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Implementation of a Low-Dose, High-Frequency Cardiac Resuscitation Quality Improvement Program in a Community Hospital

Lorna Rozanski Dudzik, DNP, RN, APN; Debra G. Heard, PhD; Russell E. Griffin, MBA, LP, FP-C; Mary Vercellino, MSN, RN, ACNS-BC, CWON; Amanda Hunt, MS, BSN, RN; Adam Cates; Maureen Rebholz, EdD, MSN, RN

Background: In 2015 the American Heart Association launched the Resuscitation Quality Improvement® (RQI®) Program to address the urgent need to improve in-hospital cardiac arrest survival through a novel competency-based model for health care provider (HCP) cardiopulmonary resuscitation (CPR) training. This innovation differs from the traditional Basic Life Support (BLS) training model by providing self-directed, low-dose, high-frequency CPR skill activities with the objectives of skills mastery and retention. A program implementation study was conducted at the first hospital in the state of Illinois to adopt RQI in 2016.

Methods: The study was designed to evaluate implementation of the RQI program, CPR performance during RQI simulation sessions, and participant impressions at a community hospital. Quantitative data were evaluated based on psychomotor compression and ventilation performance. Quantitative and qualitative data were evaluated based on a perceptual CPR confidence and program satisfaction survey.

Results: Statistical analysis demonstrates significant improvement in HCPs' quarterly psychomotor CPR skill performance over a one-year period in first compression score, and first and highest ventilation score per quarterly session. The number of attempts to pass the ventilation skill session decreased between the first and fourth quarter. Survey results of HCPs' program perceptions 30 months post–RQI implementation indicate satisfaction with the RQI program and an increase in CPR skill confidence.

Conclusion: Findings demonstrate that the RQI program for ongoing verification of BLS skill and knowledge provides improvements in HCPs' CPR psychomotor competence and confidence/satisfaction using an efficient and sustainable method at a community hospital.

In-hospital cardiac arrest (IHCA) presents unique and critical challenges in which health care providers' (HCPs') performance quality, or lack thereof, can significantly alter patient survival rates. Apprehension due to lack of confidence or skill incompetence can play a detrimental role in patient outcomes. According to the American Heart Association (AHA), high-quality cardiopulmonary resuscitation (CPR) is critical for patient survival,[1] and The Joint Commission requires that hospital staff are trained through evidence-based training programs to recognize the need for and use of resuscitation equipment/techniques.[2] However, HCPs report feeling ill-prepared to respond effectively to inpatient resuscitation emergencies,[3] and research has found that HCPs routinely fall short in the delivery of high-quality CPR.[4–6]

IHCA is a low-frequency event, which contributes to HCPs' reported lack of confidence. The median incidence of cardiac arrest was 4 per 1,000 admissions in a study of more than 100,000 adult IHCAs at 358 hospitals in the United States between 2000 and 2009.[7] National statistics indicate that approximately 25% of American adults who suffered IHCA in 2017 survived to discharge.[8] Research has demonstrated a 42% variation in unadjusted survival rates between US hospitals, suggesting substantial disparities in the quality of resuscitation across geographic regions and between hospitals.[9] Differences in survival rates between hospitals could be due, among other factors, to inconsistent HCP CPR quality. As a result, emphasis is placed on hospitals' responsibility to invest in quality initiatives to ensure the best possible cardiac arrest outcomes for their patients.[9,10]

According to the AHA, the significance of inadequate retention of HCP CPR skills is common and crosses all disciplines and providers, from nurses to physicians.[11] Traditionally, HCPs complete Basic Life Support (BLS) provider-level training/certification via the biennial instructor-led classroom training model. However, research demonstrates that high-dose, low-frequency training does not sustain provider CPR competence, and skills decay within 3 to 12 months following training.[5,6,11–14]

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Figure 1: This mobile station houses the Laerdal Resusci Anne® adult/infant manikins, bag-valve mask, and an integrated computer laptop to connect the learner to American Heart Association training material for quarterly cardiopulmonary resuscitation (CPR) skill activities. Resuscitation Quality Improvement® (RQI) Program images included with the permission of RQI Partners, LLC, on behalf of the American Heart Association and Laerdal Medical A/S. QCPR, Quality CPR; BVM, bag valve mask.

