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## Research Article

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### The Difference Between Conventional and Simulation-based BLS Training on Nursing Students' Knowledge Acquisition and Self-Efficacy in Jordan

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#### Abstract

**Background:** Advanced technology in education and training is a challenging task that requires appropriate assessment of new innovative methods. **Objective:** To evaluate the difference between conventional and simulation-based basic life support (BLS) training on nursing students' knowledge acquisition and self-efficacy. **Methods:** A pretest-posttest quasi-experimental design was utilized. 87 nursing students (43 in the control and 44 in the intervention groups) were recruited. The data were analyzed using descriptive statistics, an independent-samples t-test, a paired-samples t-test, Spearman's correlation, ANCOVA, and a multiple linear regression. **Results:** Significant differences were reported in exam scores between the intervention control groups pre- and post-intervention. Post-intervention exam scores were statistically higher in the simulation group (difference= 2.8), with both groups achieving pass scores. Significant differences between the groups in the total self-efficacy scores for resuscitation were reported. ANCOVA results showed significant differences in exam scores between the two groups ( $p=0.013$ ), and the intervention had a significantly positive effect on students' knowledge (7% of the variance in exam scores) ( $\eta^2=0.07$ ). **Conclusions:** Students' BLS knowledge and self-efficacy significantly improved after training, regardless of the training method, although simulation-based training showed statistically significant improvement in BLS knowledge acquisition. The modest difference indicates limited educational significance, particularly in the context where conventional training already achieves the competency threshold. Educators and policymakers should consider including simulation-based BLS training in nursing education. However, traditional BLS training is still efficient in improving student knowledge and self-efficacy, especially in limited-resource countries.

**Keywords:** BLS; Cardiopulmonary resuscitation; Knowledge; Nursing students; Simulation training; Self-efficacy.

الفرق بين التدريب التقليدي والتدريب القائم على المحاكاة في برنامج إحصاءات العمل في اكتساب المعرفة وكفاءة طلاب التمريض في الأردن

#### الخلاصة

**الخلفية:** التكنولوجيا المتقدمة في التعليم والتدريب مهمة صعبة تتطلب تقييماً مناسباً للطرق المبتكرة الجديدة. **الهدف:** تقييم الفرق بين تدريب دعم الحياة الأساسي التقليدي والمعتمد على المحاكاة على اكتساب المعرفة والكفاءة الذاتية لدى طلاب التمريض. **الطرائق:** تم استخدام تصميم شبه تجريبي قبل الاختبار وما بعد الاختبار. تم اختيار 87 طالباً تمريضاً (43 في المجموعة الضابطة و44 في مجموعة التدخل). تم تحليل البيانات باستخدام الإحصاء الوصفي، واختبار  $t$  للعينات المستقلة، واختبار  $t$  للعينات المزدوجة، وارتباط سبيرمان، وANCOVA، والانحدار الخطي المتعدد. **النتائج:** تم الإبلاغ عن فروق ذات دلالة إحصائية في درجات الامتحان بين مجموعات التدخل قبل وبعد التدخل. كانت درجات اختبار ما بعد التدخل أعلى إحصائياً في مجموعة المحاكاة (الفرق = 2.8)، حيث حقق كلا المجموعتين درجات نجاح. تم الإبلاغ عن فروق ذات دلالة إحصائية بين المجموعات في إجمالي درجات الكفاءة الذاتية للإحياء. أظهرت نتائج ANCOVA فروقاً ذات دلالة في درجات الامتحان بين المجموعتين ( $p=0.013$ )، وكان للتدخل تأثير إيجابي كبير على معرفة الطلاب (7% من تباين درجات الامتحانات) ( $\eta^2=0.07$ ). **الاستنتاجات:** تحسنت معرفة الطلاب في BLS وفعاليتهم الذاتية بشكل ملحوظ بعد التدريب، بغض النظر عن طريقة التدريب، رغم أن التدريب القائم على المحاكاة أظهر تحسناً ذا دلالة إحصائية في اكتساب المعرفة في BLS. يشير الفرق المتواضع إلى دلالة تعليمية محدودة، خاصة في السياق الذي يحقق فيه التدريب التقليدي بالفعل عتبة الكفاءة. يجب على المعلمين وصانعي السياسات النظر في تضمين تدريب BLS القائم على المحاكاة في تعليم التمريض. ومع ذلك، لا يزال التدريب التقليدي على نظام إحصاءات العمل فعالاً في تحسين معرفة الطلاب وكفاءة الذات، خاصة في الدول ذات الموارد المحدودة.

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## INTRODUCTION

Nursing educators face challenges in innovative clinical teaching [1], but simulation is becoming essential for critical situations like cardiopulmonary arrest [2]. Simulation bridges the gap between theory and practice and integrates into the health workforce. A systematic review found simulation-based training effective for

acquiring and retaining clinical skills, but further research is needed due to mixed evidence [1]. Koukourikos and Tsaloglidou [2] reviewed the available data on the use of simulation in the clinical education of nursing students and summarized the findings that simulation education strengthens students' clinical decision-making skills for significant issues they encounter during their work. Furthermore, students' self-

