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Effects of basic life support training on the knowledge of healthcare students: A quasiexperimental and multicenter study

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Abstract:

BACKGROUND: Cardiac arrest (CA) is defined as the sudden cessation of effective cardiac function. This condition is highly prevalent worldwide and is associated with significant morbidity and mortality. Basic Life Support (BLS), encompassing circulation, airway, and breathing management, is crucial in improving outcomes for CA patients. However, gaps in BLS training among nonphysician healthcare professionals necessitate targeted training programs. The objective is to evaluate the knowledge of healthcare students before and after theoretical–practical BLS training using the just-in-time methodology.

MATERIALS AND METHODS: We developed a cross-sectional, analytical, pre-experimental study that employed a quantitative approach to evaluate students' BLS knowledge before, immediately after, and 1 month post training. Participants were from various healthcare courses at public and private universities in São Paulo, Brazil. The training combined theoretical instruction with practical sessions using mannequins and medical equipment, applying the just-in-time teaching method. Data were collected through a 15-question objective test, administered at three time points, and analyzed using the Wilcoxon signed rank test for statistical significance.

RESULTS: Out of 162 registrants, 95 students completed the training and were included in the analysis, with 57 students responding to the 1-month follow-up. All domains of the test showed a statistically significant improvement in correct answers immediately post training compared to pretraining. Although a slight reduction in scores was observed after 1 month, the decline was not statistically significant for most domains.

CONCLUSIONS: The training had a notable impact on students' knowledge. Furthermore, students demonstrated substantial retention of the material.

Keywords:

Basic life support, education, health personnel, knowledge retention, simulation training, students

Introduction

Cardiac arrest (CA) is a sudden cessation of effective cardiac function, marked by the absence of circulation, and remains a prevalent cause of morbidity and mortality globally.[1] In the United States, approximately 450,000 cases occur annually, with survival rates as low as 10%.[1] In Brazil, ischemic cardiovascular diseases, key contributors to CA, rank as the leading cause of death.[2] Basic Life Support (BLS)

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provides a structured framework—Circulation, Airway, Breathing (CAB)—to enhance survival outcomes.[3] However, significant training gaps persist among nonphysician healthcare professionals.[4] In this sense, this study evaluated the impact of just–in–time theoretical–practical training on multicentric students from diverse healthcare disciplines on their BLS knowledge and its retention.

Materials and Methods

Study design and setting

Figure 1 brings an eight-step framework of the theoretical methodology employed in this research. Below, the methodology is detailed and discussed in its specificities.

This research employs a cross-sectional, analytical, and pre-experimental design, adopting a quantitative approach. The study assessed participants' knowledge of BLS practices at three intervals: prior to the training, immediately after, and 1 month following the training. The primary objective was to evaluate the effect of an independent variable (BLS training) on dependent variables (students' knowledge acquisition and retention).

Study participants and sampling

The study was conducted at both a public and a private university located in the São Paulo state heartland, Brazil. The target population comprised students enrolled in Dentistry, Speech Therapy, Physiotherapy, Biomedicine, Nutrition, and Physical Education programs.

Many studies already presented in the literature assume that practically all students exposed to basic life support training present a statistically significant improvement in their knowledge, and almost all would show statistically significant knowledge retention.[2,4-8] However, for scientific research purposes, and based on preliminary results, the authors of this research chose to take a more cautious approach in the analysis. So, we predicted that 95% of the students would present an improvement in their knowledge after carrying out the activities and 90% would present a statistically significant knowledge retention. Therefore, the minimum sample to be considered was calculated based on the theorem presented below in compliance with the central limit theorem and the laws of large numbers.