RQI PROGRAM AND THEORETICAL UNDERPINNINGS

According to an AHA consensus statement published in 2013, "Poor quality CPR should be considered a preventable harm."[1(p. 418)] In 2018 the AHA partnered with Laerdal Medical, an international manufacturer of simulation manikins, life support training, and technology, on an initiative to save an additional 50,000 lives each year by developing and implementing Resuscitation Quality Improvement® (RQI®) nationwide.[15,16] RQI is vastly different from the traditional BLS model, as RQI includes brief online eSimulation and psychomotor skill modules practiced quarterly on mobile training stations. RQI is designed with a competency-based approach that emphasizes skill mastery through low-dose, high-frequency training,[15,17] which is the opposite of the traditional BLS certification model that uses a high-dose, four-hour classroom training session and low-frequency biennial training.

The concept of mastery learning proposes that all learners can and should achieve excellence with consistent measurable outcomes instead of simply meeting minimum standards. The mastery learning model includes a pretest, curriculum delivery and deliberate practice, posttest, review of the curriculum/skills and repeat testing if needed, and frequent refresher training.[18] In 2018 the AHA published a scientific statement to address gaps in educational strategies for resuscitation, including the need to use mastery learning, deliberate practice, and spaced learning as methods to improve HCP BLS training.[19] RQI uses these innovative educational strategies and has demonstrated enhanced CPR quality and performance.[20] The RQI online cognitive modules contain video education and interactive cardiac arrest eSimulations. The mobile training station consists of a Laerdal Resusci Anne® adult/infant manikin and a Quality CPR (QCPR) measurement device embedded in the chest and integrated with a laptop monitoring system (Figure 1). As the single learner practices psychomotor skills, the QCPR sensors measure compression/ventilation performance according to the most recent AHA standards and provide real-time audiovisual feedback via the RQI laptop screen to facilitate adaptive learning (Figure 2).[17] On completion of 60 compressions and one minute of ventilations, the laptop screen promptly displays a detailed feedback analysis and score of compression/ventilation performance with areas of improvement identified (Figure 3). The RQI program is designed with an expectation that learners will return for training every quarter; however, compliance tracking and disciplinary enforcement is ultimately a participating hospital's decision and responsibility. Individual learners' CPR performance data are archived in the RQI analytic program for quality improvement tracking and retrieval.