esteem, sense of security, and confidence increased when working in a protected environment. Therefore, learning in highly realistic environments prepares students to face clinical situations, amplifies real experiences in safe and controlled environments, and enhances the development of critical thinking, self-confidence, and clinical judgment [3]. The lived learning experience during high-fidelity simulation is examined in an interpretive phenomenological qualitative study by MacLean and Janzen [4]. Data collection included written reflections and semi-structured interviews on student learning in simulation and the factors influencing it. The results revealed that a supportive learning environment is key for learning in simulation. Anxiety and stress can impact student learning, and measures to keep anxiety at optimal levels need to be the continual focus in simulation. The same study concluded that doing simulation more often in the program and having an opportunity for a “do-over” in the simulation were identified as areas that would enhance student learning [4]. Another study by Lesā, Daniel [5], examined nursing students' simulation-based learning experiences and provided strategies to improve learning in these settings. The study observed and interviewed twelve third-year nursing students as part of a qualitative case study. Five themes, including the perception of reality, ease with role-playing, reaction to perceived failure, simulation expectations, and people's personalities in the students' simulation group, were found to characterize students' simulation learning experience. It was concluded that the complexities of the learner's contributions to the simulation affect what they see, react, and reflect on what they have learned. These complexities might lead to learner inconsistency and performance anxiety if not considered [5]. The concepts of knowledge acquisition and self-efficacy are essential in nursing education, and healthcare professionals have examined the research, measuring them as outcomes of simulated approaches. Knowledge acquisition refers to the process of acquiring, assimilating, and integrating new knowledge and information. It involves actively seeking and obtaining knowledge through various means. Knowledge acquisition enables individuals to expand their understanding and expertise in specific areas or domains [6]. Nursing students often struggle with Cardiopulmonary Resuscitation (CPR) due to weak knowledge, poor training, or low self-efficacy [7,8]. High-fidelity simulation (HFS) is a recent technological innovation that allows students to practice critical incidents in a monitored setting, improving clinical practice, resuscitation, patient safety, and clinical judgment abilities [9,10]. Training nursing students in CPR skills enhances their BLS competencies, with studies showing significant improvement in knowledge and skills after training [11]. Self-efficacy is another factor influencing CPR and cardiac arrest management [12]. Srivilaithon and Amnuaypattanapon [13] conducted a study to evaluate the retention of knowledge and skills after training following the 2010 BLS guidelines with

149 second-year medical students. Participants were tested for knowledge and skills of BLS prior to training (pre-test), immediately after training (post-test), and six months after training (retention test). The study found that the knowledge and skills of BLS significantly improved in second-year medical students after training sessions. However, knowledge decreased six months after training, although the BLS skills remained the same. In their literature review, Hakami and Rabie [14] found that simulation training is more effective than traditional training, with most studies reporting a positive impact on students' self-efficacy. In Jordan, a study examined the effect of high-fidelity BLS simulation on the knowledge acquisition, retention, and self-efficacy of Jordanian nursing students. It found that traditional training when teaching BLS to undergraduate nursing students is as effective as high-fidelity simulation training. This was explained by the fact that BLS skills require mastery-level competencies and professional commitment. This study improved students' knowledge after BLS training, regardless of the teaching method [15]. Simulation education in Jordan is a relatively new teaching method, with the Higher Education Accreditation Commission (HEAC) currently limiting its use to 20% of clinical courses [16]. However, many nursing students lack the essential knowledge and skills to perform CPR, with only 11% fully aware of the universal compression-ventilation ratio and 14.2% aware of the recommended compression depth [17,18]. Although previous studies in Jordan, like the one by Akhu-Zaheya *et al.* (2013), looked at the usefulness of simulation-based BLS training [15], the results have been mixed, especially when it comes to knowledge acquisition and self-efficacy outcomes. With revised training criteria, improved simulation technology, and an authorized training environment, the current study seeks to expand previous work within a modern educational setting. To the best of our knowledge, this study is one of the few studies conducted at Jordanian academic institutions accredited as a certified center by the AHA. This study aims to shift the focus towards advanced training methods to ensure patient safety and improve the culture of nursing education. The study examines the difference between conventional and simulation-based BLS training on nursing students' knowledge acquisition and self-efficacy and analyzes the effect of students' demographic characteristics on these outcomes. This will help set policies and protocols focusing on simulation lab preparation before real-life patient training [19].

## METHODS

### *Study design and setting*

This study utilized a pretest-posttest quasi-experimental design (Figure 1). A pretest-posttest experimental design is a quasi-experimental approach that aims to establish a cause-and-effect relationship with limited ability for randomization. Since students' inclusion was based on

their registration for the training, each group received the same training. Clusters (groups) were used as the unit of randomization, with groups assigned to either the control or the intervention arm using random numbers. The allocation sequence was concealed from investigators responsible for participant enrollment to minimize the risk of selection bias.

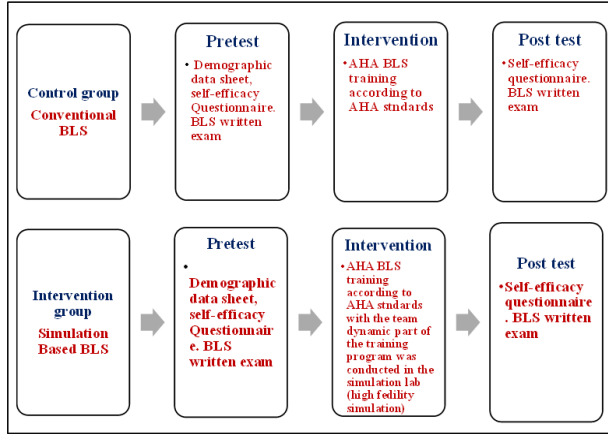


Figure 1: Conceptual Framework.

### The study's hypotheses

There are differences between control and intervention groups in knowledge acquisition. There are differences between control and intervention groups in resuscitation self-efficacy.

### Sample selection

The sample was collected using convenience sampling. All nursing students were invited to participate in the study. The inclusion criteria include being a current nursing student and completing at least the first two years of the bachelor's program in nursing. BLS competencies are not included in the first two years of the nursing program, and none of the enrolled students had prior formal education in BLS during their studies. The students were asked to report whether they had any prior BLS training. Nursing students who have previous BLS training were excluded from the study. Also, the AHA repository was used to verify any previous BLS training. The G\*Power program calculated the sample size [20]. The independent samples t-test was utilized using an alpha level of 0.05, an effect size of 0.6, and a power of 0.8. The estimated total sample size required was at least 72 students, 36 in each group. An additional 20% (15 participants) were added to the calculated sample to increase the power and to account for the possibility of sample loss. Eighty-seven students were enrolled in this study: 43 in the control group and 44 in the intervention group. Each training session consisted of six to nine students. Students' training sessions were randomly assigned after their registration to either a conventional (control) group or a simulation training (intervention)

group using cluster randomization. The data collection process occurred from December 2023 to February 2024.

### Intervention and outcome measurements

The study was conducted at one of the leading private universities in Jordan, which houses a health training center accredited by the American Heart Association (AHA) as a BLS training center in Jordan. Training for the conventional group took place in faculty laboratories equipped with high-resolution interactive screens and an ideal setup that meets AHA standards for BLS training [21]. The training of the intervention group was conducted in a simulation lab, which mimics an intensive care unit featuring a high-fidelity adult simulator capable of receiving CPR with a feedback screen and a hemodynamic monitor that provides parameters consistent with the manikin's condition. A web-based monitoring and debriefing system was utilized to record and retrieve the training sessions. The training for the intervention and control groups was delivered by the same trainers, who were assigned to student groups at random using random numbers.

