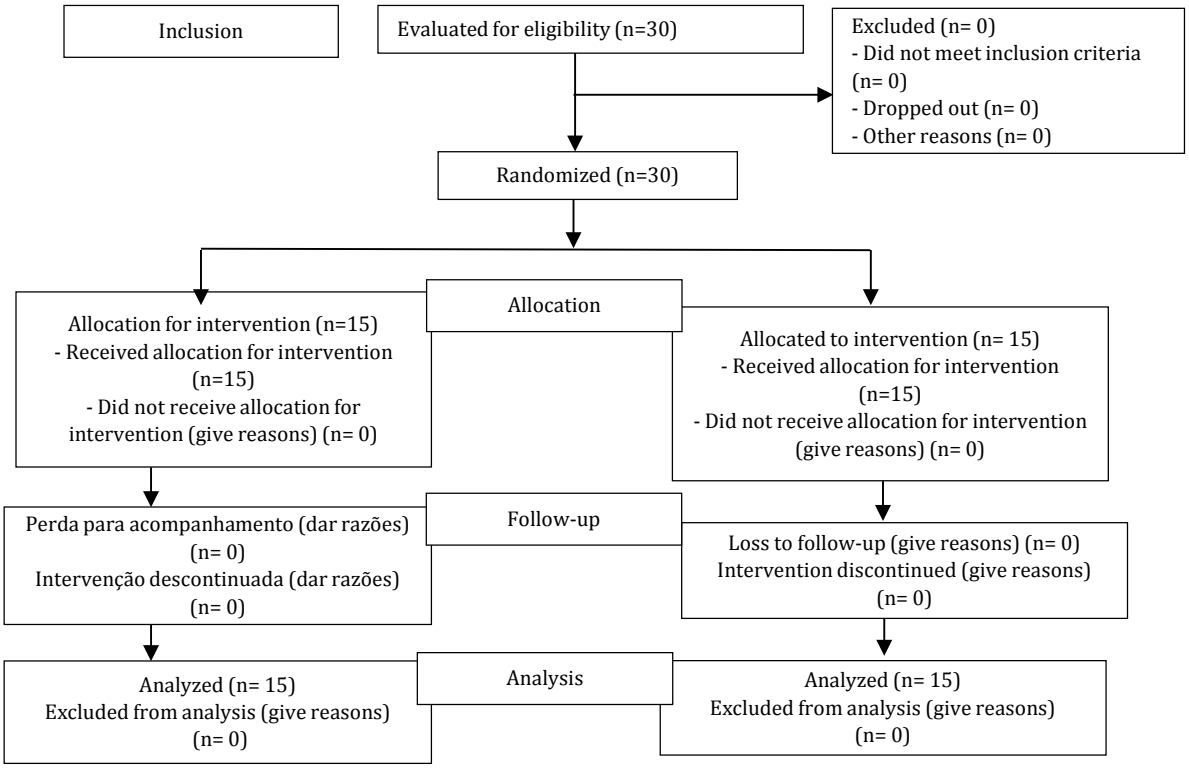


**Figure 1** – Flowchart of the research. Natal, RN, Brazil, 2018

In the pre-test, implemented in the intervention and control groups, there was no statistically significant difference in the number of correct answers for each question, indicating homogeneity in the groups' prior knowledge. In relation to the post-test, there was also no statistical difference between the intervention and control groups when the number of correct answers was analyzed for each question individually. It is noteworthy that questions 1, 2, and 9 had 100% of correct answers in the intervention group, which made it impossible to form the 2×2 table. The percentage of correct answers per question is shown in Table 2.

**Table 2** – Distribution of hits of the intervention and control group (n=30). Natal, RN, Brazil, 2018

| Questions | Pre-test | | | Post-test | | |
|---|---|---|---|---|---|---|
| | Intervention (%) | Control (%) | p-value* | Intervention (%) | Control (%) | p-value* |
| 1 | 100.0 | 66.7 | - | 100.0 | 60.0 | – |
| 2 | 46.7 | 53.3 | 0.610 | 100.0 | 53.3 | – |
| 3 | 33.3 | 53.3 | 0.600 | 66.7 | 66.7 | 1.000 |
| 4 | 40.0 | 20.0 | 1.000 | 86.7 | 73.3 | 0.470 |
| 5 | 40.0 | 80.0 | 0.520 | 73.3 | 80.0 | 1.000 |
| 6 | 40.0 | 53.3 | 0.310 | 80.0 | 40.0 | 0.520 |
| 7 | 13.3 | 33.3 | 0.520 | 26.7 | 13.3 | 0.470 |
| 8 | 80.0 | 66.7 | 1.000 | 66.7 | 60.0 | 0.580 |
| 9 | 73.3 | 86.7 | 1.000 | 100.0 | 86.7 | – |
| 10 | 40.0 | 60.0 | 1.000 | 86.7 | 46.7 | 1.000 |