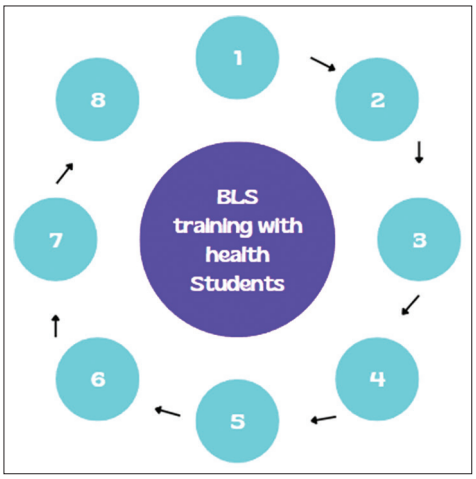

Figure 1: An eight-step framework of the theoretical methodology employed in this research. 1 - Defining the study design; 2 - Defining study population; 3 - Study sampling; 4 - Sample method; 5 – Participant's inclusion and exclusion; 6 - Program setting; 7 - Data preparation and collection; 8 - Data analysis. (Author's own made using Canva free ® online program)

$$n = \frac{S^2 \cdot p \cdot q}{e^2}$$

Here, S^2 represents the critical value corresponding to the 95% confidence level, that is, 1.96. p represents the expected proportion of students who would demonstrate improvement in knowledge after completing the training (95%) and proportion of students who would have statistically significant retention of knowledge after completing the training (90%). q represents the expected proportion of students who would not demonstrate improvement in knowledge after completing the training (5%) and the proportion of students who would not have statistically significant retention of knowledge after completing the training (10%). Finally, e^2 represents as the accuracy – margin of error – considered (5%).

Subsequently, the minimum sample size required was adjusted to the total number of eligible students. In the case of the original sample, the eligible students were the students' total number that were in the courses and institutions to which the activities were presented – roughly, 1000 students. In the case of the sample which aimed to assess knowledge retention, the number of eligible students corresponded to the number of students who participated in the activities – 95 students. The following formula was used to develop this analysis:

$$n_{adjusted} = \frac{n}{1 + \frac{n-1}{N}}$$

Here, $n_{adjusted}$ represents the adjusted sample for the evaluated population, represents the calculated sample size, and N the number of eligible students.

In the end, it was considered that 68 and 57 would be the minimum samples necessary to assess the students' knowledge gain and retention.

Data collection tool and technique

The training program created was publicized through social media such as Whatsapp ®, emails, and Instagram ®, with an own profile being created for Bauru and another for Ribeirão Preto as follows: (https://www.instagram.com/_cops_2023_bru?igsh=YjFkdjRmMXY1Nm1l) and (https://www.instagram.com/cops.2023?igsh=MXZyNzMyYWZ0dWlobg==).

Students were invited to participate free of charge via messages. The days and times of the training were organized via social media, and a 4-hour certificate was issued to each course participant.

In the end, the sample was created by convenience, according to the students' interest and participation.

We included students from the specified courses who registered for the training, attended the sessions, signed the Free and Informed Consent Form (FICF), and completed all activities. Excluded were students who did not register, were under 18 years of age, declined to consent, or failed to attend or complete the activities.

The activity program consisted of theoretical classes that were recorded online by a higher education professor specializing in the subject and which were presented personally to the students. The class presentation has 43 minutes, took about BLS according to the CAB mnemonic defined by the AHA, and was the same presented to all students who participated in the training.

The training consisted of practical activities structured using the just-in-time (JIT) teaching tool, in which each party of BLS – C, A, and B – took a break from the theoretical presentation so that students practice the concepts learned. At the end of the class presentation, a large training session was carried out, in which all BLS points were practiced together. The training counts with cardiorespiratory resuscitation mannequins (CRMs), bag-valve-mask devices (BVMDs), and Automatic External Defibrillators (AEDs) loaned by the institutions in which the study was carried out.

The training was based on recognizing and taking first measures on a cardiorespiratory arrest (assessing the safety of the care location, correctly identifying a CRM, requesting help and AED); performing effective compressions; managing airway (using airway deconstruction maneuvers, such as chin lift and jaw thrust, put in position and correctly use the BVMD, and coordinate ventilation and compressions); and, finally, using AED (connect, put in position, use, and maintain the AED).

