

Teamwork in Pediatric Resuscitation: Training Medical Students on High-Fidelity Simulation

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Background: Simulation training and teamwork for medical students are essential to improve performance in pediatric cardiopulmonary resuscitation.

Purpose: To evaluate if a specific approach to teamwork improves technical and nontechnical performance.

Methods: We performed quasiexperimental, prospective, pre- and postinterventional, and nonrandomized research with 65 students in the fourth year of their medicine course. This was a case-control study in which teams used a customized TeamSTEPPS protocol (n=34) or not (n=31) for cardiopulmonary arrest training in children using high-fidelity simulation. All participants answered a sociodemographic and satisfaction questionnaire and underwent theory and practice pre- and posttesting. The survey data were collected in 2019 and analyzed using χ^2 , Mann-Whitney, κ , and Wilcoxon tests. $p < 0.05$ was considered significant.

Results: Intervention and control groups achieved better scores in theory posttesting ($p < 0.001$ and $p = 0.049$), but there was no difference between them in pre- ($p = 0.291$) and posttesting ($p = 0.397$). In the checklist of the practice test, all groups obtained their best outcomes in posttesting and the intervention group achieved higher scores ($p < 0.001$). All groups increased the number of teamwork events and reduced the time span to perform resuscitation first steps ($p < 0.001$) in posttesting.

Conclusion: The use of teamwork training based on a customized TeamSTEPPS protocol improved performance in team behavior and group technical achievement. The evaluation of the students about the training was positive.

Keywords: cardiopulmonary resuscitation, medical education, patient-care team, patient safety, simulation training

Introduction

Associations among teamwork, quality of assistance, and patient safety are already widely proven in the literature.¹⁻⁹ Important medical organizations like the American Heart Association (AHA) and the International Liaison Committee on Resuscitation support an increase on teamwork emphasis and suggest this training for members of a resuscitation team.¹⁰

The uniqueness of critical patient care, such as the need for fast decision-making, concurrently ongoing multiple complex processes, and an adverse environment enclosed by noise and disruption contribute to failures.^{11,12} In respect of pediatric patients, these features are enhanced by the childcare itself, particularly when medication doses must be calculated and devices based on weight or age chosen.¹³

Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS) is a specialist approach to training health professionals in teamwork. This strategy is based on scientific evidence, and was developed by the Patient Safety Program of the Department of Defense of the US in partnership with the Agency for Healthcare Research and Quality (AHRQ).¹⁴ TeamSTEPPS has been tested in several pediatric services,^{8,15-19,21,22} obtaining excellent results.^{8,15-21} This methodology has also been used in a variety of clinical contexts, apart from pediatrics,^{12,23,24} and is part of the practices of

great American hospital associations.²⁵ The program determines leadership, situation management, mutual support, and communication as the main skills to be trained, and also highlights tools and strategies to reinforce these skills.¹⁴

The active methodology comprises an interactive system where students turn into leaders in the learning process, while teachers become their assistants.²⁶ Bonini-Rocha et al²⁷ reinforced the need for technology and innovation as supports in the development of new proposals to improve the educational process. According to Melo et al,²⁸ basic or advanced simulations can enhance and improve skills. This process allows the participants to cope with emergencies in a safe environment where “errors are forgiven”, and enables education and training of health professionals.

Teams can be instructed to better decision-making, improve performance under stress, and increase their technical achievements.²⁹ Practical training raises the impact of acquisition, execution, and maintenance of teamwork skills on health issues.³⁰ Following those pieces of evidence, this research aimed to evaluate whether a specific approach to teamwork based on TeamSTEPPS training attached a cardiopulmonary resuscitation (CPR) and high-fidelity simulation training founded on AHA protocols would improve technical performance and teamwork.

Methods

Design and Setting

We performed an experimental, prospective, controlled, nonrandomized study on 65 students in their fourth year of medical school from a private faculty of Belo Horizonte (Figure 1). The research was conducted in the faculty's simulation facility using high-fidelity rooms with SimJunior's mannequins from Laerdal. The participants were divided into three control groups and three intervention groups by convenience sampling. Each group attended a meeting for training and evaluation, with a total workload of 6 hours per participant. Both groups (control and intervention) received standard training with a theory class, the intervention, and received teamwork training based on the American protocol of TeamSTEPPS Essentials. After the training, the students underwent practice training using high-fidelity simulation.

