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Posted Date: 23 April 2025

doi: 10.20944/preprints202504.1979.v1

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

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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 stimulator, 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-hour Basic Life Support Seminar. It consisted of 5 hours theoretical instruction followed by 3 hours of practical training using the OMNI2 simulator. Each student was tasked with identifying cardiac arrest and performing 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 stimulator's specified targets. Statistically significant differences ($p < 0.05$) were observed across all parameters, except for peak inspiratory pressure. Concluding, 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 accuracy, potentially leading to improved patient outcomes in the future.

Keywords: Cardiopulmonary Resuscitation; CPR; Simulation-Based Training; Undergraduate Nursing Education; OMNI2 Simulator; Skills Development

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 bystander with CPR skills has a mean value of 58%, but with a range varying between 13 and 83% in 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].

 doi:10.20944/preprints202504.1979.v1

In 2021, the European Resuscitation Council (ERC) refined their guidelines for Advanced Life Support (ALS) highlighting the importance of delivering high-quality chest compressions and minimizing gaps between cycles [4].

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. These deviations can significantly impact patient outcomes, highlighting the critical need for innovative and effective training methodologies [5,6].

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 manikins has been thought to be the gold standard method of acquiring CRP skills. Technology advancements has 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 [7,8].

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 depth, recoil, rate, and ventilation quality, ensuring accurate technique. The system accommodates age-specific protocols for adults, pediatrics, and infants, and includes a virtual shock panel for defibrillation practice. A built-in virtual patient monitor displays over 25 vital signs, including ECG rhythms and blood pressure, enabling realistic clinical scenarios [9].

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 CPR skills and ensuring readiness for real-life emergencies [9].

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

Materials and Methods

Study Design and Objectives

This observational study was conducted at the National and Kapodistrian University of Athens (NKUA) to evaluate how simulation-based training improves CPR proficiency among undergraduate students. 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.

Participants

Our study enrolled 144 undergraduate students from the NKUA Health Sciences department, of Nursing School, with no prior professional official CPR training. All participants filled a written informed consent. Demographic characteristics were documented and all participants filled a first aid questionnaire before and immediately after the seminar. The questionnaire consisted of 20 multiple choice questions, of a single best answer.

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.

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

The theoretical Introduction, lasted 5 hours, 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). The theoretical part ended with a demonstration of a cardiac arrest case and performance of CPR. In the practical training part, which lasted 3 hours, participants practiced on a manikin connected to the OMNI2 simulator one by one.

Each participant was assigned to identify a cardiac arrest case and perform two sequential cycles of CPR, which were recorded and analyzed. 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).

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

Table 1. Undergraduate Students. 2 Cycles of CPR Using the OMNI2 Simulator

Parameters	Test target value	Mean value ± SD	Mean Difference	P value
Total session time (sec)	60	75.35 ± 11.19	15.354	<0.05
Cycles performed	2	1.71 ± 0.43	-0.257	<0.05
Compressions / cycle	30	37.33 ± 13.77	7.326	<0.05
Ventilations / cycle	2	1.51 ± 0.68	-0.493	<0.05
Compression rate / min	110	103.57 ± 8.68	-6.431	<0.05
Compression depth (cm)	5.7	6.765 ± 2.52	1.0653	<0.05
Full recoil (%)	100	90.9 ± 17.67	-9.097	<0.05
Ventilation rate / min	11	15.69 ± 12.51	4.668	<0.05
Ventilation PIP (cmH2O)	**20**	**19.25 ± 13.23**	**-0.750**	**>0.05**
Ventilation duration (sec)	1	0.763 ± 0.45	-0.2368	<0.05

Statistical Analysis

Data were collected and analyzed using SPSS software. A paired t-test compared measured values to the simulator's target values, with a significance threshold of $p < 0.05$.

Results

Demographic Findings

Our study cohort included participants aged 19–23 years, with a majority of 62.3% being female. Most participants were adept with modern technologies, owning both a computer and a smartphone. 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.

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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. On a first aid questionnaire, 58% scored below the 10 points baseline initially, but significant improvement was observed post-seminar, with 74% achieving scores above 15 out of 20.