Study participants filled out a form in which general data and data about the participants' knowledge on the topic were collected. Regarding the general aspect, the student's age, gender, educational institution, graduation course, and course duration were collected.

In parallel, the student's knowledge was evaluated by 15 objective questions, grouped into four domains (I - Recognizing and taking first measures on a Cardiorespiratory arrest; II – Perform effective compressions; III – Airway management; IV – Using Automatic External Defibrillator), created based on checklists validated by literature.[7-9] The forms were applied immediately before the training, immediately after the training, and 1 month after the date on which a student carried out the activities.

Data are categorized, for statical analysis, in gender (woman and man), course duration (less than half or more than half), graduation course, age (less than 20 years or more or equal than 20 years old), and university (public or private).

Ethical consideration

The project was approved by the Faculdade de Odontologia de Bauru, Universidade de São Paulo Research Ethics Committee under CAAE registration number: 63540722.4.1001.5417 and had approval from the administration of Estácio University Center of Ribeirão Preto for its implementation.

Statistical analysis method

A statistical analysis was performed using the Wilcoxon signed rank test to determine statistical significance when comparing with the means of graduates before, immediately after, and 1 month after training using the statistical software R 4.4.2 ®.

Results

Among the 162 individuals who initially enrolled, 95 students completed the training and were included in the final sample for analysis, allowing their performance to be assessed both before and immediately after the training. Of these, 57 students completed the evaluation forms again 1 month after the training.

All questions and domains demonstrated a statistically significant increase in the average number of correct answers when comparing pretest and post-test results, as shown in Table 1. When analyzing the average number of correct answers across the evaluated subgroups, all of them exhibited a statistically significant improvement between the pretest and post-test results, as presented in Table 2.

Comparing the immediate post-test results with those obtained 1 month later, a slight reduction in the average number of correct answers was observed across all

questions and domains; however, this decrease was not statistically significant. Domains I and II did not show a statistically significant reduction, whereas Domains III and IV did, as indicated in Table 1. When evaluating the subgroups' performance between the immediate post-test and the 1-month post-test, a minor decrease in the average number of correct answers was noted, but this reduction also lacked statistical significance, as shown in Table 2.

Discussion

Our findings demonstrated a significant increase in the average number of correct answers across all domains and questions when comparing the pretest and immediate post-test results, with no significant differences among subgroups. This suggests that the JIT training methodology effectively enhanced theoretical knowledge regardless of individual characteristics.

Table 1: Average percentage of correct answers and statistical significance when comparing the performed test by the evaluated domains and questions

Domain	Question	Students' Average Percentage of Correct Answers on the Pre-Test Questions	Students' Average Percentage of Correct Answers on the immediate Post-test Questions	Statistical significance (*P*) when comparing the pre-test and immediately post-test	Students' Average Percentage of Correct Answers on the immediate Post-test Questions	Students' Average Percentage of Correct Answers on the 1 month Post-test Questions	Statistical significance (*P*) when comparing the immediate post-test and the 1 month post-test
All	-	39.55%	76.29%	*P*<0.01	72.96%	61.19%	*P*=0.429
I	-	44.52%	74.02%	*P*<0.01	70.23%	65.61%	*P*=0.261
	1	77.29%	91.76%	*P*<0.01	80.16%	81.46%	*P*<0.01
	2	32.29%	79.54%	*P*<0.01	74.59%	64.25%	*P*=0.510
	3	30.86%	44.12%	*P*<0.01	40.53%	31.29%	*P*=0.297
	4	42.47%	83.51%	*P*<0.01	72.67%	72.43%	*P*<0.01
II	-	37.26%	82.39%	*P*<0.01	80.23%	78.26%	*P*=0.512
	5	34.27%	83.47%	*P*<0.01	82.53%	80.47%	*P*<0.01
	6	17.52%	59.46%	*P*<0.01	55.79%	53.83%	*P*=0.359
	7	26.84%	85.64%	*P*<0.01	79.53%	79.01%	*P*<0.01
	8	45.43%	92.12%	*P*<0.01	90.15%	79.63%	*P*=0.628
	9	31.79%	8752%	*P*<0.01	88.46%	81.26%	*P*=0.126
III	-	38.56%	75.73%	*P*<0.01	70.12%	68.92%	*P*<0.01
	10	37.29%	77.29%	*P*<0.01	75.29%	74.13%	*P*<0.01
	11	37.93%	47.23%	*P*<0.01	45.18%	40.29%	*P*=0.546
	12	35.64%	86.52%	*P*<0.01	88.43%	85.74%	*P*<0.01
IV	-	28.73%	63.46%	*P*<0.01	46.29%	45.26%	*P*<0.01
	13	22.15%	59.17%	*P*<0.01	55.74%	52.89%	*P*<0.01
	14	31.56%	52.96%	*P*<0.01	50.15%	49.43%	*P*<0.01
	15	28.49%	65.36%	*P*<0.01	68.43%	59.23%	*P*=0.056