### Data collection tool

The data collection tools used in this study consist of three parts: the demographic data sheet, the Resuscitation Self-Efficacy Scale, and the AHA written exam. The demographic datasheet contains the student's code, age, and gender. Student resuscitation self-efficacy was measured using the Resuscitation Self-efficacy Scale developed by Roh and Issenberg [22]. The scale consists of 17 positively worded items on a self-administered 5-point Likert-type scale, ranging from 1 (least confident) to 5 (very confident). The scale contains items about recognition, debriefing and recording, responding and rescuing, and reporting. Higher mean scores indicate higher degrees of resuscitation self-efficacy. The scale was previously validated using construct validity and has an internal consistency reliability of 0.91 [22]. For Jordanian student participants, the self-efficacy scale was not translated because the student participants study in English, so face validity was done by a panel of three experts from the nursing field, and they reported that the scale items sufficiently included the idea of self-efficacy and are comprehensible to prospective responders. The Cronbach's alpha was measured in the current study, and the reliability was 0.95. The third section consists of the standardized AHA exam. The BLS exam assesses students' cognitive knowledge mastery. The exam consists of 25 multiple-choice questions; each question has one correct answer with a score of 4. The incorrect answers scored as zero, with a total exam score out of 100. Questions are based on the 2020 AHA guidelines for CPR, and desirable scores should be above 84 to have the BLS certificate. The English version of the exam was used, which has four different forms: A, B, C, and D, which measure the same constructs. Permission was

obtained from the AHA to use the BLS exams in the study.

### Data collection

Data collection began after obtaining ethical approvals. Data were collected using paper-based self-administered questionnaires. Four BLS trainers certified by the AHA were responsible for the data collection process, which was conducted in the pre-training and post-training phases. At the beginning of each session, students were asked to fill out the demographic data sheet, followed by the self-efficacy questionnaire. The last part consists of the BLS written exam provided by the AHA. All students received the BLS training according to the AHA standards and guidelines, using torso manikins with tablet feedback devices. The team dynamic part of the training program for the intervention group was conducted in the simulation lab. Students were given a case scenario of a patient in the Intensive Care Unit (ICU) and asked to intervene according to the patient's situation. The high-fidelity simulator (manikin) was capable of showing a real, palpable pulse; eye-opening; and respiration with chest rise that are consistent with the patient's hemodynamic monitor. Students have to work as a team to resuscitate the patient according to their role in the CPR team. After that, a debriefing session with video playback was used to allow students to find their strengths and areas for improvement during the session. The control group conventionally performs the team dynamic session using torso manikins that are capable of receiving chest compression and ventilation. All students were asked to fill out the self-efficacy questionnaire and the AHA written exam in the post-training phase, directly after finishing their written and practical exams. Students received different forms of the AHA written exam test pre- and post-training.

### Ethical considerations

Ethical approval was obtained from the scientific and research committee at the Faculty of Nursing / Al-Ahliyya Amman University (Date: August 10, 2023; Certificate ID: #MM 12/02-2023). Also, official approval from the AHA was ensured for using the written exams in this study. Students' participation was voluntary; a BLS training certificate is not a curricular requirement. Students usually receive BLS education in an advanced course before graduation. Students were assured that the data would be used for research purposes only, maintaining their anonymity and confidentiality. A consent form that includes the study objectives, confidentiality issues, and the respondents' anonymity and privacy was signed by each student before being included in the study.

### Data analysis

Data were analyzed using the Statistical Package for the Social Sciences version 22 [23]. There were no missing

data and no subjects who dropped out of the study. Descriptive statistics were calculated to describe the students' demographics. The assumption of normality was assessed before conducting the statistical analyses. The Shapiro–Wilk test found most of the data not normally distributed (ranging between 0.013 and  $<0.001$ ), and visual inspection of histograms and Q–Q plots showed approximately normal distribution with slight skewness. Given our moderate sample size ( $n \approx 40$  per group), parametric tests (paired and independent *t*-tests) are considered robust to minor violations of normality. However, we conduct a sensitivity analysis by adding a Mann-Whitney U test to compare the findings between groups for this purpose. The paired sample *t*-test was used to compare students' knowledge and resuscitation self-efficacy in the same group before and after the test. The independent sample *t*-test was used to compare students' knowledge and resuscitation self-efficacy between the intervention and control groups. Moreover, the Spearman correlation was used to find the association between students' pre- and post-intervention scores of knowledge, resuscitation self-efficacy total scores and domains, and age for the control and intervention groups. Analysis of Covariance (ANCOVA) that adjusts for baseline imbalance (pre-test score) was used as the primary method to assess the effectiveness of the intervention program in improving students' knowledge and resuscitation self-efficacy. Moreover, the Analysis of Variance (ANOVA) result was also reported in the table as part of the sensitivity analysis. Alpha was set at  $<0.05$ .

## RESULTS

Our study successfully enrolled 87 participants: 43 in the control group and 44 in the intervention groups (Table 1). There were no significant differences in the average age and gender proportion across the two groups. The intervention group had 24 males (54.5%) and 20 females (45.5%), with an average age of  $23.73 \pm 3.34$  years. The control group comprised 19 males (44.2%) and 24 females (55.8%), with an average age of  $22.74 \pm 3.94$  (Table 1).

**Table 1:** Demographics of control and intervention groups

Characteristics	Total (n=87)	Intervention group (n=44)	Control group (n=43)	<i>p</i> -value
Age (year)	23.24 $\pm$ 3.66	23.73 $\pm$ 3.34	22.74 $\pm$ 3.94	0.212*
Gender				
Male	43(49.4)	24(54.5)	19(44.2)	0.334**
Female	44(50.6)	20(45.5)	24(55.8)	

Values are presented as frequency, percentage, and mean $\pm$ SD. \*Independent *t*-test; \*\*Chi-square test.

