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From classroom to emergency: knowledge acquisition and retention following nurse-led simu-lation-based BLSD education in secondary schools

Dall'aula all'emergenza: acquisizione e consolidamento delle conoscenze a seguito di un corso di formazione BLSD basato sulla simulazione e condotto da infermieri nelle scuole secondarie

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ABSTRACT

Introduction: Out-of-Hospital Cardiac Arrest (OHCA) remains a major public health challenge in which early Car-diopulmonary Resuscitation (CPR) and automated external defibrillator (AED) use are critical deter-minants of survival. Despite international recommendations promoting Basic Life Support and Defib-rillation (BLSD) education in schools, first-aid training is not systematically implemented in Italian secondary education. This study evaluated the effectiveness of a nurse-led simulation-based BLSD training program in improving theoretical knowledge and medium-term retention among high school students.
Materials and Methods: a total of 430 final-year students attended an Italian Resuscitation Council (IRC)-based BLSD course including interactive lectures, realistic simulations, and structured debrief-ing. Knowledge was assessed using a standardized 20-item questionnaire administered before training (T0), immediately after training (T1), and four months later without prior notice (T2).
Results: mean correct responses increased from 42.34% at T0 to 77.02% at T1 ($p < 0.001$). At fol-low-up, scores remained significantly higher than baseline (70.44%; $p < 0.001$), despite a moderate decline compared with immediate post-training results. No gender-related differences emerged.
Conclusions: simulation-based BLSD education appears effective in promoting both knowledge ac-quisition and medium-term retention in adolescents. These findings support the potential value of nurse-led BLSD training programs in secondary schools and suggest that their integration into school curricula may represent an important educational and public health strategy.

Key words: BLSD; simulation-based education; CPR training; nurse educator; high school students; experiential learning; first responders.

RIASSUNTO

Introduzione: l'arresto cardiaco extraospedaliero (OHCA) rimane una delle principali sfide per la salute pubblica, in cui la rianimazione cardiopolmonare (RCP) precoce e l'uso del defibrillatore automatico esterno (DAE) sono fattori determinanti per la sopravvivenza. Nonostante le raccomandazioni internazionali che promuovono la formazione in materia di supporto vitale di base e defibrillazione (BLSD) nelle scuole, la formazione in primo soccorso non è sistematicamente implementata nell'istruzione seconda-ria italiana. Questo studio ha valutato l'efficacia di un programma di formazione BLSD basato sulla simulazione e condotto da infermieri nel migliorare le conoscenze teoriche e la ritenzione a medio ter-mine tra gli studenti delle scuole superiori.
Materiali e Metodi: un totale di 430 studenti dell'ultimo anno hanno frequentato un corso BLSD basa-to sulle linee guida dell'Italian Resuscitation Council (IRC), comprendente lezioni interattive, simula-zioni realistiche e debriefing strutturato. Le conoscenze sono state valutate utilizzando un questionario standardizzato di 20 domande somministrato prima della formazione (T0), immediatamente dopo la formazione (T1) e quattro mesi dopo senza preavviso (T2).
Risultati: la media delle risposte corrette è aumentata dal 42,34% al T0 al 77,02% al T1 ($p < 0,001$). Al follow-up, i punteggi sono rimasti significativamente più alti rispetto al valore basale (70,44%; $p < 0,001$), nonostante un moderato calo rispetto ai risultati immediatamente successivi alla formazione. Non sono emerse differenze legate al genere.
Conclusioni: la formazione in BLSD basata sulla simulazione sembra efficace nel promuovere sia l'acquisizione delle conoscenze sia la loro ritenzione a medio termine negli adolescenti. Questi risultati sostengono il potenziale valore dei programmi di formazione in BLSD condotti da infermieri nelle scuole secondarie e suggeriscono che la loro integrazione nei programmi scolastici possa rappresenta-re un'importante strategia educativa e di salute pubblica.