Table 2: Average percentage of correct answers and statistical significance when comparing the performed test by the evaluated soubgroups

Subgroups	Students' number that answered the pre and the post-test	Students' Average Percentage of Correct Answers on the Pre-Test Questions	Students' Average Percentage of Correct Answers on the immediate Post-test Questions	Statistical significance (*P*) when comparing the pre-test and immediate post-test	Students' number that answered the immediate post-test and the 1 month post-test	Students' Average Percentage of Correct Answers on the immediate Post-test Questions	Students' Average Percentage of Correct Answers on the 1 month Post-test Questions	Statistical significance (*P*) when comparing the immediate post-test and the 1 month post-test
Women	48	35.36%	79.17%	*P*<0.01	33	72.83%	69.14%	*P*=0.326
Men	47	34.28%	74.29%	*P*<0.01	24	73.49%	70.23%	*P*=0.529
Course duration less than half	63	30.29%	78.15%	*P*<0.01	40	76.53%	72.44%	*P*=0.450
Course duration more than half	32	32.15%	71.80%	*P*<0.01	17	74.29%	72.25%	*P*=0.823
Age <20 years old	58	36.93%	75.17%	*P*<0.01	39	79.55%	77.19%	*P*=0.479
Age more than 20 years old	37	37.72%	76.72%	*P*<0.01	18	82.73%	80.29%	*P*=0.625
Public university	62	33.69%	74.38%	*P*<0.01	33	77.19%	73.25%	*P*=0.412
Private university	33	36.64%	71.42%	*P*<0.01	24	69.16%	64.19%	*P*=0.892

A slight, statistically insignificant decline in average scores was observed when comparing immediate post-test results to those obtained 1 month later. Notably, Domains I and II retained knowledge effectively, whereas Domains III and IV exhibited significant declines. This indicates variability in knowledge retention depending on the domain, which warrants further investigation.

International recommendations and policy benchmarks:

There are international recommendations by the American Heart Association and the International Liaison Committee on Resuscitation to teach BLS to people since the school.[9,10] While some countries truly comply with it, as Norway and Japan, it is noted that in some other countries, such as Brazil, this theory does not become concrete.[9,10] As evaluated in our study, the pretest average presented by the students was relatively low, which is in conformity with other studies carried out in the country.[9,10] The possible explanations for this educational difference are the amount of resources allocated to education in each location as well as the training and incentives for teachers to develop similar activities.[9,10]

In Brazil, policy benchmarks for BLS are increasingly recognized as critical components of public health strategies aimed at reducing the burden of CA.[2,10] National guidelines emphasize the widespread dissemination of BLS training among healthcare professionals, first responders, and laypersons, in alignment with global standards set by organizations such as the American Heart Association.[2,10] However, significant disparities persist, particularly in access to training and resources across different regions of the country.[2,10] Addressing these gaps requires integrating BLS education into academic curricula, implementing mandatory certification for specific professions, and promoting community-based training programs.[2,10] Strengthening these points could enhance survival rates and mitigate the societal impact of CA.[2,10]