Inclusion and Exclusion Criteria

Since the training was part of a curricular and mandatory subject, there were 68 undergraduate medical students who were eligible to participate. Three did not agree to participate, so they were excluded. The study included all students enrolled in the course and who agreed to participate.

Data-Collection Methods

Participants underwent theory pretesting with 20 multiple-choice questions filled within 30 minutes. For practice pretesting, each group was divided into two smaller groups with a maximum of six participants. In this test, all students acted as team leader in a simulated clinical case of cardiopulmonary arrest (CPA) or 3 minutes. While we assessed one team, the other one waited in a separate room, without contact.

Next, all students attended a 30-minute lecture about pediatric advanced life support (PALS) guidelines of CPR). After that, only the intervention group received additional training on teamwork using a customized TeamSTEPPS Essentials model approaching team building: occurrence and frequency of mistakes in clinical practice, discussion of the four essential abilities of effective teams (leadership, case management, mutual support, and communication), detection of barriers blocking the expected target exhibition of tools and strategies to improve teamwork, and patient safety. Then, in the practice training, each student acted as a leader in a simulated clinical case of CPA for 5 minutes, followed by a three-step debriefing. Half the students stayed in the simulation room, and the other half remained in the observation room watching the activity. When the procedure had finished, those students changed rooms. Subsequently, the students underwent theory and practice posttesting similarly to that for pretraining. Resuscitation teams remained the same in pre- and postpractice testing, only changing the leader. Ultimately, each participant filled a Likert scale satisfaction survey about the training, communication awareness, and teamwork. Figure 2 presents these study steps.

We evaluated theory knowledge through pre- and posttraining testing, with maximum score of 20 points. The students' performance on practice pre- and posttraining testing was measured using three tools. For the first, two blinded

