

Article

Improving Accuracy in Cardiopulmonary Resuscitation Training: Results on Undergraduate Nursing School Students' with OMNI2 Simulator

Fani Alevrogianni ^{1,*}, Anna Korompeli ², Christos Triantafyllou ², Theodoros Katsoulas ²,
Panagiotis Koulouvaris ³ and Pavlos Myrianthefts ²

¹ Anaesthesiology Department, KAT Hospital, 14561 Athens, Greece

² Department of Nursing, National and Kapodistrian University of Athens, 11527 Athens, Greece; akorompe@nurs.uoa.gr (A.K.); tkatsoul@nurs.uoa.gr (T.K.)

³ Orthopedics Department, Attikon Hospital, National and Kapodistrian University of Athens, 12462 Athens, Greece

* Correspondence: falevrogianni@gmail.com or falevrog@uoa.gr

Abstract

Cardiopulmonary resuscitation (CPR) is a vital skill for healthcare professionals, crucial in life-saving situations. More than 80% of cardiac arrest cases occur out of hospital. As the demand for competent CPR practitioners grows, the effectiveness of training methods becomes increasingly important, especially for undergraduate students preparing to enter the healthcare field. The primary objective of our study is to investigate the effectiveness of simulation-based teaching methods and by integrating innovative technologies, such as the OMNI2 simulator, to enhance practitioners' performance and to improve the precision and objectivity of CPR instruction. A cohort of 144 undergraduate students from the Nursing School Department of the National Kapodistrian University of Athens participated in an 8 h Basic Life Support Seminar. It consisted of a 5 h theoretical instruction followed by 3 h of practical training using the OMNI2 simulator. Each student was tasked to identify cardiac arrest and to perform two cycles of CPR according to the 2021 guidelines. Metrics, including total session time, cycles performed, compression-to-ventilation ratio, compression depth, compressions and ventilations per minute, full recoil, peak inspiratory pressure, and ventilation duration, were measured and compared against the simulator's preset targets. Statistically significant differences ($p < 0.05$) were observed for all outcomes. In conclusion, while simulation-based teaching has conventionally been proven effective for CPR proficiency, real-time data collected in this study reveal a disparity between anticipated and actual performance. Our research underscores the necessity of refining instructional methods to enhance skill acquisition, potentially leading to improved patient outcomes in the future.

Keywords: cardiopulmonary resuscitation; CPR; simulation-based training; undergraduate nursing education; OMNI2 simulator; skills development



Academic Editors: Rahul Pandit and Duarte Ferreira

Received: 13 October 2025

Revised: 15 November 2025

Accepted: 20 November 2025

Published: 25 November 2025

Citation: Alevrogianni, F.; Korompeli, A.; Triantafyllou, C.; Katsoulas, T.; Koulouvaris, P.; Myrianthefts, P. Improving Accuracy in Cardiopulmonary Resuscitation Training: Results on Undergraduate Nursing School Students' with OMNI2 Simulator. *Int. Med. Educ.* **2025**, *4*, 51. <https://doi.org/10.3390/ime4040051>

Copyright: © 2025 by the authors. Published by MDPI on behalf of the Academic Society for International Medical Education. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Cardiopulmonary resuscitation (CPR) is an essential, life-saving skill that healthcare professionals must master. Timely and effective CPR plays a crucial role in improving survival rates during cardiac arrest, whether in a hospital or out-of-hospital setting [1].

According to literature, 80% of cardiac arrest cases will occur outside the safe hospital environment, with a yearly incidence rate of 67–170 per 100,000 residents. Global statistics highlight the importance of CPR training, as timely bystander intervention significantly increases survival rates following cardiac arrest. However, the proportion of bystanders with CPR skills, when present, during cardiac arrest averages 58%, with rates ranging from 13% to 83% across European countries [2]. The American Heart Association (AHA) states that survival rates for out-of-hospital cardiac arrests (OHCA) are a mere 8% but can increase significantly when high-quality CPR is administered promptly. Similarly, data from European regions indicate that survival rates have doubled in areas with robust CPR training initiatives [3].

Nursing education curricula have increasingly recognized the necessity of equipping their undergraduate students with robust competencies in first-response and basic life support (BLS) skills. As nurses often serve as the first point of contact in clinical and community emergencies, early and structured BLS training is essential to ensure prompt, effective intervention during cardiac arrest or other life-threatening situations. Teaching BLS enables nursing students to develop critical thinking, rapid decision-making, and psychomotor skills that directly influence patient survival outcomes. Moreover, incorporating BLS instruction reinforces the principles of patient safety, teamwork, and adherence to evidence-based resuscitation guidelines. Simulation-based learning and scenario-driven practice provide safe, controlled environments for students to build confidence and competence before applying these skills in real settings. Ultimately, BLS education is not only a technical requirement but also a professional and ethical imperative that prepares future nurses to respond effectively, uphold care quality, and contribute meaningfully to emergency preparedness within healthcare systems [4].

In 2025, the European Resuscitation Council (ERC) refined their guidelines for Basic Life Support (BLS) highlighting the importance of delivering high-quality chest compressions and minimizing interruptions between cycles [5].