Parole chiave: BLSD; formazione basata sulla simulazione; formazione in RCP; infermiere formatore; studenti delle scuole superiori; apprendimento esperienziale; primi soccorritori.

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Introduction

Out-of-Hospital Cardiac Arrest (OHCA) is a major public health problem in Europe and a leading cause of death. According to the EuReCa ONE study, the incidence of Emergency Medical Service (EMS)-treated OHCA ranges from approximately 19 to 104 cases per 100,000 inhabitants per year across participating European regions, reflecting substantial geographic variability. Survival to hospital discharge in patients receiving resuscitation attempts was approximately 10% in this study. Subsequent data from the EuReCa TWO registry confirmed persistent low survival, reporting survival to hospital discharge of about 8% across Europe. Because neurological outcome and survival are highly time-dependent, the European Resuscitation Council emphasizes the importance of rapid activation of the chain of survival, including early recognition of cardiac arrest, immediate bystander Cardiopulmonary Resuscitation (CPR), and early defibrillation, as delays in treatment are strongly associated with reduced survival and worse neurological outcome.[1-3]

For this reason, international organizations such as the European Resuscitation Council (ERC) and the World Health Organization advocate the widespread dissemination of Basic Life Support and Defibrillation (BLSD) competencies among laypersons, particularly adolescents. The ERC Guidelines 2021 on Education for Resuscitation specifically recommend the implementation of CPR training in schools and support the "Kids Save Lives" initiative, which promotes the systematic teaching of resuscitation skills to school-aged children and adolescents. Schools represent an ideal setting for emergency education because students are highly receptive to active learning approaches and may act as multipliers of health knowledge within their families and communities.

Despite these recommendations, BLSD education is not systematically integrated into Italian secondary school curricula. Consequently, many students reach adulthood without adequate preparation to recognize and respond to cardiac arrest situations.

Simulation-based education has increasingly emerged as an effective strategy for emergency training. According to experiential learning theory, active participation and reflection on experience facilitate knowledge acquisition and retention.[4,5] In healthcare education, simulation provides opportunities to apply theoretical knowledge in realistic and controlled environments, supporting the development of practical skills, clinical reasoning, and decision-making abilities.[6,7]

Furthermore, simulation-based training has been associated with improved cognitive, psychomotor, and affective learning outcomes and has demonstrated greater educational effectiveness compared with traditional teaching approaches across a variety of healthcare education settings.[8]

Debriefing is widely recognized as a core element of simulation-based education, facilitating guided reflection, feedback, critical analysis of actions, and the integration of new knowledge into future practice.[9,10] Within this educational framework, nurse instructors play an important role in planning, facilitating, and evaluating simulation activities, contributing to the effectiveness of the learning process.[11]

The present study aimed to evaluate the effectiveness of a nurse-led simulation-based BLSD course in improving theoretical knowledge and medium-term knowledge retention among high school students. These outcomes were assessed using a standardized 20-item questionnaire administered at baseline, immediately after training, and four months following course completion.

Materials and Methods

A longitudinal observational study was conducted involving 430 final-year secondary school students. Participants were recruited from five different educational pathways, including a scientific high school (n = 86), a classical high school (n = 86), a technical institute (n = 86), a vocational institute (n = 86), and a humanities high school (n = 86). This distribution was intended to provide a heterogeneous sample representative of different secondary educational backgrounds.

No student had previously participated in CPR teaching activities at school.

All participants were legally adults at the time of enrollment. The sample included 232 female students (53.95%) and 198 male students (46.05%).

This study was an anonymous, non-interventional educational research project conducted in secondary schools and involving competent adult participants. The study did not include any clinical interventions, collection of biological samples, or processing of sensitive health-related data. In accordance with the applicable Italian regulations governing non-interventional educational research, formal approval by an Ethics Committee was not required.