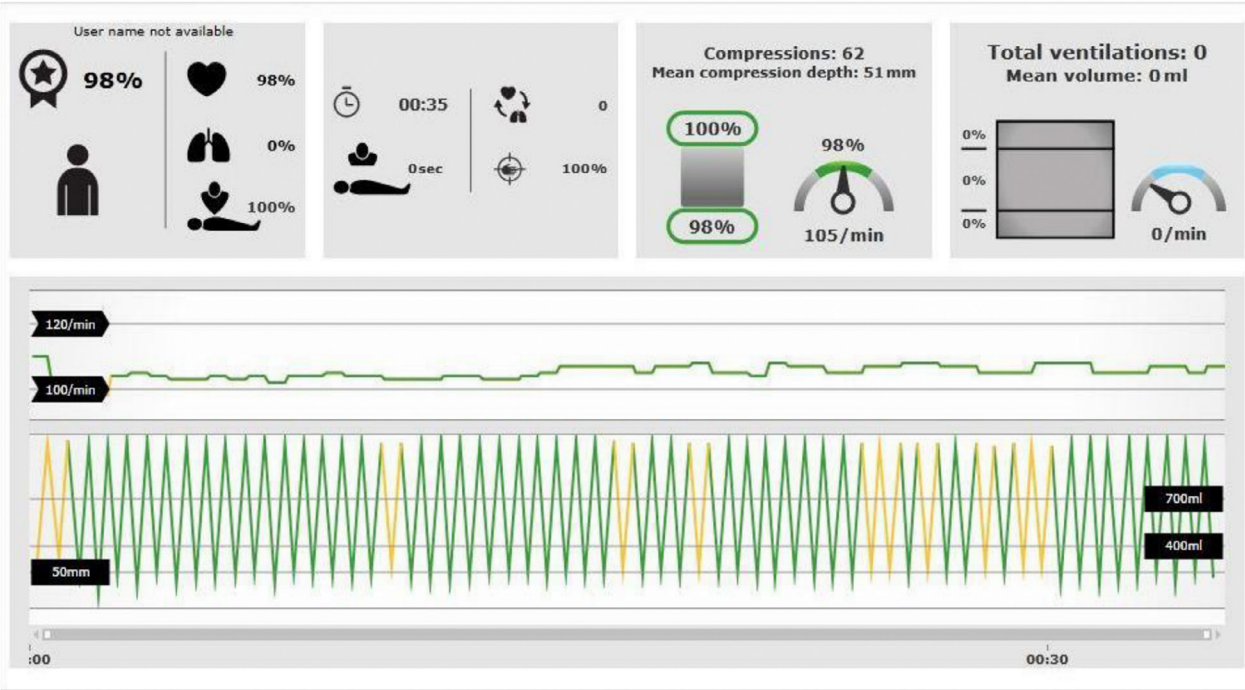

Figure 2: This is an example of a student debriefing screen from a ventilation skills exercise, showing the student's overall score (98%) with the key performance metrics (for example, rate, depth, hand placement). During the RQI quarterly cardiopulmonary resuscitation (CPR) training activities, learners are provided real-time audiovisual feedback and debriefing analytics showing the overall score with key compression/ventilation performance metrics for adaptive learning. Resuscitation Quality Improvement® (RQI) Program images included with the permission of RQI Partners, LLC, on behalf of the American Heart Association and Laerdal Medical A/S.

OBJECTIVE

This implementation study sought to evaluate the RQI program at a community hospital with an analysis of program implementation, CPR performance technique, and participant impressions. We examined HCPs' compression/ventilation skill competence as a result of the RQI program over four quarters. In addition, we studied the effects of RQI training on HCPs' CPR performance confidence and satisfaction with the educational method compared with traditional BLS certification and maintenance.

METHODS

Setting

This study began in 2016 at the first hospital in the state of Illinois to implement RQI: Illinois Valley Community Hospital (IVCH), Peru. This 49-bed rural acute care hospital and accompanying outpatient clinics serve portions of three counties located approximately 100 miles south of Chicago.[21]

CPR Training Policies Before the Intervention

Prior to 2016 all HCPs were required to participate in biennial BLS training taught by an instructor via the traditional classroom model. Paid training for several four-hour classroom sessions was offered at IVCH for employees to attend during nonwork time. To fulfill BLS certification requirements, attendees were required to pass a CPR skills test based on instructor visual inspection of their compression and ventilation performance, per AHA guidelines.

Study Participants

IVCH provided required certification internally for HCPs using RQI for BLS certification during the program implementation and evaluation. The participants in the psychomotor skills section of this study were all HCPs who began initial RQI training in the first quarter of 2016. Between 2016 and 2018, RQI training continued for original participants and was initiated for new hires and HCPs not enrolled at the program start. The participants for the perceptual survey section of this study were all HCPs enrolled in RQI during June 2018. This study was granted approval by the Lewis University Institutional Review Board.

Study Time Line

RQI psychomotor score data were collected for all RQI training sessions in 2016. Perceptual data were collected via a survey sent out June 5, 2018, with responses collected until June 29, 2018.

Outcome Measures

Psychomotor Performance Data. RQI learner CPR psychomotor skill is measured through the QCPR manikin