Table 2 shows the average exam scores within and between the control and intervention groups regarding knowledge acquisition. Within-group comparison: the average exam score before and after the intervention was found to significantly differ in the control ( $35.91 \pm 16.94$  vs.  $85.02 \pm 2.63$ ,  $p < 0.001$ ) and the intervention groups ( $45.02 \pm 20.93$  vs.  $87.82 \pm 4.88$ ,  $p < 0.001$ ).

**Table 2:** Comparison of preintervention and postintervention students' knowledge within the intervention and controlled groups

Outcome	Preintervention	Postintervention	Gain score	p-value
<i>Intervention group (n=44)</i>				
Exam score	45.02±20.93	87.82±4.88	42.8	<0.001
<i>Control group (n=43)</i>				
Exam score	35.91±16.94	85.02±2.63	49.11	<0.001

Values are presented as mean±SD. Standard deviation.

Regarding between-group comparisons, the average exam score was found to be significantly different at the point before (control = 35.91 ± 16.94, intervention = 45.02 ± 20.93,  $p= 0.028$ ) and the point after (control = 85.02 ± 2.63, intervention = 87.82 ± 4.88,  $p= 0.001$ ) the intervention (Table 3). Also, similar to the independent t-test findings, Mann-Whitney U shows a similar finding: the average exam score was found to be significantly different at the point before ( $p= 0.027$ ) and the point after ( $p= 0.001$ ) the intervention.

**Table 3:** Comparison of preintervention and postintervention students' knowledge between the intervention and control groups

Exam Score	Intervention group (n=44)	Control group (n=43)	p-value	Effect Size
Preintervention	45.02± 20.93	35.91±16.94	0.028	0.48
Postintervention	87.82±4.88	85.02±2.63	0.001	0.71

Values are presented as mean±SD.

Although statistically significant ( $p= 0.001$ ), the absolute difference between the intervention and control groups

**Table 4:** Comparison of preintervention and postintervention of resuscitation self-efficacy within the intervention and controlled groups

Outcome	Preintervention	Postintervention	Gain score	p-value
<i>Intervention group (n=44)</i>				
Recognition	3.61±0.97	4.74±0.37	1.13	< 0.001
Debriefing and recording	3.65±1.07	4.66±0.47	1.01	< 0.001
Responding and rescuing	3.18±1.11	4.73±0.48	1.55	< 0.001
Reporting	3.69±0.94	4.85±0.32	0.81	< 0.001
Total score of resuscitation self-efficacy	3.49±0.9	4.75±0.37	1.26	< 0.001
<i>Control group (n=43)</i>				
Recognition	3.54±1.03	4.56±0.67	1.02	< 0.001
Debriefing and recording	3.33±1.0	4.73±0.44	1.40	< 0.001
Responding and rescuing	3.02±1.2	4.76±0.37	1.74	< 0.001
Reporting	3.27±1.14	4.77±0.41	1.50	< 0.001
Total score of resuscitation self-efficacy	3.28±0.99	4.71±0.36	1.43	< 0.001

Values are presented as mean±SD.

Table 5 demonstrates the average scores of resuscitation self-efficacy before and after the intervention between the control and intervention groups. Between-group comparisons: the average scores of domains of recognition, debriefing, recording, responding and rescuing, and reporting, as well as the total score of resuscitation self-efficacy, were found to be non-significantly different at the point before and the point after the intervention (all  $p> 0.05$ ). Compared with the control group, the intervention group reported higher averages but non-significant average total scores in all domains and for the total score of resuscitation efficacy at the points before and after the intervention (Table 5). Also, similar to the independent t-test findings, the Mann-Whitney U shows a similar finding: the average scores of the domains of recognition, debriefing, recording, responding and rescuing, and reporting, as

was relatively small, and both groups exceeded the competency threshold, indicating comparable practical outcomes. Concerning the difference in the average exam score at the baseline, a possible interpretation is that other confounding variables in the study may not have been accounted for. For instance, prior experiences may also impact knowledge and self-efficacy for some participants who may have taken clinical courses that utilized simulation labs. Table 4 shows the average scores of resuscitation self-efficacy before and after the intervention within the control and intervention groups. In the control group, the average scores of domains of recognition, debriefing and recording, responding and rescuing, and reporting, as well as the total score of resuscitation self-efficacy, were found to be significantly different before and after (all  $p< 0.001$ ). Also, in the intervention groups, the average scores of domains of recognition, debriefing and recording, responding and rescuing, and reporting, as well as the total score of resuscitation self-efficacy, were found to be significantly different before and after the intervention (all  $p< 0.001$ ). Compared with the control group, the intervention group reported higher averages in all domains and the total score of resuscitation efficacy before and after the intervention (Table 4).

well as the total score of resuscitation self-efficacy, were found to be non-significantly different at the point before and the point after the intervention (all  $p> 0.05$ ). The associations between the pre- and post-intervention scores of age, exam score, domains, and total scores of resuscitation self-efficacy in the intervention group were examined. Concerning age, it is found to be significantly correlated with the post-score of debriefing and recording score ( $r= -0.364$ ), responding and rescuing ( $r= -0.433$ ), reporting ( $r= -0.447$ ), and the total score of resuscitation self-efficacy ( $r= -0.347$ ); however, it is found not to be correlated with the exam scores. Concerning exam scores, the post-exam scores were found to be significantly correlated with scores of pre-exam ( $r= 0.346$ ), pre-recognition ( $r= 0.353$ ), pre-debriefing and recording score ( $r= 0.317$ ), pre-responding and rescuing ( $r= 0.362$ ), pre-reporting ( $r= 0.379$ ), and a pre-total score

of resuscitation self-efficacy ( $r= 0.392$ ). Concerning the domains of resuscitation self-efficacy and domains of debriefing and recording, the post-debriefing and

recording score was found to be significantly associated with all domains of pre- and post-scores of resuscitation self-efficacy, except for only the pre-recognition score.