The project was approved by the governing bodies of the participating schools, including the School Council and the Class Councils, in accordance with institutional procedures. Prior to participation, all students, who were 18 years of age or older, received detailed information about the study and provided written informed consent. Participation was entirely voluntary, all questionnaires were completed anonymously, and participants were informed of their right to decline participation or withdraw at any time without any academic or personal consequences.

The BLSD training program was developed according to Italian Resuscitation Council (IRC) guidelines and delivered by IRC-certified instructors with professional experience in emergency and critical care settings. The educational team included 33 nurses specifically trained in simulation-based education.

Participants were recruited from five secondary schools located in the same geographic area. Schools were selected through a convenience sampling strategy based on institutional availability and prior educational collaborations. Participation was approved at the institutional level by the school leadership, the teachers' councils, and the school boards of the participating institutions, which agreed to take part in the study.

A total of 430 final-year students participated, with 86 students enrolled from each school. All participants were adults (≥18 years old) and provided written informed consent prior to participation. All eligible students within the selected classes were invited to participate. The final sample therefore represents students who attended the scheduled training sessions and provided complete data at all assessment time points.

The course was structured into three sequential phases: pre-course assessment, interactive theoretical session, and simulation-based practical training.

Pre-course assessment

Before training, participants completed a 20-item multiple-choice questionnaire assessing theoretical knowledge of cardiac arrest recognition, Cardiopulmonary Resuscitation (CPR), Automated External Defibrillator (AED) use, emergency system activation, and foreign body airway obstruction management.

The questionnaire was developed by the research team through a structured expert-based process involving clinicians and instructors with experience in emergency care and BLSD training. Items were generated based on the IRC-BLSD curriculum and the

learning objectives of the training program. The draft instrument underwent expert review to assess content relevance, clarity, and appropriateness for adolescent learners, leading to minor revisions to improve comprehensibility.

The questionnaire was not subjected to formal psychometric validation; however, content validity was ensured through expert consensus and alignment with IRC guidelines. The full instrument is provided in the Supplementary Material.

The same questionnaire was administered at all three time points to allow longitudinal comparison of knowledge acquisition and retention.

Interactive theoretical session

Students attended a 45-minute lesson covering OHCA recognition, activation of emergency medical services, CPR sequences, AED use, and airway obstruction management. The session was delivered using interactive teaching methods, including guided discussion, real-life examples, and question-and-answer activities. Educational content was adapted to adolescent learners through age-appropriate language and contextualized emergency scenarios.

Simulation-based practical training

Participants subsequently attended 3.5 hours of practical simulation training in small groups with a student-to-instructor ratio of 6:1.

Simulation sessions were conducted using adult mannequins and AED trainers in realistic scenarios reproducing familiar school environments, including classrooms, corridors, and sports facilities. Students practiced chest compressions, AED application, and foreign body airway obstruction maneuvers under instructor supervision.

The simulation design followed established principles of simulation-based education, emphasizing deliberate practice, contextual realism, active learner engagement, and structured facilitation to support meaningful learning experiences.[7,9,11]

Each session concluded with a structured debriefing phase aimed at supporting reflective learning and knowledge consolidation. Debriefing was conducted according to contemporary simulation-based education frameworks, which identify guided reflection, feedback, learner-centered discussion, and psychological safety as key components of effective learning following simulation experiences.[9,10]

Post- course assessment and four- month follow- up

Immediately after course completion, all participants completed the same questionnaire administered at baseline (T1).

A follow-up assessment was conducted four months later (T2). The four-month interval was primarily selected for practical and organizational reasons, as extending the follow-up beyond the end of the academic year could have increased the risk of participant attrition due to school transfers, relocation, or other factors affecting student availability. This timeframe also allowed the evaluation of medium-term knowledge retention while maintaining a high follow-up rate. Students were not informed in advance of the reassessment in order to reduce preparation bias and better evaluate spontaneous knowledge retention over time. All 430 participants completed all three assessment time points (T0, T1, and T2), with no loss to follow-up or missing data.

