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Simulation and education

Maintenance of CPR skills among nursing students trained using Resuscitation Quality Improvement® program

Marilyn H. Oermann [a,*], Yolanda M. VanRiel [b], Robin W. Wagner [c], Kelli D. Whittington [d], Manisa Baker [e], Debra E. Stieve [f], Patrick C. Crane [g], Carol A. Vermeesch [h]

[a] Thelma M. Ingles Professor of Nursing, Duke University School of Nursing, 307 Trent Drive, DUMC 3322, Durham, NC 27710, USA
[b] Associate Professor and Chair of Department of Nursing, North Carolina Central University, 3402 Nursing Building, 1801 Fayetteville Street, Durham, NC 27707, USA
[c] Associate Professor and Director Clinical Skills and Simulation Labs, College of Nursing, University of Cincinnati, 3110 Vine Street, Cincinnati, OH, 45221, USA
[d] Assistant Professor and Assistant BSN Program Director, School of Health Sciences, Southern Illinois University Carbondale, 1365 Douglas Drive, Carbondale, IL 62901, USA
[e] Assistant Professor and AG-CNS MSN Concentration Coordinator, Purdue University Northwest, College of Nursing, 2200 169th Street, Hammond, IN 46323, USA
[f] Coordinator of RN-BSN Program, Assistant Professor of Nursing, College of Nursing, Michigan State University, 1355 Bogue Street, East Lansing, MI 48824, USA
[g] Assistant Professor and Nurse Practitioner, College of Nursing, Michigan State University, 1355 Bogue Street, East Lansing, MI 48824, USA
[h] Instructor Emeritus, College of Nursing, Michigan State University, 1355 Bogue Street, East Lansing, MI 48824, USA

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ABSTRACT

Background: The Resuscitation Quality Improvement® (RQI) program is a competency-based approach that provides low dose, high frequency cardiopulmonary resuscitation (CPR) skills training. Limited research has evaluated its effectiveness with nursing students who need to be prepared to respond to cardiopulmonary emergencies despite their student status and to be competent in CPR as they transition into practice.
Objective: The objective of this multisite longitudinal study was to examine the maintenance of adult and infant compressions and ventilation skills by nursing students at 3 and 6 months following practice with real-time feedback using the RQI® program.
Methods: The effectiveness of brief practice of CPR skills at the RQI® simulation station on the maintenance of skills was analyzed with 238 nursing students from six universities across the United States. Participants completed three practice sessions, at baseline (month 0), 3 months, and 6 months. At baseline, they performed compressions and ventilation with a bag-valve mask on adult and infant manikins without feedback (pretest), followed immediately by a session integrating real-time, objective feedback (both audio and visual) on their performance. CPR practice on the manikins with feedback on performance was then repeated every 3 months.
Results: Practicing CPR skills at the RQI® simulation station every 3 months with real-time feedback enabled participants to maintain their compression and ventilation skills and improve them from baseline (month 0) to 6 months. There was no loss of skills among these participants. Median scores on the first attempt to compress and ventilate stayed above the minimum 75 % overall score that learners must achieve to be considered an adequate performance.
Conclusions: This study demonstrated that brief practice of CPR skills at the RQI® simulation station every 3 months with real-time feedback was highly effective for maintaining students' competence in compressions and ventilation. Once the RQI® program is set up in a school, students could practice on their own as needed to maintain their skills.

Introduction

Cardiopulmonary resuscitation (CPR) remains the cornerstone of cardiac arrest management. CPR is a competency for nurses and nursing students to master and retain. Several factors contribute to the deterioration of these skills: length of time in between training, limited

* Corresponding author at: Duke University School of Nursing, DUMC 3322, 307 Trent Drive, Durham, NC 27710, USA.
E-mail addresses: marilyn.oermann@duke.edu (M.H. Oermann), yvanriel@nccu.edu (Y.M. VanRiel), robin.wagner@uc.edu (R.W. Wagner), kellid@siu.edu (K.D. Whittington), baker417@pnw.edu (M. Baker), stieved@msu.edu (D.E. Stieve), cranepat@msu.edu (P.C. Crane), vermeesc@msu.edu (C.A. Vermeesch).

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exposure to cardiac arrest situations, inconsistent training, and variable evaluation of competency.

The need for practice of CPR skills to retain them has been well documented through multiple studies.[1–4] CPR skills decay rapidly, within weeks to months after training, if not used or practiced. In some clinical settings such as intensive care, providers often perform CPR and thus are able to maintain their skills. In most settings, however, providers rarely use their CPR skills, leading to diminished skill proficiency and highlighting the need to practice these skills to retain them.