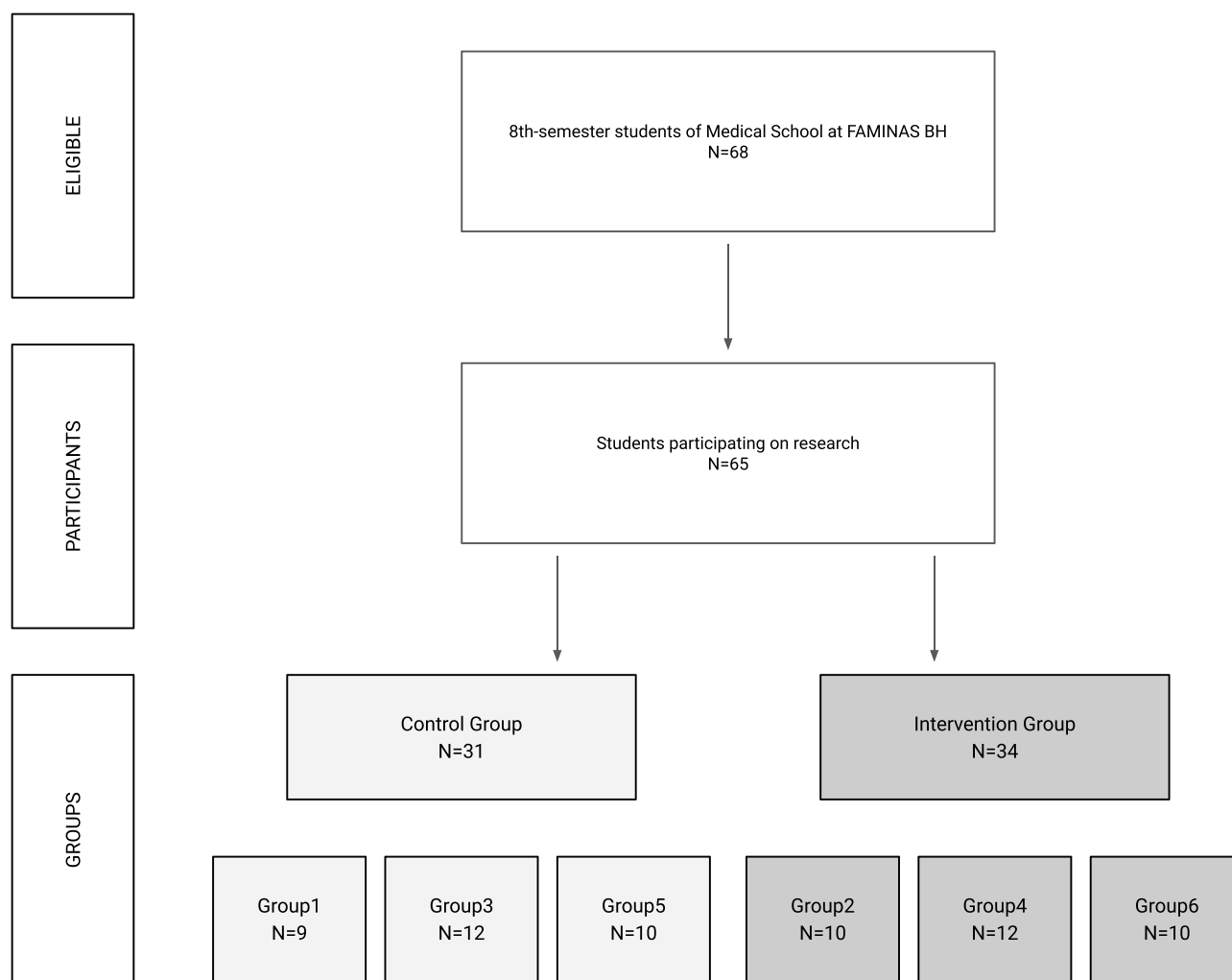


Figure 1 Sample-selection flowchart 64 medical students from FAMINAS-BH allocated to the control and intervention groups.

examiners analyzed the scenarios using checklists of expected acts, and likewise in PALS courses of AHA, and we obtained the percentage of hits in the checklist in relation to the maximum possible grade. To check agreement between examiners, we employed the κ index. Another evaluation was carried out separately by a teamwork-trained researcher who assessed the number of team-behavior events (use of nontechnical skills like leadership, situation management, mutual support, and communication) in each simulated clinical case, using absolute values. The third analysis was conducted using recorded material of practice pre- and posttesting, measuring in each scenario the time that the leader took to begin resuscitation: CPA recognition, first compressions, first adrenaline (nonshockable rhythms) or first shock (shockable rhythms), and the total time to progress from the first steps. Then, we compared the scores of the control and intervention groups on the three tools, both prior to and after training. Schematic presentation of the study design, protocol, and flow is presented in Figure 2.

Data Analysis

We analyzed data using the SPSS 23. Regardless of sociodemographic and academic sample features, we compared noncontinuous variables of control and intervention groups using the χ^2 test. Descriptive statistics — median, minimum, and maximum — were evaluated for group performance. While we applied the Mann–Whitney test to compare the difference between control and intervention groups at the same time (between-group comparison), the Wilcoxon test