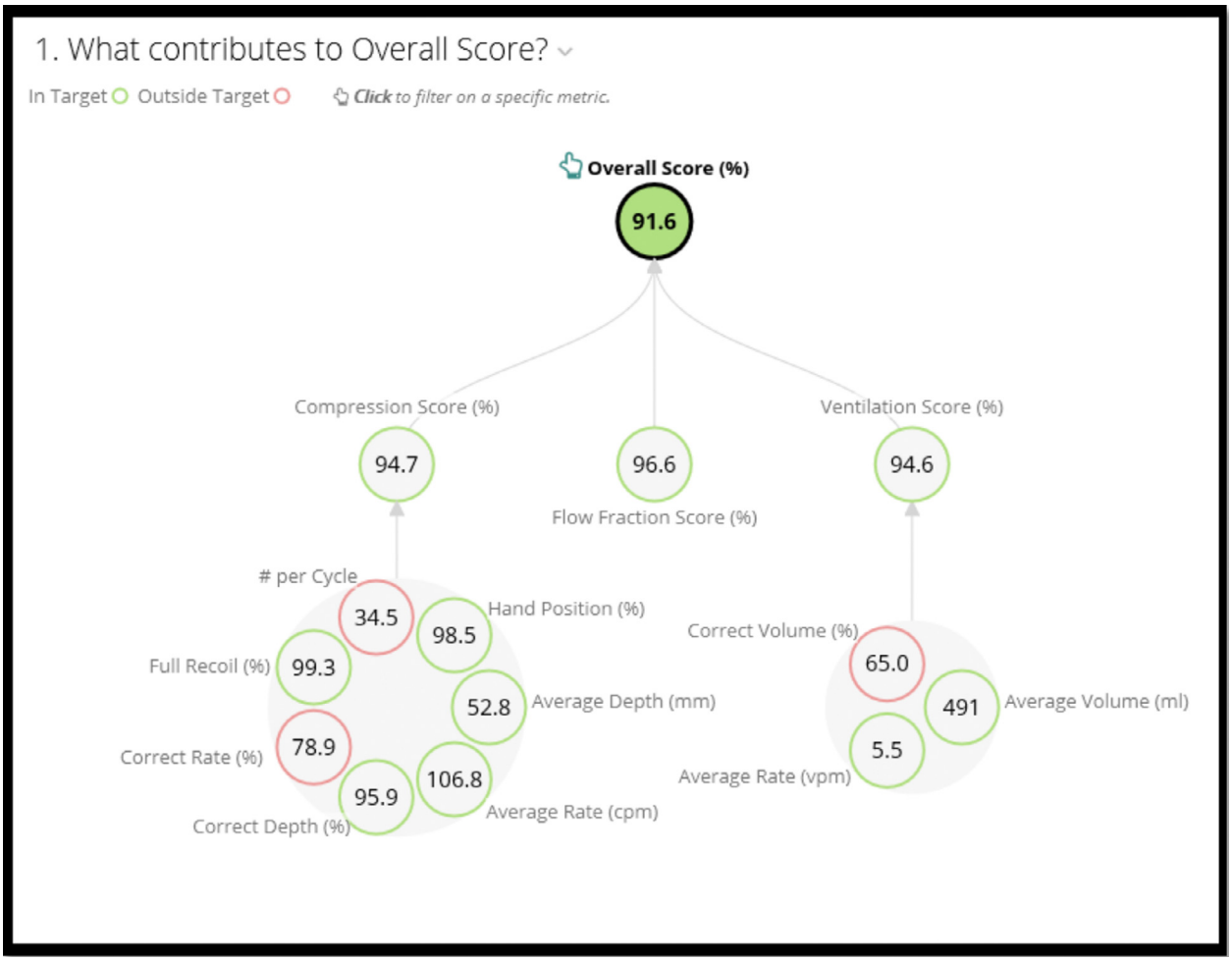

Figure 3: The RQI score is based on the learner's performance and is calculated using the portrayed compression/ventilation parameters, which reflect the most up-to-date American Heart Association guideline target metrics for high-quality cardiopulmonary resuscitation (CPR). Resuscitation Quality Improvement® (RQI) Program images included with the permission of RQI Partners, LLC, on behalf of the American Heart Association and Laerdal Medical A/S.

of the RQI mobile training station. The compression/ventilation performance data are uploaded to the RQI analytic system, where they are archived for retrieval and analysis.[22]

In accordance with the AHA guidelines for target CPR performance metrics,[23] RQI QCPR manikins are programmed to measure the learner's ability to meet core CPR quality standards. The RQI compression score is calculated using the following five adult parameters: (1) compression rate between 100 and 120 per minute, (2) compression depth > 50 mm, (3) chest recoil (complete release with no leaning), (4) flow fraction (proportion of total resuscitation time that compressions are performed, with a target minimum of 60%), and (5) correct hand position. The RQI ventilation score is calculated using the following two adult parameters: (1) ventilation volume of 400 to 700 mL tidal volume, and (2) ventilation rate of 8 to 12 breaths/minute.[22,23] A testing score of 75% or higher is required for the RQI learner to pass the compression/ventilation skill evaluation, and unlimited attempts are allowed to achieve a passing score (Figure 3). The RQI software does not stop learners from completing additional attempts after they achieve a passing score.