Background/rationale.

Low dose, high frequency training involves short, targeted simulation-based learning activities spaced over time. This type of training improves CPR skill performance and retention.[1,5–9] Lauridsen et al.[4] conducted a scoping review of 110 studies to identify the optimal strategy for CPR training. They found that brief frequent retraining anywhere from 1 to 6 months was better than less frequent refreshers. Panchal et al.[7] tested this type of training with quarterly practice on two nursing units in a teaching hospital. Low dose, high frequency CPR training resulted in retention of skills (compression rate, depth, and fraction), and the quality of these skills improved significantly.

The Resuscitation Quality Improvement® (RQI®) program is an evidence-based program that provides low dose, high frequency CPR skills training (done quarterly) and verifies skills competence. Positive outcomes of training with RQI® were reported in multiple studies with health care providers.[5,10–13] However, only a few studies have evaluated its effectiveness with nursing students.[9,14]

Objective.

The objective of this multisite longitudinal study was to examine the maintenance of adult and infant compressions and ventilation skills by nursing students at 3 and 6 months following practice with real-time feedback using the RQI® program.

Methods

Study Design and Setting.

This was a longitudinal study to examine the maintenance of CPR skills among nursing students over time. Participants were from six schools of nursing throughout the United States that had adopted the RQI® program in their schools.

Participants.

The sample included a convenience sample of 238 nursing students who had completed three practice sessions with real-time feedback using RQI®, at baseline (month 0), 3 months, and 6 months. Each of the 238 participants had complete demographic and skills performance data for all time points.

All nursing students were eligible to participate in the study. Students who had a physical health problem precluding their ability to perform CPR were excluded. The Institutional Review Board of Mass General Brigham in the United States reviewed the study and determined it was exempt from further review. The study was conducted over a 6-month period at each school.

CPR Training.

Participants were enrolled in the RQI® 2025 Student Healthcare Provider Program. Developed by RQI® Partners, a collaboration between the American Heart Association (AHA) and Laerdal Medical, the program and scoring algorithm adhere to AHA CPR guidelines and clinical evidence. The program includes both an eLearning course, which students completed first, coupled with practical skills activities at the RQI® simulation station. The eLearning course reinforced and assessed students' grasp of key competencies in basic life support (BLS), encompassing compressions, rescue breaths, ventilation, and the use of automated external defibrillators.

In addition to the eLearning course, participants practiced CPR skills on Resusci Anne adult and Resusci Baby manikins at the RQI® simulation station. At baseline, practical skills activities began with an initial assessment of compression and ventilation with a bag-valve mask proficiencies. Students performed 60 consecutive compressions and administered 12 ventilations with a bag-valve mask on the manikins without feedback (pretest), followed immediately by a session integrating real-time, objective feedback (both audio and visual) on their performance. CPR practice on the manikins with audio and visual feedback on performance was then repeated every 3 months. Students view their performance as they are compressing and ventilating the manikin via the display monitor at the simulation station.

Participants practiced at the RQI® station until they achieved the 75 % required passing score. Participants who did not meet the proficiency standards (75 % passing score) for compressions or ventilation with bag-valve mask continued to practice at the RQI station. The RQI® program recommends that participants who are not able to adequately perform CPR after the third practice session take a break before attempting the skill again.

Variables and Measurement.

Demographic data were collected via a questionnaire completed at the beginning of the study prior to CPR practice. Data were collected on age, length of time in the nursing program, prior experience in health care, experience with CPR, type of CPR training, and perception of CPR skills.

The outcomes were students' compression and ventilation skills. In RQI® compressions are evaluated for factors including hand placement, rate, depth, chest recoil, and chest compression fraction, while ventilation performance is assessed based on volume and rate. Participants' proficiency is quantified through scores ranging from 0 to 100 %, with a minimum threshold of 75 % deemed necessary in each skill category (adult compressions, adult ventilation, infant compressions, and infant ventilation) to pass. The scoring algorithm and passing score of 75 % for RQI® were developed by members of the AHA's Emergency Cardiovascular Care Subcommittees and co-authors of the 2013 AHA Consensus Statement on CPR Quality, and are continually updated to align with the AHA Guidelines for CPR.

Statistical Measures.

The RQI® simulation station collects the performance data, which were downloaded and analyzed for this study. Descriptive statistics were calculated including frequencies, percents, means (with standard deviations), and medians (with 25th and 75th percentiles). The data underwent analysis using the cloud computing platform Databricks, with a cluster equipped with Apache Spark 3.4.1.

Results

Demographic Data.