Despite the clear importance of CPR, research reveals persistent gaps in performance quality. Many trainees fail to adhere consistently to recommended guidelines, such as maintaining a compression depth of 5–6 cm or a compression rate of 100–120 per minute. Major problems faced also include delay in cardiac arrest recognition and interruptions more than 5 s between cycles of CPR performed. These deviations can significantly impact patient outcomes, highlighting the critical need for innovative and effective training methodologies [6,7].

Simulation-based education has emerged as a game-changer in medical training, offering trainees an opportunity to practise and perfect skills in a controlled environment. For many years now, training on mannequins has been thought to be the gold standard method of acquiring CRP skills. Technology advancements have emerged in the field of emergency medicine and life support, implementing modern simulators to provide real-time feedback, enabling learners to identify and correct errors during practice [8,9].

The OMNI[®] 2 CPR simulator is an advanced training tool designed to enhance CPR proficiency by offering real-time feedback on critical performance metrics. It measures parameters such as compression and ventilation rate and quality, compression depth and full recoil, ensuring accurate technique. The system accommodates age-specific protocols for adults, pediatrics, and infants, and includes a virtual shock panel for defibrillation practice. Therefore, the simulator has the ability to assess real-time performance by comparing to preset target values, respective to the ERC guidelines. A built-in virtual patient monitor displays over 25 vital signs, including ECG rhythms and blood pressure, enabling realistic clinical scenarios, for advanced trainees [10].

This simulator supports thorough debriefing through detailed session logs, performance analytics, and feedback scoring, allowing trainees to identify and improve upon weaknesses. A touchscreen interface provides intuitive control, while wireless connectivity enables flexibility in individual or group training setups. The system's combination of advanced feedback, customizable protocols, and immersive features makes it a powerful tool for building BLS skills and ensuring readiness for real-life emergencies [10].

Our study's aim was to evaluate the undergraduate nursing school students' performance in CPR when using the OMNI2 simulator for training. By analyzing their performance, our research highlights the strengths and limitations of simulation-based learning, and the potential of emerging technologies in revolutionizing medical education.

2. Materials and Methods

2.1. Study Design and Objectives

This observational quantitative study was conducted at the National and Kapodistrian University of Athens (NKUA) to evaluate how simulation-based training improves CPR proficiency among undergraduate students. Ethical approval was obtained by the respective committee of the NKUA under the number 461—21/09/2023. The primary objective was to assess students' ability to meet key CPR metrics using the OMNI2 simulator. Secondary objectives included identifying challenges in CPR execution and exploring the role of real-time feedback in skill enhancement.

2.2. Participants

The study population consisted of 144 undergraduate students from the Nursing School, Department of Health Sciences, National and Kapodistrian University of Athens, none of whom had received prior formal cardiopulmonary resuscitation (CPR) training. The study was conducted within the compulsory First Aid Education course, offered in the second year of the undergraduate curriculum. This course took place during the third semester of study, met twice weekly, and included a Basic Life Support (BLS) seminar. All participants filled out a written informed consent before the beginning of the seminar. Demographic characteristics, prior exposure to first aid training and familiarity with technology were also documented in a survey, disseminated to and filled obligatory by all participants anonymously. All students filled a knowledge assessment test on first aid before and immediately after the seminar. The written examination consisted of 20 multiple choice questions of a single best answer, with an allotted timeslot of 15 min, under the same supervised classroom conditions [Appendix A]. Anonymity was preserved throughout the study. The survey, knowledge assessment test, and simulator performance report were matched by assigning each student a unique 9-digit code, consisting of the seminar date (DD/MM/YEAR) and their order of registration.

2.3. Training Structure

All the equipment available for the training program was donated by the Stavros Niarchos Foundation (SNF) in terms of their national program to improve education and healthcare.

The training program consisted of an 8 h Basic Life Support (BLS) seminar based on the 2021 European Resuscitation Council (ERC) guidelines, which was divided into two components:

The theoretical introduction began immediately after all participants filled out the first questionnaire. It lasted 5 h and consisted of an overview of the chain of survival, a description of the pathophysiology of cardiac arrest and explanation of the ERC guidelines for Basic Life Support (BLS), as published in 2021. The instructional methods included

PowerPoint presentations delivered by five faculty members, as well as audiovisual material provided by the European Resuscitation Council (ERC) demonstrating a cardiac arrest scenario and the corresponding stepwise management approach. The theoretical part ended with a demonstration of a cardiac arrest case and performance of CPR by the faculty.

In the practical training part, which lasted 3 h, participants practiced on a manikin connected to the OMNI2 simulator one by one. In detail, each participant was assigned to identify a cardiac arrest case and perform 2 sequential cycles of CPR, which were recorded by the simulator and analyzed in a performance report. The following parameters were measured by the simulator:

- Total session time and no flow time fraction.
- Compression depth, rate, and recoil.
- Compression-to-ventilation ratio.
- Ventilation duration and peak inspiratory pressure (PIP) by providing mouth-to-mouth ventilations.

Important to highlight is that the simulator has the ability to identify and document performance metrics in real-time that meet preset target values. Consequently, although a student may have completed what they perceived as 2 cycles of CPR, the simulator could register fewer, leading to a calculated average different than the anticipated.