Comparison with existing literature

These results align with findings from Kim *et al*.,[11] who reported significant improvements in BLS knowledge and practical skills among dental students after retraining, with theoretical knowledge and skills improving by over 40% ($P < 0.01$) after training sessions. However, our study observed statistically significant improvements solely in theoretical knowledge. This discrepancy might be attributed to differences in methodology as our training did not assess practical skills. Similarly, Boonmak *et al*.[12] found that both traditional and online BLS training significantly enhanced knowledge retention over 3 months, with reductions in retention observed after this period. This echoes our findings of keeped retention after 1 month, though their study emphasized the potential of varied teaching modalities to sustain knowledge retention.[12]

In contrast to Akaltan *et al*.,[13] who observed superior post-test scores using game-based learning methods, our methodology involved a 40-minute theoretical session complemented by JIT training with simulation mannequins under supervision. While both approaches demonstrated efficacy, our method emphasizes immediate application, making it well suited for practical, time-sensitive environments.[13]

Educational methodology

JIT training presents several strengths.[14-16] One of its key advantages is its efficiency as this methodology minimizes downtime and ensures that the recently learned information is immediately applicable.[14-16] Furthermore, the training can be highly customized to individual learning needs since the instructor can direct the practice toward answering the student's questions and helping them to better understand the subject.[14] So, this methodology, makes learning be more realistic, which engages the students and helps them understand and retain the content.[14]

Nonetheless, it presents some drawbacks. In this sense, the immediacy required by JIT training can lead to logistical challenges and increased pressure on training resources as the programs that propose to develop similar practices require assistance and a more robust infrastructure and equipment backup.[15] Furthermore, this methodology might not be suitable for complex topics that require comprehensive understanding and prolonged study as it tends to focus on short-term, task-specific knowledge.[15,16] Finally, this teaching practice requires trained professionals, with experience in the area and time to carry out similar activities, which does not always occur adequately.[14]

The methodology employed in this study—combining brief theoretical instruction with immediate hands-on training—proved effective in fostering short-term knowledge acquisition. JIT training has well-documented advantages, including contextual relevance and learner engagement. However, as highlighted by Aranda-García *et al*.,[17] skill retention diminishes over time without periodic refreshers, particularly for complex tasks such as airway management and hand positioning. This underscores the importance of integrating spaced repetition into BLS curricula, as recommended by the American Heart Association.[17]

Furthermore, the focus on theoretical knowledge in our study diverges from studies assessing practical skills. Kochhar *et al*.,[18] for instance, evaluated both domains

among medical students and noted that practical assessments often reveal gaps that theoretical evaluations may overlook.[18] Future iterations of our study could incorporate practical assessments to provide a more holistic evaluation of training efficacy.

Students' retention:

Our study observed that students showed significant content retention 1 month after completing the training. In this case, content retention is a critical aspect of effective training and education.[7-9,12,14] This concept is closely tied to the learning curve, which illustrates the rate of a learner's progress in acquiring new skills/knowledge and highlights the challenge of maintaining information over time.[7-9]

In this sense, numerous methodologies have been developed to enhance content retention, including spaced repetition, the use of multimedia resources, and active learning, in which JIT fits.[7] Some studies have shown that JIT helps students to better understand the content since the practical experience makes learning more realistic and memorable.[8,9] However, the articles discuss that, as JIT is a one-off activity and carried out immediately after contact with theoretical concepts, it is expected that students will show a certain drop in their knowledge levels over time because they do not repeat the training.[7-9]

Therefore, the literature suggests that there should be periodic and successive activities, which would not only reinforce the content learned, allowing it to be memorized more effectively, but also enable students to carry out the activities with increasing mastery and abilities.[7-9,12,14]

Influence of individual factors

Although no statistically significant relationships were found between individual characteristics and performance in this study, existing literature suggests these factors could play a role.[19] Younger students, for example, may adapt more readily to novel teaching methodologies, while older students often leverage life experience to enhance learning outcomes.[19] Additionally, sex differences in learning preferences and academic performance, as reported in studies by Ranjbar *et al*.,[19] could influence outcomes in larger, more diverse samples.