The majority of participants were beginning students who had just started their nursing program (n = 205, 86.1 %). Participants' age ranged from 21 or younger (n = 90, 37.8 %) through 52 to 57 years old (n = 2, 0.80 %). The majority were 21 years old or younger. Although some of the participants had experience working in health care, for example, as a nursing assistant or emergency medical technician, the majority had never performed CPR in their jobs (n = 192, 80.7 %) or only used these skills once a year (n = 23, 9.7 %). The majority of

students completed a BLS or comparable course prior to entering the nursing program or before beginning this study. They believed that their CPR skills remained the same (n = 108, 45.4 %) or decreased slightly (n = 80, 33.6 %) since this training.

Maintenance of CPR Skills.

Practicing CPR skills at the RQI® simulation station every 3 months with real-time feedback enabled participants to maintain their compression and ventilation skills and improve them from baseline (month 0) to 6 months. There was no loss of skills among these participants. Median scores on the first attempt to compress and ventilate stayed above the minimum 75 % overall score that learners must achieve to be considered an adequate performance (Fig. 1). Table 1 reports the measurements for compressions and ventilation.

Percent Passing on First Attempt.

Although most students had a BLS or comparable course prior to this study, only 70.6 % were able to perform adequate compressions on the adult manikin on their first attempt to compress. With quarterly practice, this percent increased to 81.5 % at the 6-month reassessment (Fig. 2). Participants had difficulty performing adult ventilation, with only 71.9 % able to ventilate properly at baseline on their first attempt to ventilate, followed by a decrease in the percent able to ventilate on their first attempt at 3 months before returning to 71.9 %, the same as baseline. Infant compressions and ventilation demonstrated improvement in the percent who could pass these skills from baseline to 6 months as shown in Fig. 2.

Number of Attempts to Pass.

As students practiced CPR with real-time feedback from RQI®, they required fewer attempts to achieve the 75 % overall score needed for passing adult and infant compressions and infant ventilation but not adult ventilation. Fig. 3 displays the average number of attempts that participants needed to achieve the 75 % passing score each quarter.

Table 1
Mean Values for Compressions and Ventilation.

	Baseline M (SD)	3 months M (SD)	6 months M (SD)
Adult Compressions			
Mean Depth (mm)	51.85 (4.84)	52.65 (3.81)	52.97 (3.53)
Mean Rate (cpm)	102.87 (12.37)	103.61 (10.89)	104.52 (9.91)
Adult Ventilation			
Mean Rate (cpm)	13.14 (5.12)	13.31 (3.74)	12.60 (2.86)
Mean Volume (ml)	510.37 (82.27)	496.13 (70.03)	502.21 (62.68)
Infant Compressions			
Mean Depth (mm)	41.56 (2.16)	41.79 (1.82)	42.08 (1.77)
Mean Rate (cpm)	104.31 (10.36)	104.75 (12.06)	106.66 (12.53)
Infant Ventilation			
Mean Rate (cpm)	25.39 (4.88)	25.08 (4.46)	25.08 (4.69)
Mean Volume (ml)	33.87 (7.57)	32.10 (5.06)	32.30 (4.88)

M, mean. SD, standard deviation.

Discussion

Key Results.

This longitudinal study examined low dose, high frequency practice of CPR skills using the RQI® program. CPR is a life-saving skill that requires competence in unpredictable situations. Because of this, it is typically a requirement that nursing students maintain BLS certification throughout their nursing education and be prepared to take on the role of rescuer when the situation arises. Therefore, it is imperative that students retain their knowledge and skills to respond to cardiopulmonary emergencies despite their student status.

The outcomes of this study with nursing students demonstrated that the RQI® program was effective for students to maintain their CPR skills consistent with other studies.[5,10–13] Mota,[13] using a pre-postintervention design, tested the outcomes of RQI® with 30 critical care nurses. Following RQI® training, the quality of the nurses' compressions improved, and RQI® helped them retain those skills. In our study with nursing students, adult and infant compressions and infant ventilation skills improved with this training, and there was no loss of adult ventilation skills at 6 months.

Despite our finding that a 3-month practice interval was effective for preventing loss of skills, the ideal practice interval remains uncertain.[8] Multiple studies have demonstrated practice sessions at a frequency of 1 to 6 months are likely to help health care providers and students retain these psychomotor skills.[2,4,6,14] This study supports this finding as CPR skill retention was maintained or improved at 6 months. Schools of nursing, medicine, and other health care professions should be encouraged to incorporate frequently scheduled CPR practice sessions into their curricula.