Each participant at the end of the CPR session received a report [Appendix B] for his performance and metrics were compared to preset target values of the simulator. Target values were set according to the recommended 2021 ERC guidelines. [Table 1].

Table 1. Preset target values of OMNI2 simulator (ERC Guidelines 2021).

Parameters	Test Target Value/Range
Total session time (sec)	60
Cycles performed	2
Compressions/cycle	30
Ventilations/cycle	2
Compression rate/min	100–120
Compression depth (cm)	5–7
Full recoil (%)	100
Ventilation rate/min	10–13
Ventilation PIP (cmH ₂ O)	18–22
Ventilation duration (sec)	1

At the end of the seminar, all participants were asked to fill the same 20-multiple choice, single best answer questionnaire.

2.4. Statistical Analysis

Statistical analyses were performed in R (version 4.3.2). Continuous outcomes were screened with the Shapiro–Wilk test and compared to prespecified targets using one-sample *t*-tests when approximately normal or Wilcoxon signed-rank tests when not; highly tied/discrete outcomes were summarised as counts (k/N, %) with exact binomial/sign tests. For four measures with prespecified acceptable ranges (compression rate 100–120 rpm; compression depth 5–7 cm; ventilation rate 10–13/min; ventilation PIP 18–22 cmH₂O) we created within-target indicators and modelled them with logistic regression, reporting adjusted marginal probabilities (bootstrap 95% CI, B = 3000). Adjusted analyses (age, gender) used linear regression on y–target with HC3 robust SEs for approximately normal

outcomes and quantile regression with bootstrap inference for non-normal continuous outcomes; two-sided $p < 0.05$ was considered significant.

3. Results

3.1. Demographic Findings

Our study cohort included participants aged 19–23 years, with a majority of 62.3% being female. Most participants reported high familiarity with modern technologies, owning both a computer and a smartphone, which likely facilitated interaction with audiovisual materials. None had professional CPR experience; however, 48% reported some knowledge of CPR, and 46% had undergone prior resuscitation training. Of those with previous experience, nearly all had attended seminars, though only 14% of these lasted over six hours. Self-assessed knowledge on a 1–10 scale showed fewer than 10% rating themselves above 8, finding consistent with the low pre-seminar scores. In detail, on the first aid knowledge assessment test, 58% scored below the 10 points baseline initially, but significant improvement was observed post-seminar, with 74% achieving scores above 15 out of 20. This confirms that the educational intervention successfully met its theoretical learning objectives.

Additionally, 18% of participants owned a resuscitation manual, and 19% had a first aid kit. About 18% had previously provided first aid, with 10% doing so in a workplace setting and confidently performing necessary actions.

3.2. Performance Results

Table 2 summarizes unadjusted and age/gender-adjusted performance for the ten prespecified metrics of undergraduate Nursing School students using the OMNI® 2 simulator to perform two sequential CPR cycles. In unadjusted analyses median total session time exceeded the 60 s target (median 73.5 s, IQR 68.0–82.0; $p < 0.001$). Exceeding the recommended time indicates delays in transitions between compressions and ventilations—an issue that can reduce real-world CPR effectiveness where minimizing interruptions is critical. Only 74.3% of students completed the expected two full cycles, reflecting challenges in procedural fluency and timing, underscoring the need for repeated practice to build automaticity. For range-based targets, 102/144 (70.8%) were within the 100–120 rpm compression-rate range (adjusted probability 70.8%, 95% CI 63.4–78.2%), indicating a reasonable rhythm control, whereas only 45/144 (31.2%) met the 5–6 cm compression-depth range (adjusted 31.3%, 95% CI 24.1–38.8%). Inadequate depth reduces perfusion; this finding highlights one of the most clinically significant areas needing improvement. Median recoil was 98%, slightly below the ideal 100%, meaning some students leaned on the chest between compressions—another factor known to reduce CPR effectiveness. These findings collectively show that while students generally maintained an appropriate rhythm, many struggled to deliver compressions of sufficient depth with full chest recoil, both of which are essential components of high-quality CPR.

As for ventilation metrics, participants revealed lower adherence to targets. Ventilation duration was shorter than the 1.0 s target (median 0.70 s, IQR 0.50–1.10; $p < 0.001$) ventilation rate and PIP were infrequently within target (4/144, 2.8% and 19/144, 13.2%, respectively; adjusted 2.8%, 95% CI 0.6–6.2% and 13.2%, 95% CI 8.0–19.1%). These results suggest that students had particular difficulty coordinating breath timing and pressure. Both under-ventilation and over-ventilation can compromise oxygenation during CPR, highlighting the need for more structured practice with real-time feedback.

Table 2. Undergraduate Students performance 2 Cycles of CPR Using the OMNI2 Simulator.