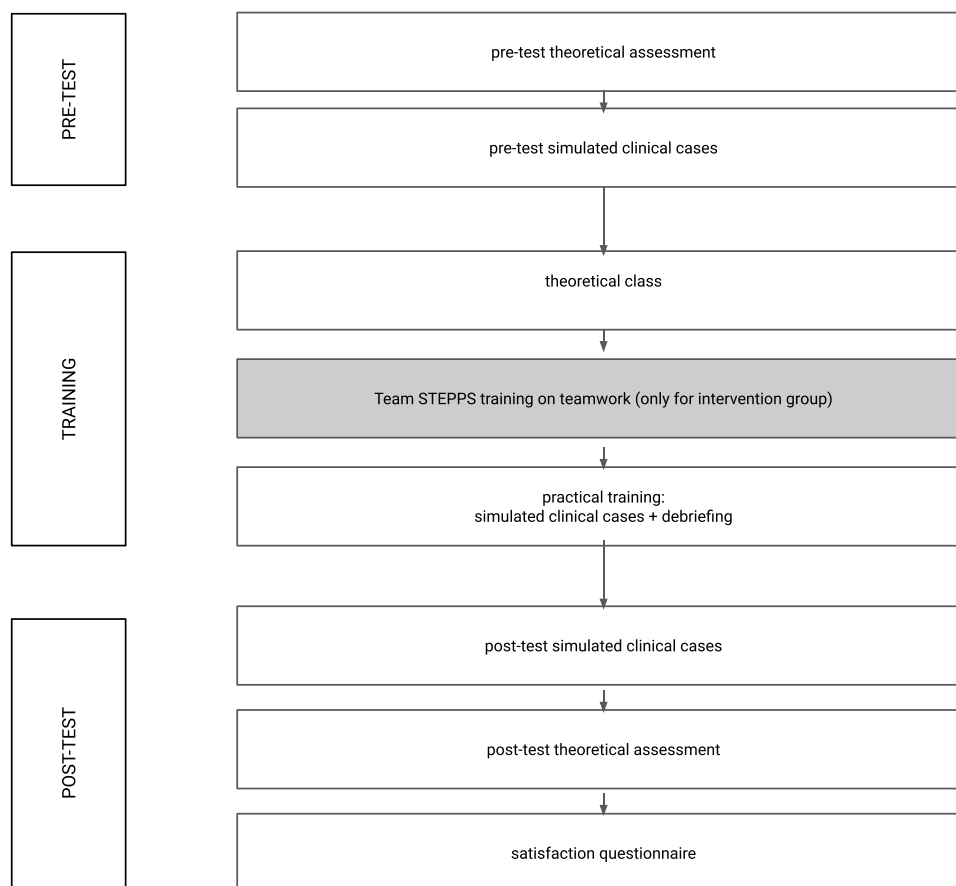


Figure 2 Data-collection stages: activities carried out for training and evaluation of study participants.

contrasted pre- and posttesting in the same group at different time points (within-group comparison). To check agreement between examiners, we employed the κ index. Our standard of significance was $p < 0.05$.

Ethics

Participation in the research was voluntary, and students could withdraw from the study at any moment without penalty. All participants signed the form for free and informed consent. All the documents (tests, checklists, surveys) were anonymous, and confidentiality criteria were followed. The study was approved by the Research Ethics Committee at the Federal University of Minas Gerais (CAAE: 10753419.2.0000.5149).

Results

The demographic data analyzed showed that there was no statistical difference between the control and intervention groups for any variables, as seen on Table 1. The results of pre- and posttraining theory and practice testing, number of teamwork-intervention events, and time to perform the first resuscitation steps are presented in Table 2. Figure 3 shows that there was no difference between the control and intervention groups on results of pre- and posttraining theory testing, though there was improvement in both groups on results of pre- and postpractice testing and number of teamwork-intervention events, with a more pronounced advance seen in the intervention group. Figure 4 shows the reduction in time in seconds for the recognition of CPA, initiation of CPR, and administration of epinephrine and/or shock according to the indication on the cases. Table 3 shows the results of the survey on satisfaction with the training divided according to a Likert scale into grades 1 and 2, and 4 and 5 (no answer 3). The scores given by examiners on the posttraining practice test checklist had few indices calculated, due to nonvariable answers. The examiners significantly agreed on the evaluation of the topics scored: 87% of topics on pretesting and 92% on posttesting. The satisfaction survey

Table I Analyses of sociodemographic and academic profiles of students participating in the research