**Table 5:** Comparison of preintervention and postintervention of resuscitation self-efficacy between the intervention and control groups

Outcome	Intervention group (n=44)	Control group (n=43)	p-value	Effect size
Preintervention recognition score	3.61±0.97	3.54±1.03	0.755	0.07
Postintervention recognition score	4.74±0.37	4.56±0.67	0.137	0.32
Preintervention debriefing and recording score	3.65±1.07	3.33±1.0	0.301	0.30
Postintervention debriefing and recording score	4.66±0.47	4.73±0.44	0.530	0.15
Preintervention responding and rescuing score	3.18±1.11	3.02±1.2	0.524	0.14
Postintervention responding and rescuing score	4.73±0.48	4.76±0.37	0.776	0.07
Preintervention reporting score	3.69±0.94	3.27±1.14	0.067	0.40
Postintervention reporting score	4.85±0.32	4.77±0.41	0.284	0.21
The preintervention total mean score of resuscitation self-efficacy	3.49±0.9	3.28±0.99	0.293	0.23
The postintervention total mean score of resuscitation self-efficacy	4.75±0.37	4.71±0.36	0.623	0.11

Values are presented as mean±SD.

The associations between the pre-and post-intervention scores of age, exam scores, domains, and total scores of resuscitation self-efficacy in the control group were conducted. Age was not significantly correlated with exam scores or any domain for resuscitation self-efficacy. Also, exam scores were not significantly associated with age and all domains and total scores of resuscitations self-efficacy except between post-exam and self-efficacy recognition scores ( $r= 0.356$ ). This part was not reported

in a table. Table 6 reported results of Analysis of Covariance (ANCOVA) that adjusted for baseline imbalance (pre-test score) as the primary method to assess the effectiveness of the intervention program in improving students' knowledge and resuscitation self-efficacy. Moreover, the Analysis of Variance (ANOVA) result was also reported in the table as part of the sensitivity analysis. without and with adjustment for a covariate (preintervention exam score).

**Table 6:** The effectiveness of interventional programs in improving students' knowledge acquisition and resuscitation self-efficacy outcomes for the intervention and control groups with and without adjustment for covariate (pr-test score)

Outcomes		p-value	$\eta^2$ *
Exam score	Without adjustment	0.001	0.115
	With adjustment	0.013	0.070
Resuscitation self-efficacy: Recognition	Without adjustment	0.134	0.026
	With adjustment	0.126	0.028
Resuscitation self-efficacy: Debriefing and recording	Without adjustment	0.530	0.005
	With adjustment	0.583	0.004
Resuscitation self-efficacy: Responding and rescuing	Without adjustment	0.776	0.001
	With adjustment	0.872	0.001
Resuscitation self-efficacy: Reporting	Without adjustment	0.284	0.013
	With adjustment	0.276	0.014
Resuscitation self-efficacy: Total score	Without adjustment	0.623	0.003
	With adjustment	0.566	0.004

\*  $\eta^2$ : partial eta squared. Effect size: Small effect  $\approx 0.01-0.05$ , Medium effect  $\approx 0.06-0.13$ , Large effect  $\geq 0.14$

After adjustment for preintervention exam score, the intervention significantly improved student knowledge ( $p= 0.013$ ), accounting for 7% of the variance in exam scores ( $\eta^2= 0.07$ ). However, the results showed no significant differences in the domains and total self-efficacy scores for resuscitation. Finally, we conduct stepwise multivariable regression analysis to find the best-fit models and factors contributing to the primary

outcomes: knowledge acquisition represented by the posttest exam score and the total self-efficacy score. Table 7 shows factors associated with posttest exam scores. Intervention, pretest baseline exam score, and pretest debriefing and recording were significantly associated with the posttest exam score ( $R^2= 0.311$ ). These three factors could explain 31.1% of the overall posttest exam score. Findings related to total self-efficacy were not reported due to a lack of model significance.

**Table 7:** Factors associated with knowledge acquisition (post-test exam score)

Independent variable	B±SE	$\beta$	95% CI	p-value
Intervention (Intervention group vs. Control group)	1.89±0.78	0.23	0.35-3.44	0.017
Exam score (baseline)	0.08±0.02	0.37	0.04-0.12	<0.001
Debriefing and recording (baseline)	0.76±0.38	0.19	0.01-1.51	0.046

Model summary:  $p < 0.001$ ,  $R^2 = 0.311$ , Adjusted  $R^2 = 0.286$ .

Dependent variable: posttest exam score. Independent variables: age, gender, and baseline exam scores, recognition, debriefing and recording, responding and rescuing score, reporting, and total resuscitation scores. Only significant variables are considered in the model.

## DISCUSSION

Based on the first hypothesis in this study, which suggests that there are differences between the control and intervention groups in knowledge acquisition. The results showed strong evidence that BLS knowledge acquisition varied between students who had received traditional BLS training and those who had undergone simulation-based BLS training, so the hypothesis is accepted. Even though the intervention group's advantage may be due to higher baseline knowledge rather than superior training. However, the second hypothesis, which indicates that there are differences between control and intervention groups in resuscitation self-efficacy, is rejected because this study revealed no statistical variation in students' self-efficacy between the two training approaches. These results are consistent with several previous studies' results, which utilized the same design [11,13,17,24], but inconsistent with those of Akhu-Zaheya and Gharaibeh [15]. Nonetheless, the results within the groups in this study showed improved knowledge acquisition and self-efficacy post-test in both the control and intervention groups, similar to many other studies [25-27]. In terms of improving knowledge acquisition, this study supports previous research demonstrating the importance of simulation-based knowledge acquisition and retention for clinical practice, as this method helps retain knowledge longer than alternative approaches [28]. Another study by Cecilio-Fernandes and Brandão [29] showed similar results in regard to knowledge acquisition and retention. Simulation-based BLS training may also increase the satisfaction of students and instructors by providing a realistic context for practice with less cognitive and emotional effort to enhance learning [29,30]. Another explanation is that simulation-based BLS promotes active involvement and engagement, leading to better information retention and application of learned skills in practical settings. Additionally, the simulation scenario in the current study was followed by debriefing sessions that clarified students' mistakes, contributing to knowledge improvement. The post-test scores showed a statistically significant difference, although the actual magnitude of the difference is quite minor. Importantly, both groups' scores were higher than the minimum passing mark required for BLS certification. Given that both training methods seem to provide competency-level information, this calls into question the findings' educational value. As a result, even if simulation-based training might provide incremental advantages, its value over traditional approaches in terms of knowledge acquisition alone might be limited in environments with limited resources. Regarding self-efficacy, Lee *et al.* [31] assessed the effects of a clinical reasoning module on the self-efficacy of 49 senior nursing students in South Korea, aligning with high-fidelity simulation principles. Two groups were involved: the experimental group received education through simulation linked to the clinical reasoning course component, while the control group was instructed using