Parameters	Target Value/Range	Unadjusted (Mean/Median- q1q3 or n/N (%))	Adjusted (Mean/Median or % (95% CI))	p-Value (Unadjusted)
Total session time (s) *	60	73.50 (68.00–82.00)	73.80	<0.001
Cycles performed *	2	107/144 (74.3%)	2.00	<0.001
Compressions/cycle *	30	30.00 (30.00–32.25)	30.00	<0.001
Ventilations/cycle *	2	88/144 (61.1%)	2.00	<0.001
Compressions/min	100–120	102/144 (70.8%)	70.8% (63.4–78.2%)	<0.001
Compression depth (cm)	5–6	45/144 (31.2%)	31.3% (24.1–38.8%)	<0.001
Full recoil (%) *	100	98.00 (91.00–100.00)	98.56	<0.001
Ventilations/min	10–13	4/144 (2.8%)	2.8% (0.6–6.2%)	<0.001
Ventilation PIP (cmH ₂ O)	18–22	19/144 (13.2%)	13.2% (8.0–19.1%)	<0.001
Ventilation duration (s) *	1	0.70 (0.50–1.10)	0.71	<0.001

Note: Unadjusted: continuous variables were tested vs. preset numeric targets (one-sample t if Shapiro–Wilk $p > 0.05$; Wilcoxon otherwise). For within-range outcomes we report counts (n/N, %) and exact 95% CIs (no distributional p -value shown). Adjusted: models include age and gender—linear regression (HC3 SE) for near-normal outcomes, quantile regression with bootstrap for non-normal continuous outcomes, and logistic regression reporting adjusted marginal % (bootstrap 95% CI) for within-range binaries. Bootstrap $B = 3000$. Normality violation is marked with (*).

Adjustment for age and gender produced estimates similar to crude values for most outcomes. Overall, while students could often maintain the correct compression rate, significant challenges were observed in compression depth, recoil, and especially ventilation technique. These deficiencies reflect well-documented difficulties in CPR skill acquisition and highlight the value of simulation-based training with real-time feedback to improve performance.

4. Discussion

The demographic profile of our study provides important context for interpreting the study findings. Consistent with trends reported in the literature, the study population was composed primarily of young female adults, a demographic profile that commonly characterizes undergraduate nursing programs. This predominance of female students reflects broader patterns within the nursing profession and reinforces the relevance of the study's findings to the typical population entering nursing education and early clinical practice [11,12]. Their technological comfort likely facilitated their engagement with instructional materials and supported knowledge acquisition. Simulation-based training and technological advancements have been incorporated in healthcare education, showing how practices have evolved from very early training models to modern high-fidelity simulation systems. Expanding and standardizing SBT could help address persistent safety gaps in healthcare delivery by improving undergraduate students' both technical and non-technical skills [13]. Although nearly half of them reported some prior exposure to resuscitation training, the short duration and seminar-based nature of those experiences suggest that their pre-existing knowledge was relatively superficial. The dissemination of the pre- and post-test on theoretical knowledge was not to directly correlate these results with the students' practical performance on the simulator. Rather, the tests were primarily intended to assess participants' baseline knowledge of first aid. The significant improvement in post-test scores, however, demonstrated the achievement of the seminar's learning objectives in the theoretical component. Furthermore, the low rates of resuscitation manual ownership,

first aid kit possession, and actual first aid experience indicate limited opportunities for skill reinforcement outside the classroom.

A cross-sectional study on undergraduate nursing school students supported that the overall BLS knowledge of undergraduate nursing school students is markedly weak, indicating significant gaps in essential life-saving competencies. Although prior BLS training might lead to modest improvements in knowledge and confidence, the small difference between trained and untrained students suggests that existing courses may be insufficiently comprehensive or practice-oriented to achieve true mastery. At the same time, the strong willingness of students to attend BLS courses demonstrates a receptive and motivated learner population, highlighting an opportunity for curricula to incorporate more robust and repeated BLS instruction. Notably, the most common barriers—lack of confidence, fear of performing CPR incorrectly, and concerns about potential consequences—emphasize the need for greater hands-on practice, simulation-based training, and structured feedback. Strengthening these components within nursing programs could help build competence, reduce anxiety, and better prepare students to respond effectively in real clinical emergencies [14].

Another study revealed that nursing students possessed very limited theoretical knowledge of BLS, highlighting the need for structured training. Key findings demonstrated that none of the nursing students answered all questionnaire items correctly, and the majority scored below 50%, indicating significant gaps in awareness of essential BLS concepts such as recognition of cardiac arrest and CPR sequence. Their theoretical background deficiency was concerning, as nursing students are often expected to act as first responders in clinical emergencies. The findings underscore the urgent need for structured, mandatory BLS education within nursing curricula, complemented by simulation-based training to bridge the gap between knowledge and practical application. According to the authors, simulation enables students to practice critical skills in a safe, controlled environment, reinforcing theoretical concepts while improving confidence, decision-making, and readiness to respond effectively during real-life emergencies. Integrating both robust theoretical instruction and hands-on simulation can enhance overall competency, patient safety, and preparedness among future nursing professionals [15].