Survey Data. Data collection for learners' self-assessment of CPR confidence and RQI satisfaction level was initiated via an IVCH employee e-mail invitation in June 2018 to access a survey link. The survey was adapted from two previously used research surveys created by the University of Rochester [24,25] and consisted of 10 demographic items, 6 Likert scale items, and qualitative open-ended items. Survey responses were voluntary and anonymous.

Study Design and Analysis

Quantitative psychomotor data were analyzed using Stata 13.1 (StataCorp LLC, College Station, Texas). RQI psychomotor performance data for learners completing training in every quarter were analyzed using two skill activities,

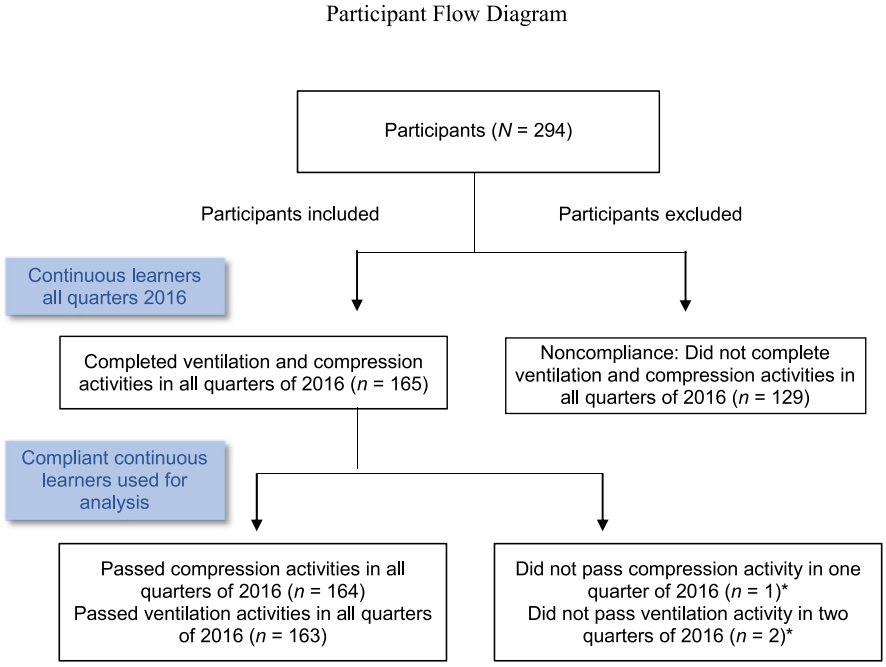

Figure 4: This figure provides the flow of IVCH RQI participants that resulted in the final analysis *n* that were eligible for inclusion in psychomotor skills analysis. IVCH, Illinois Valley Community Hospital: RQI, Resuscitation Quality Improvement. * These additional continuous learners were excluded from either the compression or ventilation analysis due to inability to pass the respective skills in all four quarters of the study period.

(1) compressions and (2) ventilations, and three measurements: quarterly scores for the (1) first score per session and (2) highest score per session achieved for each skill activity and (3) quarterly number of attempts completed to successfully pass each skill activity. These three outcome measurements were then analyzed between Q [quarter]1 and Q4 using a Wilcoxon signed rank test for each of the skill activities.

Survey data, including learner demographics and Likert scale survey responses, were analyzed via descriptive statistics to yield frequencies, standard deviations, and percentages. Open-ended item responses were analyzed for key word/phrase and theme frequency.

RESULTS

Compliance with RQI

In Q1 2016, 294 HCPs were enrolled in RQI and completed at least one training day. Only 165 (56.1%) HCPs completed quarterly training in both ventilation and compression activities for all the remaining quarters of 2016. Noncompliance is described in Figure 4.

Psychomotor Performance

The results for participants completing four continuous quarters of compression and ventilation activities with RQI are displayed in Table 1. For compression skill activity, median first score per session was higher in Q4 2016 compared to Q1 2016 (89.0 vs. 84.0; $p = 0.0011$). For ventilation skill activity, the median first score and highest score per session were higher in Q4 2016 compared to Q1 2016 ([84.6 vs. 62.0; $p = 0.0000$] and [98.0 vs. 92.0; $p = 0.0000$], respectively). For ventilation skill activity, although Table 1 shows 0 median difference score in number of attempts to pass from Q1 to Q4, the rank sums are significantly different between Q1 and Q4 and median number of attempts to pass is lower in Q4 than in Q1 (1.0 vs. 2.0; $p = 0.0000$). Score performance by quarter is shown in Figures 5 and 6.