| | | Controls, n=31 (47.7%) | Intervention, n=34 (52.3%) | Total, n=65 |
|--|---------------------|-----------------------------------|---------------------------------------|--------------------|
| Sex | | | | |
| | Female | 23 (74.2%) | 20 (58.8%) | 43 (66.2%) |
| | Male | 8 (25.8%) | 14 (41.2%) | 22 (33.8%) |
| Age | | | | |
| | 19–21 years old | 1 (3.2%) | 3 (8.8%) | 6.2% |
| | 22–25 years old | 22 (71.0%) | 23 (67.6%) | 69.2% |
| | >25 years old | 8 (25.8%) | 8 (23.5%) | 24.6% |
| First aid training | | | | |
| | No | 28 (90.3%) | 28 (82.4%) | 56 (86.2%) |
| | Yes | 3 (9.7%) | 6 (17.6%) | 9 (13.8%) |
| Time since last training | | | | |
| | 6 months to 2 years | 0 | 3 (50.0%) | 3 (33.3%) |
| | More than 2 years | 2 (66.7%) | 3 (50.0%) | 5 (55.6%) |
| Basic life-support course | | | | |
| | No | 27 (87.1%) | 30 (88.2%) | 57 (87.7%) |
| | Yes | 4 (12.9%) | 4 (11.8%) | 8 (12.3%) |
| Time since last training | | | | |
| | Less than 6 months | 2 (50.0%) | 0 | 2 (25.0%) |
| | 6 months to 2 years | 0 | 2 (50.0%) | 2 (25.0%) |
| | More than 2 years | 2 (50.0%) | 2 (50.0%) | 4 (50.0%) |
| Pediatric advanced life-support course | | | | |
| | No | 30 (96.8%) | 33 (97.1%) | 63 (96.9%) |
| | Yes | 1 (3.2%) | 1 (2.9%) | 2 (3.1%) |
| Time since last training | | | | |
| | More than 2 years | 1 (100%) | 1 (100%) | 1 (100%) |
| Hospital work experience registered in curriculum | | | | |
| | No | 23 (74.2%) | 22 (64.7%) | 45 (69.2%) |
| | Yes | 8 (25.8%) | 12 (35.3%) | 20 (30.8%) |

(Continued)

Table 1 (Continued).

| | | Controls, n=31 (47.7%) | Intervention, n=34 (52.3%) | Total, n=65 |
|--|---------------------|-----------------------------------|---------------------------------------|--------------------|
| Work experience | | | | |
| | Less than 6 months | 3 (37.5%) | 4 (33.3%) | 7 (35.0%) |
| | 6 months to 2 years | 3 (37.5%) | 6 (50.0%) | 9 (45.0%) |
| | More than 2 years | 2 (25.0%) | 2 (16.7%) | 4 (20.0%) |
| Hospital work experience not registered in curriculum | | | | |
| | No | 22 (71.0%) | 20 (58.8%) | 42 (64.6%) |
| | Yes | 9 (29.0%) | 14 (41.2%) | 23 (35.4%) |
| Work experience | | | | |
| | Less than 6 months | 6 (66.7%) | 8 (57.1%) | 14 (60.9%) |
| | 6 months to 2 years | 1 (11.1%) | 6 (42.9%) | 7 (30.4%) |
| | More than 2 years | 2 (22.2%) | 0 | 2 (8.7%) |

indicated very good participant opinions about the training (Table 3). We did not perform statistical analysis on these data, due to no variation in answers.

Discussion

The analyses of sociodemographic and academic medical profiles revealed a sample like other national and international research on the same topic.^{31–36} The results indicated that students' experience on CPR was limited before the training. Theory testing demonstrated improvement in scores after training in both groups. Patterson et al obtained similar results in theory assessments prior to and after multidisciplinary training relying on simulation emphasizing teamwork and communication.²⁵ The practice-test outcomes indicated better posttraining scores in both groups, corroborating the improvement in students' performance. Canadian multicentric research³⁷ employing 300 health professionals divided into 60 teams evaluated the effect of teamwork adopting simulation and PALS guidelines, but without a control group. The intervention group posttesting achieved a higher percentage of correct answers, proving that teamwork training enhanced their technical performance. There are few standard techniques to assess teamwork, and there is no agreement on which one should be applied for medical students. Some studies, such as the Clinical Teamwork Scale,³⁷ Teamwork Evaluation of Non-Technical Skills,¹⁵ and TeamSTEPPS — Teamwork Attitudes Questionnaire, adopted scores that highlight key areas of teamwork using the Likert scale.²¹ Despite none of these studies being controlled, all of them showed better performance in the intervention group. In our research, the number of positive teamwork events increased in both groups. Despite the higher number of teamwork events in the intervention group before training, the addition of events before training was significantly higher than the control group. Similar research adopting control and randomized data evaluated medical internship students that underwent neonatal resuscitation training using simulation. These authors also concluded that the intervention group improved its performance as a team.²⁰ In that research, they compared them only after training, limiting any evaluation on performance improvement.