Other factors, such as course stage and institutional resources, also merit consideration.[19] Students in advanced stages of their education may benefit from more robust foundational knowledge, while those attending well-resourced universities may have access to superior learning materials and facilities.[19]

Broader Implications and Cross-Population Application:

Our results underscore the importance of tailoring BLS training methodologies to the specific needs and resources of different populations. While our study focused on a homogeneous group, the generalizability of findings to diverse populations—such as speech therapy or nutrition undergraduates—remains a critical question. Evidence from fields like sports science and nursing highlights the adaptability of BLS training to various educational contexts.[17] For instance, Aranda-García *et al*.[17] demonstrated sustained CPR skill retention in sports science undergraduates, emphasizing the importance of tailoring periodic refreshers to specific skillsets.

Similarly, Kim *et al*.[11] advocated for reflective practice to enhance skill retention following BLS training, which could be incorporated into our program to address declines observed in Domains III and IV. Integrating innovative approaches like game-based learning or spaced e-learning could also prove beneficial in maintaining long-term competency, as suggested by Akaltan *et al*. and Ranjbar *et al*.[11,13,19]

Study's limitations and weaknesses:

A notable weakness of the study is the limited sample size, particularly at the 1-month post-training assessment. Although it was sufficient to achieve the sample size considered necessary to statistically validate the analysis, the limited number of participants may bias the analyses and reduce their impact. Furthermore, the reliance on self-reported data regarding general characteristics of participants may have introduced inaccuracies or biases. The absence of a control group also precludes the ability to establish causal relationships definitively or compare the effectiveness of the intervention against alternative educational methods.

Study's strengths:

The study demonstrates several strengths, including its robust methodological design, which systematically evaluated knowledge acquisition and retention at a future time point, thereby providing a detailed understanding of the intervention's short-term and intermediate-term impacts. The use of validated instruments for assessing knowledge across key domains of BLS ensures the reliability and precision of the findings. Moreover, the inclusion of participants from both public and private institutions and a diverse array of healthcare disciplines enhances the external validity, making the results more representative and applicable to broader educational contexts. The integration of a structured, evidence-based curriculum with practical, hands-on training also

underscores the study's relevance in addressing critical gaps in BLS education.

Conclusions

The results of this study underscore the effectiveness of targeted training programs in significantly improving students' knowledge and skills in BLS across all evaluated domains, as evidenced by the statistically significant gains observed immediately post training. While a slight reduction in performance was noted 1 month later in some domains, the lack of statistical significance for most decreases highlights the overall durability of the training's impact.

From a health policy perspective, these findings reinforce the importance of incorporating structured, evidence-based BLS training programs into academic curricula for healthcare students. The statistically significant improvements, particularly in critical areas such as recognizing cardiopulmonary arrest and performing effective compressions, align with global benchmarks for emergency response training. Additionally, the observed retention of knowledge and skills over time supports the integration of regular refresher sessions into training frameworks to sustain proficiency.

Health policies should advocate for accessible, scalable, and standardized BLS training programs that leverage innovative teaching methods, such as just-in-time learning, to maximize learning outcomes. The demonstrated effectiveness of this approach also suggests its potential applicability in broader community-based training initiatives, ultimately contributing to improved public health outcomes and enhanced survival rates in out-of-hospital CA scenarios.

Suggestions for further research

Future studies should focus on exploring the long-term retention of BLS knowledge and skills over extended periods, incorporating evaluations at 6 months and 1 year post-training. Investigating the efficacy of periodic refresher modules or digital interventions, such as mobile applications or virtual reality simulations, could provide insights into innovative methods for reinforcing BLS competencies. Furthermore, expanding the study population to include a broader range of healthcare and non-healthcare professionals and exploring the impact of demographic factors such as prior experience, motivation, and cognitive styles could enhance the generalizability of the findings.

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Conflicts of interest

There are no conflicts of interest.

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