*Fisher's exact test

However, there was an increase in the number of correct answers in most of the questions applied after the intervention in the group submitted to realistic simulation. In this group, the mean number of correct answers varied from 4.87 in the pre-test to 2.13 in the post-test. On the other hand, in the control group, it was observed that the students either decreased or maintained the number of correct answers in the post-test. In this sense, the mean error rate of this group increased, from 3.87 in the pre-test to 4.0 in the post-test.

When applying the t-test for independent samples, we noticed a significant difference between the overall sample means, with a value of approximately 0.0007 and a positive hit statistic of 3.79. The result obtained shows very strong evidence in favor of realistic simulation as a learning tool for the pulmonary physical examination for undergraduate nursing students.

Regarding the degree of satisfaction of the students about the realistic simulation, the individuals in the intervention group characterized the intervention according to the data contained in Table 3.

In view of the results presented in Table 3, it was found that the individuals in the intervention group rated it as extremely satisfactory, very satisfactory, and satisfactory on most of the axes analyzed.

**Table 3** – Distribution of the degree of satisfaction with the application of realistic simulation. Natal, RN, Brazil, 2018

| Dimensions and respective items | ES (%) | VS (%) | S (%) | BS (%) |
|---|---|---|---|---|
| Satisfaction with the practical dimension | | | | |
| Overall satisfaction with the simulation | 46.7 | 26.7 | 26.7 | 0 |
| Learning achieved | 46.7 | 20.0 | 33.3 | 0 |
| Motivation when coming to the course | 60.0 | 20.0 | 20.0 | 0 |
| Simulation dynamism | 46.7 | 26.7 | 26.7 | 0 |
| Active participation in the developed scenario | 53.3 | 13.3 | 33.3 | 0 |
| Interaction with colleagues | 46.7 | 26.7 | 26.7 | 0 |
| Interaction with teachers | 53.3 | 26.7 | 20.0 | 0 |
| Satisfaction with the degree of difficulty of the scenario | 46.7 | 26.7 | 26.7 | 0 |
| Productivity during the course | 46.7 | 40.0 | 6.7 | 6.7 |
| Satisfaction with the realism dimension | | | | |
| Realism of the scenario developed | 53.3 | 33.3 | 6.7 | 6.7 |
| Credibility during the scenario | 60.0 | 26.7 | 6.7 | 6.7 |
| Quality of the material used | 40.0 | 46.7 | 13.3 | 0 |
| Quality of the equipment used | 40.0 | 46.7 | 13.3 | 0 |
| Quality of the simulator | 40.0 | 46.7 | 6.7 | 6.7 |
| Satisfaction with the cognitive dimension | | | | |
| Satisfaction with the post-scenario discussion (debriefing) | 60.0 | 26.7 | 13.3 | 0 |
| Connection of the scenario to the theory | 60.0 | 33.3 | 6.7 | 0 |
| Adequacy with the themes developed in class | 53.3 | 40.0 | 6.7 | 0 |

ES: Extremely Satisfactory; VS: Very Satisfactory; S: Satisfactory; BS: Barely Satisfactory; U: Unsatisfactory

## Discussion

This study points out that simulation is an effective active methodology with significant differences in learning when compared only to traditional teaching. The advantage of this educational technology consists in the positive results presented in several teaching areas[18-20]. Due to the multifaceted nature of realistic simulation, it can be adapted to different contexts and complexities of teaching in the health field[21].

Students who are instructed in simulated scenarios show greater confidence, self-efficacy, critical thinking, understanding of the subject matter, and mastery of the interprofessional and professional-patient dialogue[22-23], which justifies the high satisfaction rates in this research by the intervention group.