traditional means. While there was no statistically significant difference between the experimental group and the control group, the results indicate that the experimental group had higher levels of self-efficacy. La Cerra *et al.* [32], in a systematic review, showed the same results, supporting the positive impact of high-fidelity simulation on knowledge acquisition and performance among undergraduate nursing students, but found no evidence to support the idea that simulation-based training can help improve nursing students' self-efficacy. The same study recommended the importance of integrating high-fidelity simulation into undergraduate nursing programs to enhance students' knowledge and performance. This result can be explained by the importance of repeating the simulation sessions more than once to enhance students' self-efficacy, which will be reflected in their self-efficacy, and this claim is supported by many previous studies [33, 34]. A significant correlation was found between age and post-score of resuscitation self-efficacy in the intervention group, which is similar to Saunders *et al.* [35]. This can be due to self-efficacy, which depends on a person's confidence in their capacity to complete a task; this confidence may develop with time and be correlated with age. This conclusion is especially significant in light of the requirements of young students joining nursing programs and the potential benefits of enhancing performance by promoting self-efficacy [11]. Training providers may need to incorporate self-efficacy to improve training and provide the groundwork for future nursing profession advancement [36]. Moreover, a statistically significant positive correlation between self-efficacy and age may have to do with the fact that as nursing students advance through their academic level, they gain more experience, maturity, and training in various clinical learning environments. As a result, they develop a range of competencies, increasing their self-efficacy and equipping them to handle complex situations. The results of this study are somewhat different from those of Akhu-Zaheya *et al.*, who showed an increase in self-efficacy after simulation-based training but also found no significant differences in knowledge acquisition [15]. On the other hand, the current study presented no sign of a significant difference in self-efficacy between groups but a statistically significant difference in knowledge acquisition scores. These differences could be explained by the number of variables. First, learning outcomes might have been impacted by variation in simulation fidelity, structure, and debriefing techniques. Second, discrepancies in results could have been caused by variation in sample characteristics and baseline performance level. Third, both studies showed that students in both groups attained competency level results, indicating that there may not be many practical differences between training approaches. These results highlighted how important contextual consideration is when analyzing simulation-based learning outcomes. This study demonstrated a significant

positive multiple linear regression result. This study showed the effectiveness of simulation-based resuscitation in improving students' knowledge and self-efficacy. This result is similar to Mauriz *et al.* [36]. The results of this study have implications for nursing education. After simulation-based training, nursing students exhibit improved knowledge, essential to the effectiveness of nursing practice. Accordingly, typical critical clinical scenarios are created in simulation learning environments to reduce the possibility of endangering an actual patient. Therefore, nursing students can apply their knowledge in a safe setting. Given the challenges posed by the faculty shortage and the increasing number of nursing students, the study's findings have significance for nursing education and the application of unconventional techniques to produce competent future nurses. The results of this study contribute to the body of knowledge about the effects of different BLS training techniques on students' self-efficacy and knowledge acquisition. Nursing educators should consider using high-fidelity simulators as one of the instructional techniques to encourage active learning in a safe setting. In addition to enabling students to actively study rather than only passively taking in information, these simulators offer equitable training opportunities for all students. But the equal performance of conventional and simulation training groups indicates that traditional approaches are still a feasible and affordable way to achieve critical BLS competencies in resource-limited situations where simulation equipment may not be easily accessible. This interpretation is similar to a recent systematic review and meta-analysis done by Görücü *et al.* [37], which reported, according to previous literature, that simulation-based learning has been demonstrated to enhance nursing students' knowledge and clinical competencies; nevertheless, its benefit over conventional teaching methods is sometimes slight and varies based on study design and outcome measures [37]. From a practical dimension, the slight variation in knowledge acquisition scores raises significant questions about how cost-effective simulation-based training is. A significant financial investment in infrastructure, technology, and faculty training is necessary for high-fidelity simulation. Teachers and policymakers should know the advantages of simulation in nursing education and practice training, such as BLS-certified courses, which foster collaboration between educational institutions and training agencies, but at the same time they should carefully consider whether the additional cost of simulation is justified by the relatively small improvement in knowledge scores, especially in settings with limited resources, as conventional training methods in this study also produced competency level outcomes. It is necessary to conduct more studies on the efficacy of simulation-based BLS in nursing education, utilizing various samples.

### Strengths and Limitations

The study's strengths stem from the use of specific resuscitation self-efficacy measures. Self-report measures, such as self-efficacy, are prone to biases, including socially desirable responding, memory biases, and response styles. Moreover, people often overstate their skills, thereby limiting the validity and generalizability of the data due to a lack of empirical support. As a limitation, there is a chance that other confounding variables in the study were not captured. For instance, prior experiences may also impact knowledge and self-efficacy for some participants who may have taken clinical courses that utilized simulation labs. This is significant in the context of self-efficacy since more confidence in the training may lead to a stronger belief in one's competencies. Therefore, future research may need to consider simulation experience while analyzing data. The results showed better scores in self-efficacy and knowledge among students in the intervention group pretest than in the control group. It's possible that participants in the intervention group overestimated their competencies before training, which was corrected after completing the simulated training. Studies conducted in the past with self-efficacy for simulation training have indicated that learners might have given themselves higher ratings in pre-training questionnaires because of their prior experience [38]. In addition, the distribution of sample characteristics between groups may be affected by the design used; future studies may benefit from using an experimental design with proper randomization. This overestimation should not be a constraint, as this study aimed to examine the difference between conventional and simulation-based basic life support training on nursing students' knowledge acquisition and self-efficacy, which is a self-reported perception of one's competencies. It may help us better understand how participants regard themselves and their competencies. Using convenience sampling from one setting may limit the generalizability of the results. Moreover, certain demographics, such as years and semester levels, were not collected in this study, which limits the interpretation of the results. The capacity to evaluate long-term knowledge acquisition and self-efficacy, which are essential for clinical competencies in BLS, was limited. So, longitudinal follow-ups can offer important information on whether self-efficacy changes or improves following training. Internal validity concerns include self-reporting, being prone to response bias in assessing students' self-efficacy, and the short time allotted for evaluating students' knowledge and self-efficacy. Besides the abovementioned limitations, it is important to recognize a few methodological considerations. Post-intervention comparisons might have been influenced by baseline variations in pre-intervention knowledge acquisition scores between the control and intervention groups. It is impossible to completely rule out residual confounding despite statistical corrections. Neither participant nor trainer