Table 2 Performance comparison of participants before and after training between and within control and intervention groups

| | Control median (min–max) | Intervention median (min–max) | <i>p</i> ^a |
|---|--------------------------|-------------------------------|-----------------------|
| Theory test scores (20 points) | | | |
| Pretraining | 16 (7–20) | 17 (12–19) | 0.29 |
| Posttraining | 18 (11–20) | 17 (10–19) | 0.40 |
| <i>p</i> ^b | 0.001 | 0.05 | |
| Score in checklist of practice test (%) | | | |
| Pretraining | 70.8% (43.8–89.6) | 75% (35.4–85.4%) | 0.29 |
| Posttraining | 85.4% (70.8–93.8) | 94.8% (85.4–100%) | 0.001 |
| <i>p</i> ^b | 0.001 | 0.001 | |
| Teamwork-intervention events | | | |
| Pretraining | 11 (1–20) | 13.5 (7–27) | 0.02 |
| Posttraining | 15 (7–38) | 21 (14–39) | 0.01 |
| Time to first steps of resuscitation (seconds) | | | |
| Recognition of cardiopulmonary arrest (CPA) | | | |
| Pretraining | 9 (5–49) | 9.5 (3–58) | 0.96 |
| Posttraining | 7 (5–12) | 7 (4–12) | 0.75 |
| <i>p</i> ^b | 0.001 | 0.001 | |
| Starting cardiopulmonary resuscitation (CPR) | | | |
| Pretraining | 18 (7–65) | 18 (4–64) | 0.87 |
| Posttraining | 13 (8–26) | 16 (10–63) | 0.01 |
| <i>p</i> ^b | 0.001 | 0.09 | |
| Rhythm check | | | |
| Pretraining | 60.5 (33–111) | 66.5 (35–115) | 0.47 |
| Posttraining | 45 (27–62) | 41.5 (22–77) | 0.34 |
| <i>p</i> ^b | 0.001 | 0.001 | |
| First delivery: shock versus adrenaline | | | |
| Pretraining | 104 (55–159) | 108.5 (48–179) | 0.99 |
| Posttraining | 69 (55–108) | 71 (53–104) | 0.82 |
| <i>p</i> ^b | 0.001 | 0.001 | |

Notes: ^aMann–Whitney test results, comparison between groups. ^bWilcoxon test results, comparison within groups.

We also checked the technical performance through the time span to the first steps of resuscitation. Both groups improved after training, reducing the time span basically in all steps considered, except the “start CPR” of the intervention group. The control group had a decrease of 33.6% in total time to the first steps, while the intervention group registered 34.2%. Those results reinforced that all students improved practice performance with the simulation training, despite receiving or not teamwork instructions. Analogously to our study, Gilfoyle et al³⁷ found an increase in

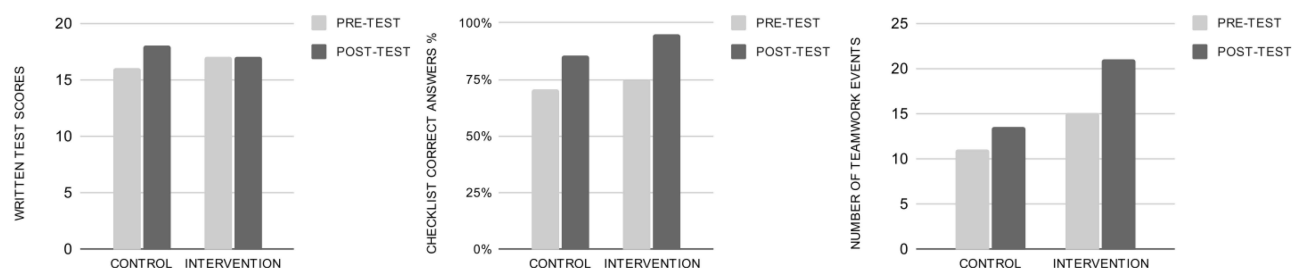


Figure 3 Results pre- and posttraining of theory testing, practice testing checklist, and number of team events per simulation.