The quality of the simulator and the simulation obtained ratings according to the satisfaction scale as extremely satisfactory, very satisfactory, or satisfactory. A similar result was verified in a study in which students showed a high level of satisfaction and confidence with the new skill, as well as better levels of understanding and self-efficacy[24].

Simulation enables meaningful learning and stimulates students' cognitive performance. In addition, its use can enable students to increase their decision-making capacity, develop skills and competencies needed to perform technical procedures, and critical-reflexive and diagnostic reasoning[9].

The items with the lowest student classification in the satisfaction scale were those related to the quality of the material, equipment and simulator used, being categorized as "not very satisfactory". Thus, the need for thorough construction of scenarios based on real facts is emphasized, with application of detailed design and investment in the qualification of professional facilitators[25]. Thus, to have a reliable simulation, investment by the educational institution and institutional teaching policies that prioritize active teaching methods are required.

It is believed that the key to the success of this teaching strategy is the dialogue aimed at building a critical-reflective thinking about the topic, made possible by the student-centered debriefing[21,24], which, as an assessment methodology for the training of health care students, has been shown to help in the assessment of the students' cognitive performance, as well as to encourage and promote the development of fundamental skills and competencies for professionals[9].

Recent research developed with undergraduate nursing students reinforces the findings of this study, focusing on the fact that realistic simulation contributes to the execution of nursing techniques and procedures in the exercise of professional conduct and autonomy[26]. This fact is relevant because of the allegation that, during graduation, students face difficulties in performing the physical examination, pointing out the directed auscultation and the distribution of time allocated to practice as the greatest difficulties[7].

Moreover, the fact that students are attracted to the simulation experience is due to the high autonomy made possible by the method, as well as the ability to make decisions on their own and provide effective patient care, which motivates students to seek personal learning strategies and be more proactive in clinical practice[26]. Recent studies have demonstrated positive effects of implementing this methodological strategy during classes on urgency and emergency[24], maternal and child health care[25], cardiovascular diseases[26] and wounds[27].

Therefore, the need to ally technology to the needs of health care students is ratified, to prepare students for the reality of clinical practice. In this sense, it is believed that the use of realistic simulation for teaching the pulmonary physical examination, before the practical performance, contributes to a safer and more effective health care.

It is also worth mentioning the importance of further studies related to the realistic simulation of the pulmonary physical examination, since there is a need for trained nursing professionals to perform the examination.

## Study limitations

The limitation of this study stems from the fact that the research was conducted in a specific manner at a public university. Thus, it is suggested that new studies be carried out covering a larger number of teaching institutions. Moreover, the scarcity of studies addressing the use of the physical examination, specifically the pulmonary examination, contributed to the limitation of the research and comparison of studies.

## Contributions to the practice

It is believed that this research can contribute to the improvement of the quality of teaching of the pulmonary physical examination, adding knowledge and strategies fostered using an active methodology. The results of this research favor the curricular insertion of simulation for teaching in undergraduate nursing. Therefore, the application of simulation can promote significant changes in students' self-confidence and satisfaction, as well as minimize the occurrence of adverse events in practice, contributing to patient safety.

## Conclusion

It was found that the application of realistic simulation for teaching the pulmonary physical examination to undergraduate nursing students improved the performance of students in the intervention group. The results of this study show a positive impact of the realistic simulation on the performance of the pulmonary physical examination, by improving the performance of theoretical and practical skills, as well as the levels of satisfaction with the methodology used by the students. Also noteworthy is the homogeneity of the characteristics of the intervention and control groups.

## Authors' contribution

Conception and design or data analysis and interpretation: Carino ACC, Fernandes RM, Fernandes MICD, Tinôco JDS, Gomes CST, Almeida ATD, Lira ALBC.
Writing of the manuscript or relevant critical review of the intellectual content: Carino ACC, Fernandes RM, Fernandes MICD, Tinôco JDS, Gomes CST, Almeida ATD, Lira ALBC.
Final approval of the version to be published: Carino ACC, Fernandes RM, Fernandes MICD, Tinôco JDS, Gomes CST, Almeida ATD, Lira ALBC.
Agreement to be responsible that all aspects of the manuscript related to the accuracy or completeness of any part of the manuscript are properly investigated and resolved: Carino ACC, Fernandes RM, Fernandes MICD, Tinôco JDS, Gomes CST, Almeida ATD, Lira ALBC.

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