Survey

Of the 359 IVCH RQI participants who were e-mailed survey invitations, 132 (36.8%) completed the survey. The survey respondents were primarily registered nurses (58.3%) and included a variety of other HCPs (for example, ancillary staff, diagnostic technicians, physicians). The participants had a mean of 18 years of health care experience and mainly represented medical-surgical, obstetrics, diagnostic imaging, and emergency departments. Of the 132 respondents, 89 (67.4%) agreed or strongly agreed that RQI was their preferred method of BLS training versus the AHA traditional model or online HeartCode BLS option.[24] The six Likert scale items showed improved CPR confidence and RQI satisfaction (Table 2).

Qualitative Responses. Of the 132 survey respondents, 81.8% provided comments regarding what they liked

Table 1. IVCH Learner RQI Compression/Ventilation Skill Performance Comparison Results

	Compressions						
		Q1 2016		Q4 2016		Median difference score	Wilcoxon signed rank test *z*, *p*
	*n**	Mean (SD)‡	Median (IQR)‡	Mean (SD)‡	Median (IQR)‡	Q1 2016 to Q4 2016 (IQR)	
Compressions first score§	164	72.2 (28.7)	84.0 (59.0–94.0)	80.2 (24.5)	89.0 (74.3–96.5)	3.6 (−5.9 to 21.1)	−3.27, 0.0011
Compressions highest score§	164	89.4 (9.7)	91.0 (84.0–97.0)	91.8 (7.8)	93.3 (88.0–97.5)	0.8 −4.4 to 9.1)	−2.36, 0.0185
Number of attempts to pass‖	164	1.7 (1.3)	1.0 (1.0–2.0)	1.6 (1.5)	1.0 (1.0–2.0)	0.0 (0.0–1.0)	2.43, 0.0151
	Ventilations						
		Q1 2016		Q4 2016		Median difference score	Wilcoxon signed rank test *z*, *p*
	n†	Mean (SD)‡	Median (IQR)‡	Mean (SD)‡	Median (IQR)‡	Q1 2016 to Q4 2016 (IQR)	
Ventilations first score§	163	56.7 (32.8)	62.0 (25.0–88.0)	74.5 (28.0)	84.6 (61.9–98.2)	14.3 (−7.0 to 43.0)	−5.32, 0.0000
Ventilations highest score§	163	90.8 (7.8)	92.0 (86.0–98.0)	94.4 (7.8)	98.0 (91.6–99.4)	2.60 (−1.7 to 10.0)	−4.56, 0.0000
Number of attempts to pass‖	163	2.3 (1.9)	2.0 (1.0–3.0)	1.6 (0.8)	1.0 (1.0 to 2.0)	0.0 (0.0–1.0)	4.50, 0.0000

IVCH, Illinois Valley Community Hospital; RQI, Resuscitation Quality Improvement; Q, quarter; SD, standard deviation; IQR, interquartile range.

* One compression 4-quarter continuous learner dropped from final data set due to no passing score in at least 1 quarter.

† Two ventilation 4-quarter continuous learners dropped from final data set due to no passing score in at least 1 quarter.

‡ Data for each score and attempt outcome are non-normal.

§ For any learners completing more than one day of training in a quarter, first scores and highest scores are averaged across all completed days.

‖ For learners passing more than one day in a quarter, number of attempts to pass is averaged across all completed days. For learners who did not pass on one day in a quarter but passed on a subsequent day, number of attempts to pass is the total number of attempts from the day without passing added to the attempts on the subsequent day until a passing score was achieved.