Data analysis

The collected data were analyzed using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) for data entry, data cleaning, and descriptive statistics. For each assessment phase (pre-course, T0; post-course, T1; and four-month follow-up, T2), the percentage of correct responses was calculated for each participant. Descriptive statistics were used to summarize demographic characteristics and performance trends across the three assessment points.

Inferential statistical analyses were performed using JASP (JASP Team, University of Amsterdam, The Netherlands, version 0.17.2). Given the repeated-measures design and the non-normal distribution of the outcome variable, changes in knowledge scores over time were analyzed using the Wilcoxon signed-rank test for paired samples. Pairwise comparisons were conducted between T0 and T1 to evaluate immediate knowledge acquisition, between T1 and T2 to assess medium-term retention, and between T0 and T2 to evaluate overall knowledge retention at four months after course completion. Statistical significance was set at $p<0.05$.

Results

The results are graphically illustrated in Figure 1. All 430 enrolled students completed the assessments at baseline (T0), immediately after training (T1), and at the four-month follow-up (T2), resulting in a 100% follow-up rate. Baseline assessment demonstrated limited theoretical knowledge regarding BLSD and OHCA management. The mean percentage of correct responses before training (T0) was 42.34% (±7.2). Immediately after course completion (T1), mean scores increased significantly to 77.02% (±6.5), corresponding to an improvement of 34.68 percentage points compared with baseline ($p<0.001$). At four-month follow-up (T2), participants maintained significantly higher scores than baseline, with a mean percentage of correct responses of 70.44% (±7.1) ($p<0.001$ *vs* T0). Although a moderate reduction compared with immediate post-course performance was observed (−6.58 percentage points), knowledge retention remained substantial.

No statistically significant differences were identified between male and female students across any assessment phase.

Discussion

The present study demonstrates that simulation-based BLSD education significantly improves theoretical knowledge among high school students and supports medium-term retention of learning outcomes.

The substantial increase in post-training scores observed in this

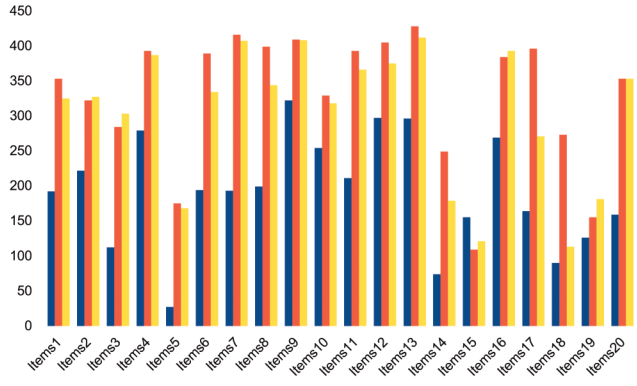

Figure 1. Analysis of BLSD knowledge assessment scores across three time points (T0, T1, T2).

study is consistent with previous research on school-based CPR and BLSD training, which has shown that active and simulation-based learning approaches are effective in improving knowledge acquisition among adolescents.[12-14] In line with the existing literature, our findings also indicate a partial decline in knowledge at follow-up compared with immediate post-training assessment; however, performance at four months remained substantially higher than baseline levels, supporting the presence of sustained medium-term retention after initial training.

These results are aligned with international recommendations from the European Resuscitation Council and the World Health Organization, which advocate for the implementation of CPR training within school curricula.[15,16] Despite these recommendations, implementation remains heterogeneous across countries and is not yet systematically integrated into secondary education in several settings, including Italy.

The intervention was based on simulation scenarios delivered in a school environment. Although this study did not assess psychosocial or affective outcomes, previous literature suggests that simulation-based education may facilitate active learning and contextual understanding in CPR training contexts.[16,17] In the present study, outcomes were limited to theoretical knowledge acquisition and retention; therefore, interpretations regarding motivational or emotional dimensions cannot be derived from the available data.