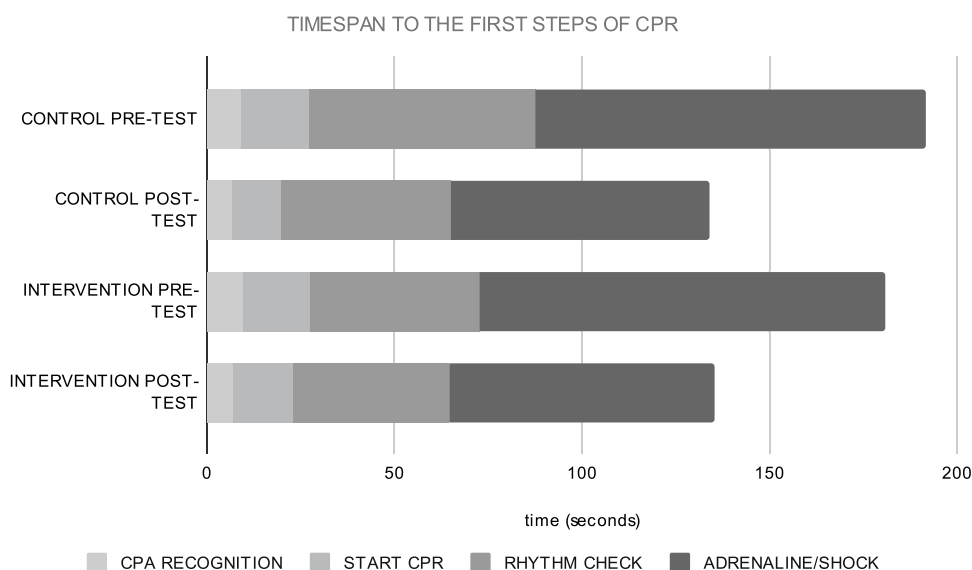


Figure 4 Results pre- and posttraining of time to perform the first steps of cardiopulmonary resuscitation.

technical efficiency after teamwork training observed in the time-span decline for thoracic compression and defibrillation. Clinical results from another study revealed a reduction in time to set extracorporeal circulation during resuscitation after teamwork training of intensive unit care pediatric professionals.¹⁵ Although neither study was controlled, they suggest that teamwork training can successfully improve clinical performance. Furthermore, Thomas et al registered a reduction of around 30% of the total time spent on resuscitation comparing control and intervention groups.²⁰ However, they did not obtain any difference between those groups, neither in each step nor in the total time to the first steps of CPR.

Facing the conflict between educational methodologies of traditional and active learning, understanding students' opinions is essential to amend the educational processes at universities.^{26,38} Following our results, participants supported the quality of the theory handout, theory and practice classes, methodologies applied, and the possibility of acquiring knowledge on the topic. The students' awareness of self-belief, which stands for the reliance on a successful task, positively assists them when they cope with life-support assistance in real patients. The section of the survey approaching teamwork training focused only on the intervention group and obtained full endorsement regarding quality and learning potential on the topic. Most research that has applied teamwork training in pediatric patients also evaluated the fulfillment and awareness of participants after instructions, recording positive feedback, mainly on reliance, knowledge, and skills to proceed with CPR.^{8,16–20,22,25,39,40} A controlled and randomized study assessed the effect of teamwork training on cooperation and coordination among professionals using the TeamSTEPPS Essentials model in the PALS course of AHA.⁴¹ This methodology is almost identical to ours and obtained significantly higher awareness of teamwork, cooperation, knowledge of the situation, and abilities to assist in teams' decision-making.