Achieving the target metrics for both chest compressions and ventilations is the cornerstone for effective, high-quality CPR and should be highlighted as a key area for improvement. The total session time exceeded the prespecified 60 s target (median 73.5 s, IQR 68.0–82.0), suggesting a need for enhanced efficiency during CPR practice. Although many participants recorded two cycles, crude completion data indicates that a notable fraction did not complete the expected two cycles within the measured interval (107/144, 74.3% reached the nominal 2-cycle value), pointing to time management and transitions between compressions and ventilations as areas that may require additional training emphasis. These results underscore the importance of optimizing procedural fluency and timing in simulation-based CPR training programs. Literature suggests that improving CPR quality requires more than just meeting basic performance targets: minimizing interruptions, ensuring correct compression depth and rate, and avoiding excessive ventilation are all critical components of high-quality CPR. The review highlights that feedback devices and real-time performance metrics can significantly enhance CPR delivery by helping rescuers monitor and correct their technique. In the context of our findings—where timing and transitions are problematic—integrating real-time feedback into simulation could help participants become more aware of inefficiencies as they occur, enabling them to adjust in the moment. Ultimately, combining strict metric-based training with feedback-guided, physiologically informed simulations may be the most effective strategy to build the procedural fluency and responsiveness needed for truly high-quality CPR [16].

In chest compression metrics, the majority of participants achieved an acceptable compression rate on the device (102/144, 70.8%; adjusted marginal probability 70.8%, 95% CI 63.4–78.2%), but adherence to the recommended compression-depth range (5–6 cm) was low (45/144, 31.2%; adjusted 31.3%, 95% CI 24.1–38.8%), demonstrating a clear need for improved depth control. Full recoil performance was generally high (median 98.0%, IQR 91–100) but did not reach the ideal 100% target, highlighting an opportunity to address technique precision in returning the chest fully to neutral position. The statistically significant deviations from some target values suggest that while students are generally able to deliver sufficient force on average, ensuring optimal depth and complete recoil remains a training priority.

This need has been underscored in literature, noting that real-time feedback devices and quantitative CPR metrics are essential tools for improving compression quality and minimizing variability. By integrating feedback systems that monitor depth, rate, and recoil, training programs can help rescuers correct technique in real time, reduce leaning, and maintain optimal compression performance under fatigue [16]. The abovementioned insights support targeting depth control and recoil precision not just as isolated metrics, but as components of a more holistic, feedback-driven, and physiologically informed CPR training strategy.

Ventilation metrics presented a mixed performance. Very few participants achieved the prespecified ventilation-rate range (10–13/min)—only 4/144 (2.8%) were within range, with an adjusted marginal probability of 2.8% (95% CI 0.6–6.2%). Median ventilation duration was shorter than the 1 s target (median 0.70 s, IQR 0.50–1.10; adjusted median 0.71 s), whereas device-measured PIP adherence was modest (19/144, 13.2%; adjusted 13.2%, 95% CI 8.0–19.1%) and the average PIP was close to the nominal target. These findings suggest participants may apply appropriate pressure during ventilations but struggle with timing and rate control, reinforcing the need for deliberate practice in ventilation techniques to ensure effective oxygen delivery during resuscitation.

In a review published in 2024, it was highlighted that while chest compressions are central to CPR, adequate ventilation is equally critical for ensuring effective oxygenation and carbon dioxide removal during cardiac arrest. The authors emphasize that incorrect ventilation—whether excessive, insufficient, or poorly synchronized with compressions—can increase intrathoracic pressure, reduce venous return, and impair perfusion, ultimately compromising CPR effectiveness. Optimal ventilation strategies, including correct rate, volume, and timing, are particularly important in in-hospital settings, during prolonged resuscitation, or when an advanced airway is in place. The review underscores the need for CPR training programs, simulation exercises, and real-time feedback devices to explicitly focus on ventilation quality alongside compression metrics. By integrating ventilation into performance monitoring and skill development, healthcare providers can improve overall CPR quality, enhance patient outcomes, and reduce the physiological detriments associated with inadequate or poorly timed ventilations [17].

Importantly, adjustment for age and gender produced estimates that were similar to crude values for most outcomes, indicating that the observed performance gaps are unlikely to be explained solely by these measured demographic factors. Several outcomes have many tied or discrete values (for example integer counts of compressions or ventilations), which complicates exact inference and can produce apparent inconsistencies between unadjusted significance tests and adjusted point estimates. Additionally, some binary within-range outcomes have very small event counts (for example ventilation-rate adherence), so those proportions and associated inference should be interpreted with caution.

In summary, while compression rate was often within the acceptable range, deficiencies in compression depth, complete recoil and ventilation timing are evident and warrant

targeted instructional focus. Simulation-based CPR training should therefore emphasise depth control, complete recoil and controlled ventilation timing in addition to rhythm maintenance. Future work should evaluate whether repeated practice, immediate feedback and longitudinal follow-up improve these specific skill domains and transfer to real-world performance.

Simulation-Based Learning: A Paradigm Shift

Simulation-based education has been established as a highly effective approach in nursing training, as demonstrated by recent studies. Clinical simulation courses on BLS significantly enhanced undergraduate nursing students' theoretical knowledge, practical skills, and confidence in performing critical interventions [14,16]. Similarly, a systematic review concluded that simulation-based learning (SBL) substantially improves nursing students' clinical competencies, preparedness, and ability to handle real-world scenarios [18]. Actually, these findings also align with earlier research which highlighted the effectiveness of simulation-based CPR training in equipping nursing students with essential skills and confidence [16]. Collectively, simulation integration into nursing curricula can improve education quality and ultimately enhance patient outcomes.