Finally, the involvement of nurse instructors ensured structured delivery of the educational intervention. While the specific pedagogical contribution of nurse-led instruction was not separately evaluated, the overall results support the effectiveness of nurse-led simulation-based BLSD training in improving and maintaining knowledge over time. Future studies should further investigate the role of instructional factors as well as potential effects on behavioral and psychosocial outcomes in school-based resuscitation education.

An additional aspect of the intervention concerns the role of the nurse instructor. In this study, nurse-led simulation-based training was associated with significant improvements in knowledge acquisition and retention among high school students; however, psychosocial outcomes such as motivation, emotional engagement, and perceptions of psychological safety were not assessed.

Within the existing educational literature, instructor facilitation in simulation-based learning is considered to support active learning through structured feedback, communication, and debriefing. In this context, the role of nurse instructors may extend beyond technical instruction to the facilitation of experiential learning processes, although this interpretation cannot be inferred from the present data.

These considerations are consistent with theoretical frameworks in simulation-based education, but they should be regarded as hypotheses requiring empirical verification in future studies rather than as findings of the present work.

The four-month follow-up demonstrated a moderate decline in scores compared with immediate post-course assessment, consistent with the natural decay of theoretical knowledge over time reported in previous studies.[18] Nevertheless, retention levels remained significantly higher than baseline, suggesting durable educational benefits. The effectiveness of such reinforcement strategies has been well-documented, particularly in educational models that include spaced repetition and blended learning.[19]

These findings support the integration of periodic refresher sessions and repeated simulation exposure to reinforce long-term retention. Educational models based on spaced repetition and recurrent simulation may further strengthen both cognitive and psychomotor competencies.

Importantly, the study also confirms that there were no statistically significant gender differences in performance across all time points, aligning with previous literature that suggests both male and female students benefit equally from structured CPR training.[20]

The study has several limitations. First, only theoretical knowledge was evaluated, while practical skills performance was not objectively assessed. Second, the absence of a control group limits direct comparison with traditional lecture-based education. The study evaluated medium-term retention only, without long-term follow-up beyond four months.

Another limitation of this study is that the questionnaire, although developed through a structured expert-based process and reviewed for content validity, was not formally psychometrically validated. Therefore, its measurement properties, including construct validity and reliability, were not formally established. While the questionnaire was specifically designed to assess the educational objectives of the IRC-BLSD training programme, the lack of formal validation may have affected the precision of the measurements and limits the external validity and generalizability of the findings.

Although inferential analyses were performed using appropriate non-parametric tests, effect size estimates were not available. The absence of effect size measures limits the interpretation of the magnitude of the observed changes in knowledge scores beyond statistical significance.

The present study focused primarily on learning outcomes in terms of theoretical knowledge acquisition and retention. While the educational intervention incorporated interactive and learner-centered instructional strategies, no formal evaluation of participants' engagement, satisfaction, perceived relevance, or educational experience was conducted. Therefore, no conclusions can be drawn regarding these process-related dimensions.

Future research should integrate both outcome and process measures to provide a more comprehensive evaluation of school-based CPR education programs. In addition, future studies should include formal psychometric evaluation of the assessment instrument in larger and more diverse populations, as well as prospective reporting of effect sizes with confidence intervals to better quantify the educational impact of CPR training programs.

Despite these limitations, the study demonstrates significant improvements in theoretical knowledge following nurse-led simulation-based BLSD training, with sustained retention at four months.

Conclusions

Nurse-led simulation-based BLSD education significantly improved theoretical knowledge and supported medium-term knowledge retention among high school students. These findings suggest that simulation-based educational approaches may be effective for teaching basic life support concepts in secondary school settings. Integrating BLSD training into school curricula could represent a valuable strategy for improving community preparedness for cardiac arrest emergencies. Further research is needed to investigate the effects of such programs on behavioral, motivational, and psychosocial outcomes.

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Informed consent: written informed consent was obtained from all participants prior to participation. Participation was voluntary, and participants were informed of their right to decline participation or withdraw from the study at any time without any academic or personal consequences.y.

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