This study found that first attempt scores for adult ventilation and infant compressions decreased slightly at the 3-month interval but improved to baseline at the 6-month interval. The decrease in adult

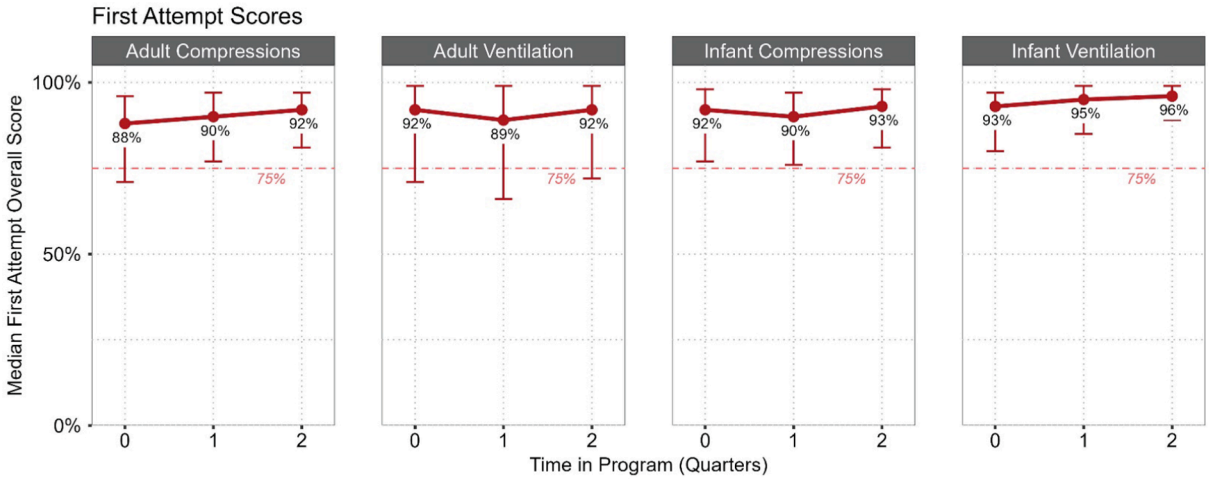

Fig. 1. Median overall scores from participants' first attempts for each activity at the RQI simulation station each quarter. The dashed line labeled 75% represents the minimum overall score that learners must achieve to be considered adequate performance. Participants' time in the program is based on the number of quarters of RQI® they had previously completed at the start of the training session. Lower and upper error bars represent the 25th and 75th percentiles, respectively.

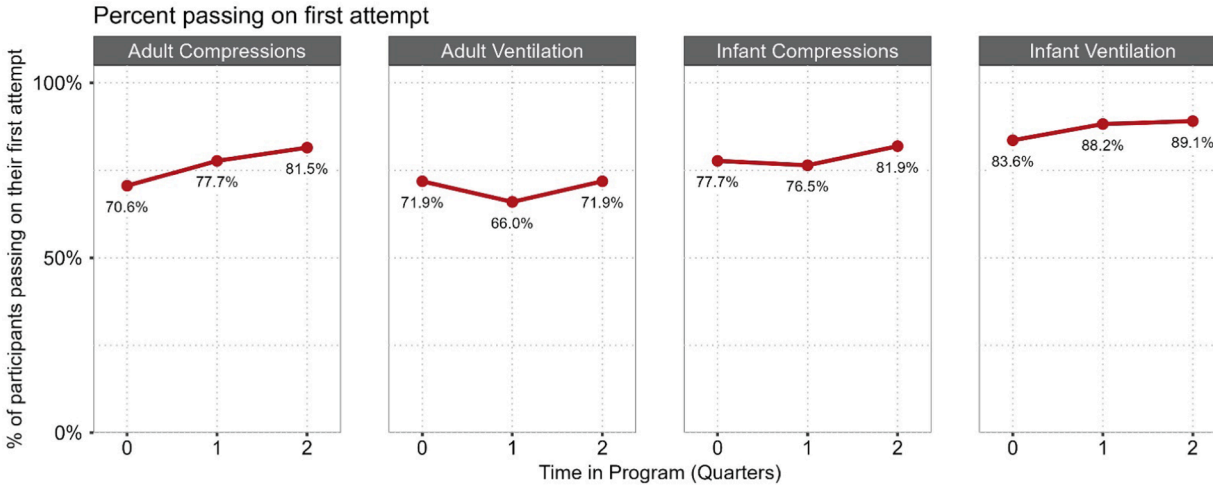

Fig. 2. Percentage of participants reaching at least a 75% overall score (i.e., passing) on their first attempt at the simulation station for each activity each quarter. Participants' time in program is based on the number of quarters of RQI they had previously completed at the start of the training session.