New technology implementation in CPR teaching, like the OMNI2 simulator, offers advanced yet user-friendly tools designed to enhance simulation-based training in healthcare education. Its features provide instructors with the ability to create realistic and adaptable scenarios, ensuring effective skills development for nursing students. This innovative tool supports the growing emphasis on simulation in healthcare training by facilitating practical, hands-on learning experiences that closely replicate real-life clinical environments [10]. The implementation of the OMNI2 simulator, as also supported by our study, offers significant advantages in CPR education. Its capacity to deliver objective, real-time feedback enables learners to immediately identify and correct errors in compression depth, rate, recoil, and ventilation quality. This interactive process not only enhances psychomotor skill acquisition but also promotes learner engagement and motivation, transforming CPR training from a passive instructional session into an active, learner-centered experience. Furthermore, the simulator allows for standardized assessment across participants, ensuring consistency and reliability in evaluating performance outcomes [10,16].

Through the implementation of this technology, we identified several challenges in traditional CPR training methods that warrant improvement. Many students struggled to consistently achieve the recommended compression depth, which may be attributed to either improper technique or insufficient physical strength, as detected by the simulator. Similar findings have been documented in previous studies, where depth and recoil were among the most difficult CPR skills to master. Furthermore, the frequent observation of overventilation and prolonged ventilation times in our cohort highlights the need for clearer instruction and more structured practice. These deficiencies suggest that conventional teaching methods, which often lack individualized feedback, may not adequately address critical aspects of CPR performance.

The abovementioned findings are consistent with those reported by Requena-Mullor et al. (2021) [19], who emphasized the importance of real-time feedback in enhancing CPR performance. Their results highlight similar challenges, particularly in achieving correct compression depth and appropriate ventilation, thereby reinforcing the necessity of repeated, simulation-based practice to achieve mastery. The capacity of simulators such as the OMNI2 to provide objective, immediate feedback represents a substantial advancement over traditional training approaches. By identifying errors in real time and guiding corrective action, simulation-based methods not only improve skill acquisition but

also promote confidence and long-term retention, ultimately supporting the development of higher-quality resuscitation practices [19,20].

5. Limitations and Future Research

Our study was limited by its single-institution sample and the assessment of CPR performance at only one time point, which does not allow evaluation of long-term skill retention. Additionally, performance was measured solely on a simulator and therefore may not fully reflect students' behavior in real clinical emergencies. Future research should include multi-center cohorts, repeated training sessions with longitudinal follow-up, and assessments in more realistic or high-fidelity scenarios to better capture skill progression and real-world applicability.

6. Conclusions

This study highlights the transformative potential of simulation-based CPR training using the OMNI2 simulator. By providing real-time feedback and objective metrics, simulators enhance the proficiency of trainees, bridging the gap between classroom learning and real-world application.

Emerging technologies promise to further revolutionize medical education, making training more effective and accessible. Investing in these innovations is essential for preparing the next generation of healthcare professionals to deliver high-quality care and improve patient outcomes globally.

Author Contributions: F.A. conceptualized the study, contributed to the methodology, data analysis, and drafted the manuscript; A.K. contributed to the methodology and data collection; C.T. was responsible for writing and drafting the manuscript; T.K. contributed to data collection; P.K. supervised the study; P.M. supervised the study. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Nursing Department (Project identification code 461, 2023-09-21).

Informed Consent Statement: Informed consent for participation was obtained from all subjects involved in the study.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: The authors would like to thank all colleagues and collaborators who contributed helpful discussions and feedback during the development of this work. No external funding was received for this study.

Conflicts of Interest: All authors have no financial support and potential conflicts of interest for this work.

Appendix A

Knowledge Assessment Test

Educational Program: Basic Life Support (BLS)

Instructions: Please select the single best answer for each question.

1. Chest compressions are performed with hand placement:
 - A. In the middle of the sternum
 - B. At the tip of the sternum

- C. Two fingers above the tip of the sternum
 - D. With one hand in adults over 18 years old
 - E. Both A + D are correct
2. The compression-to-rescue breath ratio in adult victims is:
 - A. 20:2
 - B. 15:2
 - C. 10:2
 - D. 30:2
 - E. 60:2
 3. Basic CPR is continued until:
 - A. We are replaced
 - B. Spontaneous breathing returns
 - C. The rescuer is exhausted
 - D. All of the above
 - E. None of the above
 4. Defibrillation is followed by:
 - A. Basic CPR for 1 min, then reassessment of the patient
 - B. Checking for signs of life
 - C. Basic CPR for 4 min, then reassessment for signs of life
 - D. Basic CPR for 2 min without checking pulse or breathing
 5. If the victim is unresponsive but breathing normally, all of the following apply except:
 - A. Place the victim in the recovery position
 - B. Call for help
 - C. Monitor the victim regularly
 - D. Do nothing
 6. In Basic CPR, each rescue breath has:
 - A. Duration of 1 s
 - B. Duration of 2 s
 - C. Duration of 3 s
 - D. Duration of 1 s and a volume of 500 mL
 - E. Duration of 2 s and a volume of 500 mL
 7. If the victim is unresponsive and not breathing normally, all of the following apply except:
 - A. Send someone for help, or if alone, go yourself
 - B. Start chest compressions without checking for a pulse
 - C. Check for a pulse before starting Basic CPR
 - D. Do not provide rescue breaths
 8. In severe airway obstruction with consciousness, all of the following are performed except:
 - A. Back blows
 - B. Abdominal thrusts
 - C. Alternating A and B
 - D. Finger sweep
 9. During the Basic Life Support algorithm, breathing is assessed by:
 - A. Using "look–listen–feel"
 - B. Placing the ear on the patient's chest
 - C. Placing the hand on the patient's chest