blinding was used in the intervention, which could have resulted in performance or assessment bias. Although all BLS trainers were certified by AHA and follow the same guidelines, resources, and training methods, it is still impossible to completely rule out the possibility of trainer-related effects because different trainers may have had different levels of engagement, expertise, and instructional delivery, which could have affected the training sessions' efficacy. Finally, high post-test self-efficacy scores (4.71-4.75 out of 5) may indicate a ceiling effect that limits score variability and the ability to detect meaningful differences between control and intervention groups. Although the study was powered to detect moderate effect sizes ( $d=0.6$ ), smaller differences in self-efficacy may not have been detected, which could partly explain the non-significant findings.

### Conclusion

This study sheds light on the effectiveness of different training methods in enhancing nursing students' BLS knowledge and resuscitation self-efficacy, which were significantly improved after training, regardless of the training method. Simulation-based training resulted in slightly higher knowledge scores; however, the difference may not translate into meaningful educational or clinical advantages, given that both groups achieved competence. On the other hand, no statistically significant difference in students' self-efficacy was observed between simulation-based and traditional training methods. By offering a contextual expansion of earlier studies on BLS training techniques in nursing, this study contributes to the body of knowledge by demonstrating that both simulation-based and conventional approaches are successful in attaining competency. Our findings show that standard BLS training is just as effective for undergraduate nursing students as simulation-based BLS training overall for each group. Considering the evolving nature of the nursing profession, graduates must be prepared to handle complex care situations and receive comprehensive training to meet service demands. Incorporating more advanced techniques into BLS training courses could help close the service-education gap, enhance students' knowledge, ensure patient safety, and increase students' self-efficacy.

### Conflict of interests

The authors declared no conflict of interest.

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### Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

### REFERENCES

1. Ajemba MN, Ikwe C, Iroanya JC. Effectiveness of simulation-based training in medical education: assessing the impact of simulation-based training on clinical skills acquisition and retention: a systematic review. *World J Adv Res Rev.* 2024;21(1):1833-1843. doi: 10.30574/wjarr.2024.21.1.0163.
2. Koukourikos K, Tsaloglidou A, Kourkouta L, Papanthanasios IV, Iliadis C, Fratzana A, Panagiotou A. Simulation in clinical nursing education. *Acta Inform Med.* 2021;29(1):15-20. doi: 10.5455/aim.2021.29.15-20.
3. Kim E. Effect of simulation-based emergency cardiac arrest education on nursing students' self-efficacy and critical thinking skills: Roleplay versus lecture. *Nurse Educ Today.* 2018;61:258-263. doi: 10.1016/j.nedt.2017.12.003.
4. MacLean H, Janzen KJ, Angus S. Lived experience in simulation: Student perspectives of learning from two lenses. *Clin Simul Nurs.* 2019;31:1-8. doi: 10.1016/J.ECNS.2019.03.004.
5. Lesã R, Daniel B, Harland T. Learning with simulation: The experience of nursing students. *Clin Simul Nurs.* 2021;56:57-65. doi: 10.1016/j.ecns.2021.02.009.
6. Brown AL, Palincsar AS. Guided, cooperative learning and individual knowledge acquisition; In: Knowing, learning, and instruction, Routledge; 2018. p. 393-451. doi: 10.4324/9781315044408-13.
7. Alaryani ZD, Alhafaian A, Elhady M. The relationship between knowledge and self-efficacy of nurses regarding early initiation of cardiopulmonary resuscitation and automated defibrillation in Saudi Arabia. *Belitung Nurs J.* 2021;7(5):387-394. doi: 10.33546/bnj.1670.
8. Ho SE, Tee SC. Nurses' perceptions of self-efficacy in cardiopulmonary resuscitation at a private hospital in Selangor. *Int E-J Sci Med Educ.* 2018;12(2). doi: 10.56026/imu.12.2.14.
9. L'Her E, Geeraerts T, Desclefs JP, Benhamou D, Blanié A, Cerf C, et al. Simulation-based teaching in critical care, anaesthesia and emergency medicine. *Anaesth Crit Care Pain Med.* 2020;39(2):311-326. doi: 10.1016/j.accpm.2020.03.010.
10. McInerney N, Nally D, Khan MF, Heneghan H, Cahill RA. Performance effects of simulation training for medical students - a systematic review. *GMS J Med Educ.* 2022;39(5):Doc51. doi: 10.3205/zma001572.
11. Partiprajak S, Thongpo P. Retention of basic life support knowledge, self-efficacy and chest compression performance in Thai undergraduate nursing students. *Nurse Educ Pract.* 2016;16(1):235-241. doi: 10.1016/j.nepr.2015.08.012.
12. Hernández-Padilla JM, Suthers F, Granero-Molina J, Fernández-Sola C. Effects of two retraining strategies on nursing students' acquisition and retention of BLS/AED skills: A cluster randomised trial. *Resuscitation.* 2015;93:27-34. doi: 10.1016/j.resuscitation.2015.05.008.
13. Srivilaithon W, Amnuaypattanapon K, Limjindaporn C, Diskumpon N, Dasanadeba I, Daorattanachai K. Retention of basic-life-support knowledge and skills in second-year medical students. *Open Access Emerg Med.* 2020;12:211-217. doi: 10.2147/OAEM.S241598.
14. Hakami AA, Rabie AH, Alzahrani SGM, Alnakhilan FM, Awaidhalharbi K. The impact of simulation education on self-efficacy in pre-registration nursing students. *Open J Nurs.* 2024;14(1):51-76. doi: 10.4236/ojn.2024.141005.
15. Akhu-Zaheya LM, Gharaibeh MK, Alostaz ZM. Effectiveness of simulation on knowledge acquisition, knowledge retention, and self-efficacy of nursing students in Jordan. *Clin Simul Nurs.* 2013;9(9):e335-e342. doi: 10.1016/j.ecns.2012.05.001.
16. HEAC. Guide for Quality Assurance Criteria for the Nursing and Midwifery Program 2021. Available from: <https://en.heac.org.jo/wp-content/uploads/2021/01/Nursing-and-Midwifery-Program.pdf>.
17. Sangamesh NC, Vidya KC, Pathi J, Singh A. Awareness, attitude, and knowledge of basic life support among medical, dental, and nursing faculties and students in the university hospital. *J Int Soc Prev Community Dent.* 2017;7(4):161-167. doi: 10.4103/jispcd.JISPCD\_240\_17.