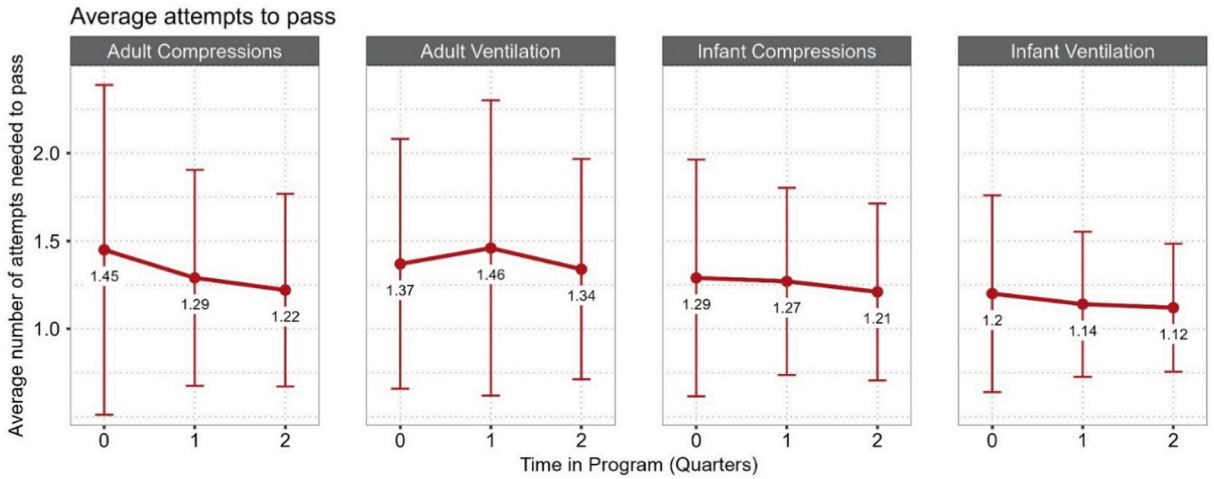

Fig. 3. Average number of attempts that participants needed to achieve the 75% overall score passing threshold each quarter. Participants' time in program is based on the number of quarters of RQI they had previously completed at the start of the training session. Error bars represent the standard deviation, and the lower bars go below 1 (the minimum possible number of attempts to pass) due to high skew in the data.

ventilation first attempt scores could be explained by difficulties with equipment. Accurate bag-valve mask ventilation is a critical component to survival of the patient in respiratory distress. Ventilation success is dependent on the provider's ability to secure the mask with an adequate seal, manipulate the self-inflating bag, and position themselves appropriately relative to the patient.[15] Individual attributes that impact optimal ventilation include provider confidence, gender, overall body size, and hand grasp.[16,17] Students in this study may not have had sufficient handgrip strength and hand width and length to make a proper seal on the manikin.

Limitations.

We did not measure the length of time between students' BLS certification and when they began the study. Most of the participants identified as females, which might have affected their handgrip strength and hand size, impacting their ventilation skills. While practice at the RQI® simulation station was effective for maintenance of competency, performance on the manikin cannot be directly extrapolated to performance in a real clinical situation.

Generalizability.

The findings are generalizable to other prelicensure nursing programs but may not be generalizable to other health care professions programs.

Conclusion

This study demonstrated that brief practice of CPR skills at the RQI® simulation station every 3 months with real-time feedback was highly effective for maintaining competence in compressions and ventilation. Importantly, students' adult and infant compression and infant ventilation skills improved. Once the RQI® program is set up in a school, students could practice on their own as needed to maintain their skills.

Funding

No funding was provided for this study.

Declaration of competing interests

The schools were early adopters of the Resuscitation Quality

Improvement® (RQI) program as part of a partnership of the National League for Nursing, Laerdal Medical, the American Heart Association, and RQI Partners to advance transformation of the standard of resuscitation care for cardiac arrest by preparing nursing students with high-quality CPR skills. The authors had sole responsibility for implementing the project in their schools and for writing and submitting the manuscript. Data on participants' performance of CPR skills were collected through the RQI® simulation station and provided to the authors. Carla Vanderbilt, PhD, Data Impact Analyst, RQI Partners, provided an analysis of the data for the authors but was not involved in writing the manuscript. Lauren Gaumer, Vice President, Research & Design, RQI Partners, read a draft of the manuscript at the authors' request. The authors declare no conflicts of interest.

CRediT authorship contribution statement

Marilyn H. Oermann: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Yolanda M. VanRiel:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Robin W. Wagner:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation. **Kelli D. Whittington:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation. **Manisa Baker:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation. **Debra E. Stieve:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation. **Patrick C. Crane:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation. **Carol A. Vermeesch:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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