- D. Placing the ear near the victim's face
 - E. With a special device
10. The primary priority when providing first aid is:
- A. Ensuring the safety of rescuer, victim, and bystanders
 - B. Providing 5 initial rescue breaths to adult victims
 - C. Starting Basic CPR
 - D. Both A + B are correct
 - E. Both B + C are correct
11. Basic CPR begins when:
- A. The victim is unresponsive to the environment
 - B. The victim has no pulse
 - C. The victim is unresponsive and not breathing normally
 - D. The victim has no pulse and no breathing
 - E. The victim has fainted
12. A rescuer performing Basic CPR should be replaced (if another rescuer is available) every:
- A. 1 min
 - B. 2 min
 - C. 3 min
 - D. 4 min
 - E. 5 min
13. If the victim is responsive and breathing normally:
- A. Leave them in the recovery position
 - B. Try to identify the underlying problem
 - C. Check for possible injuries
 - D. Reassess the victim regularly
 - E. Call for assistance and remain nearby if deterioration is possible
 - F. All of the above
14. The maximum duration for delivering two rescue breaths in Basic CPR should be:
- A. 2 s
 - B. 5 s
 - C. 10 s
 - D. None of the above
15. The compression-to-rescue breath ratio for pediatric patients by trained healthcare professionals is:
- A. 20:2
 - B. 15:2
 - C. 10:2
 - D. 30:2
16. In the case of a nosebleed:
- A. Sniff hard through the nose
 - B. Apply repeated pressure on the nostrils for at least 5 min
 - C. Tilt the head backward
 - D. Wait for it to stop
 - E. Take aspirin

17. In the care of a completely amputated limb, which of the following is not included:
 - A. Cleaning with normal saline
 - B. Wrapping with sterile gauze
 - C. Placing in a waterproof bag, then in a container with ice
 - D. Placing directly into a container with ice
18. A tourniquet is applied:
 - A. 1–2 cm above the wound, not over a joint
 - B. 3–4 cm above the wound, not over a joint
 - C. 5–7 cm above the wound, not over a joint
 - D. 8–10 cm above the wound, not over a joint
19. In first aid for an impaled object in the abdomen:
 - A. Remove the object and treat the wound
 - B. Do not remove; secure it firmly before transport
 - C. Do not remove; secure it loosely before transport
 - D. None of the above
20. In mild airway obstruction with consciousness:
 - A. Perform back blows
 - B. Perform abdominal thrusts
 - C. Alternate A and B
 - D. Encourage the victim to cough
 - E. Both A + D are correct
 - F. Both B + D are correct

Appendix B

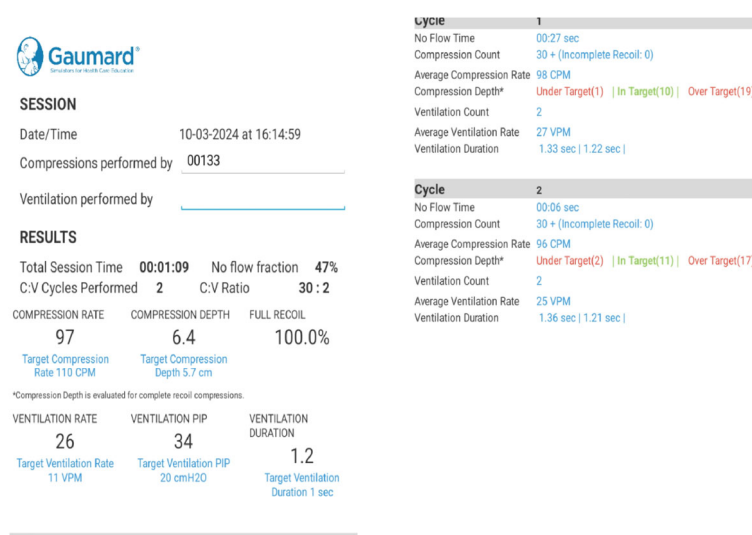


Figure A1. OMNI2 example report for participant.

References

1. Patel, K.; Hipkind, J.E. Cardiac Arrest. In *StatPearls [Internet]*; StatPearls Publishing: Treasure Island, FL, USA, 2023; Updated 2023 April 7. Available online: <https://www.ncbi.nlm.nih.gov/books/NBK534866/> (accessed on 26 November 2024).
2. Myat, A.; Ong, M.E.H.; Perkins, G.D.; Nolan, J.P. Out-of-hospital cardiac arrest: Current concepts. *Lancet* **2018**, *391*, 970–979. [CrossRef] [PubMed]
3. Tang, X.; Zhuang, H.; Yu, H. A bidirectional Mendelian randomization analysis between COVID-19 and cardiac arrest. *Int. J. Environ. Health Res.* **2024**, *35*, 233–244. [CrossRef] [PubMed]