18. Vural M, Koşar MF, Kerimoğlu O, Kızırcan F, Kahyaoglu S, Tuğrul S, İşleyen HB. Cardiopulmonary resuscitation knowledge among nursing students: a questionnaire study. *Anatol J Cardiol*. 2017;17(2):140-145. doi: 10.14744/AnatolJCardiol.2016.7156.
19. Ministry of Higher Education and Scientific Research. National organizations' priorities for research organizations are to obtain support from the new Scientific Research and Innovation Support Fund 2021 2021. Available from: <http://srsf.gov.jo/National-priorities>.
20. Faul F, Erdfelder E, Lang AG, Buchner A. G\*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*. 2007;39(2):175-191. doi: 10.3758/bf03193146.
21. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, et al; Adult Basic and Advanced Life Support Writing Group. Part 3: Adult Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2020;142(16\_suppl\_2):S366-S468. doi: 10.1161/CIR.0000000000000916.
22. Roh YS, Issenberg SB, Chung HS, Kim SS. Development and psychometric evaluation of the Resuscitation Self-efficacy Scale for nurses. *J Korean Acad Nurs*. 2012;42(7):1079-1086. doi: 10.4040/jkan.2012.42.7.1079.
23. IBM Corp. IBM SPSS statistics for windows Version 24.0. Armonk, NY: IBM Corp.; 2016 ed.
24. Alinier G, Harwood C, Harwood P, Montague S, Huish E, Ruparelia K, et al. Immersive clinical simulation in undergraduate health care interprofessional education: Knowledge and perceptions. *Clin Simul Nurs*. 2014;10(4):e205-e216. doi: 10.1016/j.ecns.2013.12.006.
25. Mohamed SA, Fashafsheh IH. The effect of simulation-based training on nursing students' communication skill, self-efficacy and clinical competence for nursing practice. *Open J Nurs*. 2019;9(08):855. doi: 10.4236/ojn.2019.98064.
26. Park HR, Park JW, Kim CJ, Song JE. Development and validation of simulation teaching strategies in an integrated nursing practicum. *Collegian*. 2017;24(5):479-486. doi: 10.1016/j.colegn.2016.10.007.
27. Roha YS, Lima EJ, Issenberg SB. Effects of an integrated simulation-based resuscitation skills training with clinical practicum on mastery learning and self-efficacy in nursing students. *Collegian*. 2016;23(1):53-59. doi: 10.1016/j.colegn.2014.10.002.
28. Nestel D, Groom J, Eikeland-Husebø S, O'Donnell JM. Simulation for learning and teaching procedural skills: the state of the science. *Simul Healthc*. 2011;6 Suppl:S10-13. doi: 10.1097/SIH.0b013e318227ce96.
29. Cecilio-Fernandes D, Brandão CFS, de Oliveira DLC, Fernandes GCVR, Tio RA. Additional simulation training: does it affect students' knowledge acquisition and retention? *BMJ Simul Technol Enhanc Learn*. 2018;5(3):140-143. doi: 10.1136/bmjstel-2018-000312.
30. Hurd KD, Vlasschaert ME, Hawkins TLA, Haws J, Kupis JN, Ma IW. Effectiveness of simulation-based training for obstetric internal medicine: Impact of cognitive load and emotions on knowledge acquisition and retention. *Obstet Med*. 2021;14(4):242-247. doi: 10.1177/1753495X211011915.
31. Lee J, Lee Y, Lee S, Bae J. Effects of high-fidelity patient simulation led clinical reasoning course: Focused on nursing core competencies, problem solving, and academic self-efficacy. *Jpn J Nurs Sci*. 2016;13(1):20-28. doi: 10.1111/jjns.12080.
32. La Cerra C, Dante A, Caponnetto V, Franconi I, Gaxhja E, Petrucci C, et al. Effects of high-fidelity simulation based on life-threatening clinical condition scenarios on learning outcomes of undergraduate and postgraduate nursing students: a systematic review and meta-analysis. *BMJ Open*. 2019;9(2):e025306. doi: 10.1136/bmjopen-2018-025306.
33. Al Gharibi KA, Schmidt N, Arulappan J. Effect of repeated simulation experience on perceived self-efficacy among undergraduate nursing students. *Nurse Educ Today*. 2021;106:105057. doi: 10.1016/j.nedt.2021.105057.
34. Hung CC, Kao HS, Liu HC, Liang HF, Chu TP, Lee BO. Effects of simulation-based learning on nursing students' perceived competence, self-efficacy, and learning satisfaction: A repeat measurement method. *Nurse Educ Today*. 2021;97:104725. doi: 10.1016/j.nedt.2020.104725.
35. Saunders A, Vega MO, Ianelli H, Cross S, Attoe C. Evaluating the impact of simulation-based mental health training on self-efficacy: A retrospective data analysis. *Int J Healthc*. 2021; 1(1):3-10. doi: 10.54531/XRRK9799.
36. Mauriz E, Caloca-Amber S, Córdoba-Murga L, Vázquez-Casares AM. Effect of psychophysiological stress and socio-emotional competencies on the clinical performance of nursing students during a simulation practice. *Int J Environ Res Public Health*. 2021;18(10):5448. doi: 10.3390/ijerph18105448.
37. Görücü S, Türk G, Karaçam Z. The effect of simulation-based learning on nursing students' clinical decision-making skills: Systematic review and meta-analysis. *Nurse Educ Today*. 2024;140:106270. doi: 10.1016/j.nedt.2024.106270.
38. Fisher M, Vishwas A, Cross S, Attoe C. Simulation training for police and ambulance services: Improving care for people with mental health needs. *BMJ Simul Technol Enhanc Learn*. 2020;6(2):121-122. doi: 10.1136/bmjstel-2018-000423.