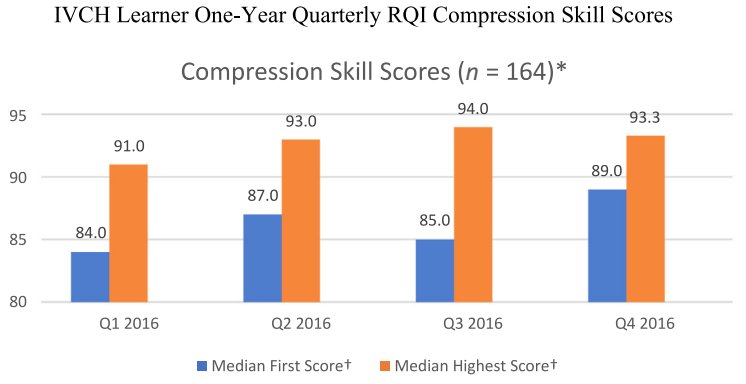

Figure 5: This figure depicts RQI quarterly data results of the median first and highest compression scores performed by Illinois Valley Community Hospital (IVCH) learners. RQI, Resuscitation Quality Improvement; Q, quarter.

* One compression 4-quarter continuous learner dropped from final data set due to no passing score in at least 1 quarter.

† For any learners completing more than one day of training in a quarter, first scores and highest scores are averaged across all completed days.

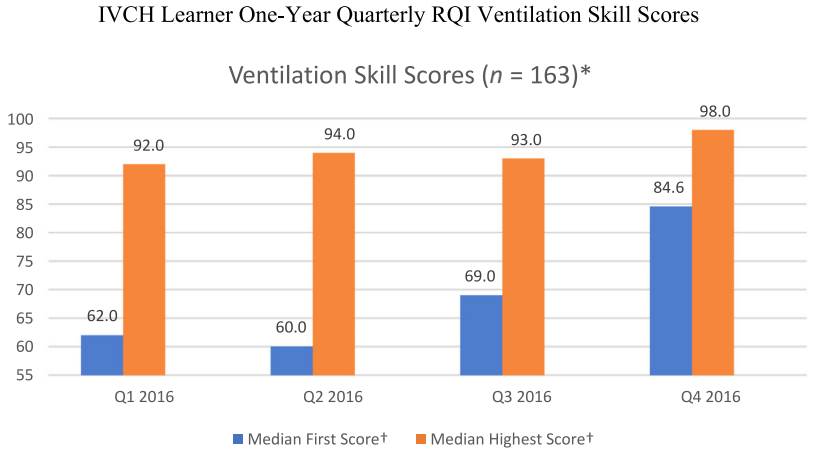

Figure 6: This figure depicts RQI quarterly data results of the median first and highest ventilation scores performed by Illinois Valley Community Hospital (IVCH) learners. RQI, Resuscitation Quality Improvement; Q, quarter.
* Two ventilation 4-quarter continuous learners dropped from final data set due to no passing score in at least 1 quarter.
† For any learners completing more than one day of training in a quarter, first scores and highest scores are averaged across all completed days.

Table 2. IVCH CPR Confidence and RQI Satisfaction Survey Results

N = 132	Strongly agree *n* (%)	Agree *n* (%)	Neither *n* (%)	Disagree *n* (%)	Strongly disagree *n* (%)	Not answered *n* (%)
The RQI modality is an effective way to learn BLS.	41 (31.1)	72 (54.5)	15 (11.4)	1 (0.8)	1 (0.8)	2 (1.5)
I prefer learning BLS using the RQI manikin to other methods.	41 (31.1)	48 (36.4)	26 (19.7)	16 (12.1)	1 (0.8)	0 (0)
The quarterly sessions of learning BLS provided by RQI manikins to test my level of CPR skill is effective.	35 (26.5)	64 (48.5)	24 (18.2)	9 (6.8)	0 (0)	0 (0)
Prior to the RQI program, I was confident in my ability to perform BLS.	30 (22.7)	65 (49.2)	25 (18.9)	12 (9.1)	0 (0)	0 (0)
After taking this RQI program, I am confident in my ability to perform BLS.	41 (31.1)	79 (59.8)	9 (6.8)	3 (2.3)	0 (0)	0 (0)
Skills obtained using the RQI program will improve how I perform BLS in the future.	34 (25.8)	68 (51.5)	24 (18.2)	5 (3.8)	0 (0)	1 (0.8)

IVCH, Illinois Valley Community Hospital; CPR, cardiopulmonary resuscitation; RQI, Resuscitation Quality Improvement; BLS, Basic Life Support.

about the RQI program. The most common reasons cited were the hands-on nature of RQI and real-time feedback provided during CPR. Additional positive comments focused on autonomy, repetition, and training at one's own pace.