4. Dormire, S.L.; Harlow Adamek, R.C.; Shields, S.M.; Wilkens, C.; McLennon, S.; Vela, C.; Moffitt, C. A Framework to Redesign Nursing Undergraduate Curriculum: One Program's Journey. *J. Nurs. Educ.* **2025**, *64*, 27–33. [\[CrossRef\]](#) [\[PubMed\]](#)
5. Greif, R.; Lauridsen, K.G.; Djärv, T.; Ek, J.E.; Monnelly, V.; Monsieurs, K.G.; Nikolaou, N.; Olasveengen, T.M.; Semeraro, F.; Spartinou, A.; et al. European Resuscitation Council Guidelines 2025: Executive Summary. *Resuscitation* **2025**, *215* (Suppl. S1), 110770. [\[CrossRef\]](#) [\[PubMed\]](#)
6. Wyckoff, M.H.; Greif, R.; Morley, P.T.; Ng, K.C.; Olasveengen, T.M.; Singletary, E.M.; Soar, J.; Berg, K.M. 2022 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations: Summary from the basic life support; advanced life support; pediatric life support; neonatal life support; education, implementation, and teams; and first aid task forces. *Circulation* **2022**, *146*, e483–e557. [\[CrossRef\]](#) [\[PubMed\]](#)
7. Perkins, G.D.; European Resuscitation Council Guideline Collaborators. European Resuscitation Council Guidelines 2021: Executive summary. *Resuscitation* **2021**, *161*, 1–60. [\[CrossRef\]](#) [\[PubMed\]](#)
8. Bray, J.E.; Greif, R.; Morley, P. The future of resuscitation education. *Curr. Opin. Crit. Care* **2022**, *28*, 270–275. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Cheng, A.; Nadkarni, V.M.; Mancini, M.B.; Hunt, E.A.; Sinz, E.H.; Merchant, R.M.; Donoghue, A.; Duff, J.P.; Eppich, W.; Auerbach, M.; et al. Resuscitation education science: Educational strategies to improve outcomes from cardiac arrest: A scientific statement from the American Heart Association. *Circulation* **2018**, *138*, e82–e122. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Omni 2: Simulation Made Easy. Available online: <https://www.gaumard.com/omni2> (accessed on 26 November 2024).
11. Prosen, M. Nursing Students' Perception of Gender-Defined Roles in Nursing: A Qualitative Descriptive Study. *BMC Nurs.* **2022**, *21*, 104. [\[CrossRef\]](#) [\[PubMed\]](#)
12. Collingburn, J.D.; Bourke, S.L.; Copnell, B. Gender Diversity in Nursing Undergraduate Curricula: A Scoping Review. *Nurse Educ. Today* **2025**, *152*, 106749. [\[CrossRef\]](#) [\[PubMed\]](#)
13. Bienstock, J.; Heuer, A. A Review on the Evolution of Simulation-Based Training to Help Build a Safer Future. *Medicine* **2022**, *101*, e29503. [\[CrossRef\]](#) [\[PubMed\]](#)
14. Alfakey, M.; Alkarani, A. Students' Knowledge and Attitudes toward Basic Life Support. *Int. J. Eval. Res. Educ.* **2021**, *10*, 871–877. [\[CrossRef\]](#)
15. Chandrasekaran, S.; Kumar, S.; Bhat, S.A.; Saravanakumar; Shabbir, P.M.; Chandrasekaran, V. Awareness of Basic Life Support among Medical, Dental, Nursing Students and Doctors. *Indian J. Anaesth.* **2010**, *54*, 121–126. [\[CrossRef\]](#) [\[PubMed\]](#)
16. Abella, B.S. High-Quality Cardiopulmonary Resuscitation: Current and Future Directions. *Curr. Opin. Crit. Care* **2016**, *22*, 218–224. [\[CrossRef\]](#) [\[PubMed\]](#)
17. van Eijk, J.A.; Doeleman, L.C.; Loer, S.A.; Koster, R.W.; van Schuppen, H.; Schober, P. Ventilation during Cardiopulmonary Resuscitation: A Narrative Review. *Resuscitation* **2024**, *203*, 110366. [\[CrossRef\]](#) [\[PubMed\]](#)
18. Demirtas, A.; Guvenc, G.; Aslan, Ö.; Unver, V.; Basak, T.; Kaya, C. Effectiveness of simulation-based cardiopulmonary resuscitation training programs on fourth-year nursing students. *Australas. Emerg. Care* **2021**, *24*, 4–10. [\[CrossRef\]](#) [\[PubMed\]](#)
19. Requena-Mullor, M.D.M.; Alarcón-Rodríguez, R.; Ventura-Miranda, M.I.; García-González, J. Effects of a clinical simulation course about basic life support on undergraduate nursing students' learning. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1409. [\[CrossRef\]](#) [\[PubMed\]](#)
20. Alharbi, A.; Nurfianti, A.; Mullen, R.F.; McClure, J.D.; Miller, W.H. The effectiveness of simulation-based learning (SBL) on students' knowledge and skills in nursing programs: A systematic review. *BMC Med. Educ.* **2024**, *24*, 1099. [\[CrossRef\]](#) [\[PubMed\]](#)

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.