Table number 1 summarizes the performance of undergraduate Nursing School students using the OMNI® 2 simulator to perform two sequential CPR cycles. The total session time averaged 75.35 seconds, significantly exceeding the target of 60 seconds. Participants performed 1.71 CPR cycles on average, which was fewer than the target of 2 cycles.

In chest compression metrics, the mean compression rate was 103.6 per minute (target: 110), with a mean depth of 6.77 cm (target: 6 cm) and 90.9% achieving full recoil (target: 100%). These results showed statistically significant differences from the target values ($p < 0.05$).

Regarding ventilation, participants achieved a mean rate of 15.69 ventilations per minute, with an average duration of 0.76 seconds per ventilation, both significantly different from preset targets. The mean peak inspiratory pressure (PIP) was 19.25 cm H2O, consistently within acceptable limits, with no significant difference.

Discussion

The findings of this study highlight key areas for improvement in undergraduate Nursing School students' CPR performance using the OMNI® 2 simulator, particularly in achieving the target metrics for both chest compressions and ventilations. The total session time exceeded the target of 60 seconds, suggesting a need for enhanced efficiency during CPR practice. Bystander CPR has been associated with better outcomes for survivors and literature suggests that the time for cardiac arrest recognition should not exceed a 10 seconds threshold. Participants' completion of only 1.71 CPR cycles on average, compared to the target of 2 cycles, indicates that time management and transitions between compressions and ventilations may require additional training emphasis. These results underscore the importance of optimizing procedural fluency and timing in simulation-based CPR training programs.

In chest compression metrics, the mean rate of 103.6 compressions per minute fell short of the target of 110 compressions per minute. However, the mean compression depth of 6.77 cm exceeded the target of 6 cm, demonstrating participants' ability to deliver adequate force. The full recoil rate of 90.9%, though commendable, did not meet the target of 100%, highlighting an opportunity to address technique precision in returning the chest fully to its neutral position. According to literature, full recoil is an essential part to facilitate venous return. The statistically significant deviations from target values suggest that while students are generally able to deliver compressions with sufficient depth, maintaining an optimal rate and ensuring complete recoil remain challenges that require focused interventions in CPR training curricula.

Ventilation metrics presented a mixed performance. Although the mean ventilation rate of 15.69 per minute and the average duration of 0.76 seconds per ventilation were significantly different from the targets, the mean peak inspiratory pressure (PIP) of 19.25 cm H2O was close to the target of 20 cm H2O, with no significant statistical difference. This suggests that participants may have a better understanding of pressure application during ventilations than they do of rate and duration. However, the significant discrepancies in ventilation timing metrics emphasize the need for more deliberate practice in this area to ensure effective oxygen delivery during resuscitation. These findings reinforce the importance of comprehensive CPR training that equally addresses compression quality and ventilation technique.

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 basic life support (BLS) significantly enhanced undergraduate nursing students' theoretical knowledge, practical skills, and

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confidence in performing critical interventions. [11] Similarly, a systematic review and concluded that simulation-based learning (SBL) substantially improves nursing students' clinical competencies, preparedness, and ability to handle real-world scenarios. [12] 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. [11] 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.[9] OMNI2 simulator implementation, as also supported by our study, offers unparalleled advantages in CPR education. Its ability to provide objective, real-time feedback transforms traditional learning approaches into dynamic, engaging experiences.

Through the implementation of this technology, we identified challenges in traditional CPR training methods that require improvement. Many students struggled to consistently achieve the recommended depth, possibly due to improper technique or insufficient strength, as detected by the simulator. Moreover, overventilation and prolonged ventilation durations indicate a need for better guidance. The abovementioned findings align with studies by Requena-Mullor et al. (2021) and Perkins et al. (2021), which emphasize the role of real-time feedback in improving CPR performance. These studies highlight similar challenges, reinforcing the need for repeated, simulation-based practice to achieve mastery.

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.

Acknowledgments: The author(s) declare that there are no acknowledgements for this study.

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