Table 3 Satisfaction and awareness of survey participants (n=65) based on five-point Likert scale

| Satisfaction survey | Scores 1 and 2, n (%) | Scores 4 and 5, n (%) |
|---|--------------------------|--------------------------|
| Based on the theory handout provided before training | | |
| The handout was available in time. | 0 | 65 (100%) |
| The content provided appropriate knowledge on pediatric cardiopulmonary resuscitation. | 0 | 65 (100%) |
| The content provided appropriate knowledge on arrest algorithms in nonshockable rhythms (PEA/asystole). | 0 | 65 (100%) |
| The content provided appropriate knowledge on arrest algorithms in shockable rhythms (VF/VT pulseless). | 0 | 65 (100%) |
| The content was comprehensible. | 0 | 65 (100%) |
| Based on the theory course | | |
| The professor approached the topic didactically. | 0 | 65 (100%) |
| The professor exhibited knowledge on the topic. | 0 | 65 (100%) |
| The professor replied properly to my questions. | 0 | 65 (100%) |
| Theory lectures taught about the rhythms of cardiopulmonary arrest. | 0 | 65 (100%) |
| Theory lectures taught about cardiopulmonary resuscitation. | 0 | 65 (100%) |
| Based on the practice course | | |
| The professor approached the topic didactically. | 0 | 65 (100%) |
| The professor exhibited knowledge on the topic. | 0 | 65 (100%) |
| The professor replied properly to my questions. | 0 | 65 (100%) |
| Practical lectures taught about the rhythms of cardiopulmonary arrest. | 0 | 65 (100%) |
| Practical lectures taught about cardiopulmonary resuscitation. | 0 | 65 (100%) |
| Practical lectures taught me how to manage a manual defibrillator. | 2 (3.07%) | 63 (96.93%) |
| Based on the whole training | | |
| Do you feel confident about applying basic life support techniques to a real patient? | 8 (12.30%) | 57 (87.70%) |
| Do you feel willing to act in a real cardiopulmonary arrest? | 5 (7.70%) | 60 (92.30%) |
| Would you recommend this training process to a colleague? | 0 | 65 (100%) |
| Based on teamwork training (questions applied only to the intervention group, n=34) | | |
| The professor approached the topic didactically. | 0 | 34 (100%) |
| The professor exhibited knowledge on the topic. | 0 | 34 (100%) |
| The training provided appropriate knowledge on the topic. | 0 | 34 (100%) |
| The training improved my communication skills within a team. | 1 (3.08%) | 33 (96.92%) |
| The training improved my ability in assisting the team to make decisions. | 0 | 34 (100%) |

Notes: Assessment based on Likert scale: 1 = completely disagree, 2 = partially disagree, 3 = neither agree or disagree, 4 = partially agree, 5 = completely agree. Nobody chose number 3.

Abbreviations: PEA, pulseless electrical activity; VF, ventricular fibrillation; VT, ventricular tachycardia.

It is needed to strengthen the team-leader component of the resuscitation skills lab and to identify students who may benefit from additional practice in the team-leader role and with other skills in which they lack confidence.⁴² The results of this study will help in the restructuring of cardiac resuscitation skills simulation involving students from other areas of health. Our outcomes follow the literature, indicating the efficiency of the TeamSTEPPS protocol as an educational source of teamwork to health professionals^{12,15,16,18,21,23–25,41} and also of the high-fidelity simulation as a teaching–learning methodology.^{7,25,43–49} Considering we could not find in Latin America experimental research on the teamwork of critical pediatric patients, our investigation added and opened new light into discussions of a relevant topic among Brazilian scientists.

Limitations

Some of the constraints registered are that we could not randomize students because of their class schedule, the relatively short time spent on teamwork training due to the time available in the simulation laboratory, and the absence of a standard tool to evaluate teamwork and measure its improvement. Despite these limitations, this study is innovative and pioneering in our country, as it provides important information about teamwork using a TeamSTEPPS-based model in CPR.

Recommendations

Scales to assess teamwork must be standardized to enhance results on this topic. The authors also suggest the development of other controlled and randomized studies and evaluation of memory retention.

Conclusion

Teamwork improved the performance of professionals coping with the assistance of critical pediatric patients. Additionally, we reinforce that simulation allows teams to safely practice technical and nontechnical skills, ensuring better performance and communication in a safe environment. Ultimately, teamwork training based on simulation should be practiced following undergraduate level and systematically sustained for all health professionals, especially those who assist critical pediatric patients.

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Disclosure

The authors report no conflicts of interest in this work.

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