Most respondents (65.2%) provided comments regarding what they disliked about RQI. The most frequently cited reason was excessive time demands of quarterly online modules and skill practice. Other negative comments pertained to perceived equipment or system flaws, which disrupted learners' training efficiency, performance, and satisfaction.

Cost Comparison

A simple cost comparison (Appendix 1, available in online article) shows that the total cost of the RQI program per year was 47.4% less than the cost of yearly traditional BLS training expenses at IVCH.

DISCUSSION

In this pilot implementation study, the RQI program resulted in improved CPR psychomotor compression and ventilation skill performance skills and greater confidence and satisfaction for program participants. Administrators

were supportive of the program because of the identified need to improve CPR confidence and competence as a patient safety and quality issue. In addition, program implementation was approved because the total cost was less for RQI than for traditional instructor-led BLS, and the logistics of placing a mobile training station within the hospital were simple.

Implementation Successes

Participant survey responses indicate subjective program success. The survey was launched 30 months after RQI was implemented at IVCH, thus some participants had completed 10 quarters of RQI before returning the survey. However, we did not track how many quarterly training sessions survey participants had completed or their performance scores. The survey findings demonstrate high satisfaction levels with the RQI program by IVCH learners and support for RQI among respondents based on the unique features of the program, such as hands-on practice, immediate feedback, self-direction, and convenient BLS training. These findings are congruent with similar research of nontraditional BLS training methods involving online eSimulation and real-time audiovisual manikin feedback technology.[24,26,27] The results of this study also align with the recent AHA scientific statement that recommends progressive educational strategies designed to improve cardiac arrest outcomes.[19]

IVCH benefited from a 47.4% annual cost reduction for BLS certification by using RQI instead of the traditional model. The main source of this cost reduction is salary costs not incurred with brief RQI training, which can be completed during scheduled work hours. Administrators were not queried to determine any positive or negative effects of brief training during scheduled shifts, which could be a valuable addition to future research.

Limitations

One main limitation of this study is that all attempts, including the first one on any given training day, include real-time audiovisual feedback that coaches participant improvement throughout the attempts. Therefore, there are no true baseline scores or follow-up measures of skill retention between quarterly training sessions. Future research should look at skill retention using a skills assessment without feedback. In light of this limitation, this study did note improvement in CPR performance over time, indicating some impact of RQI training, whether it was more familiarity with the training and testing sessions or true performance improvement and skills retention over time.

The second main study limitation is the lack of compliance with quarterly training requirements among 43.9% of participants. Although the hospital in this study expected and tracked compliance, it did not enforce disciplinary action until an employee missed two quarters of training. We do not know why the compliance rate was so low for RQI, although possible reasons are forgetting, dislike of or frustration with the system, dramatic culture change in mode of training, confidence in skills, leave of absence or medical leave, and staff changes. This study analyzed only data from learners with complete four-quarter compliance as prescribed with the RQI program, even though approximately half of the noncompliant learners missed only one quarter and returned for future training. This study did not link performance data with survey responses, which could uncover reasons for noncompliance and examine solutions to overcome noncompliance.

IVCH does not track IHCA outcomes. Thus, the impact of RQI and score improvement on real-world CPR performance and survival is unknown.

CONCLUSION

The RQI program was studied at a single hospital to verify improved competence of HCPs' CPR techniques after one year of low-dose, high-frequency training. Psychomotor compression and ventilation skill performance improved. HCPs reported greater confidence in BLS skills and high satisfaction with the learning method after participation in the RQI program. These results suggest the potential of a new training method to create high-quality CPR skill mastery and retention.

The impact of RQI should be assessed even for participants who miss some quarterly training sessions to determine the optimal spacing of training for retention and improvement, and whether that spacing varies by learner. Additional research could assess RQI scores and learner satisfaction at hospitals where compliance with training is required and closely monitored. More research is needed to overcome study limitations, confirm these findings at other hospitals, and determine whether RQI can improve IHCA patient survival outcomes.

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Conflicts of Interest. Debra G. Heard is a compensated consultant for the American Heart Association. Russell E. Griffin and Adam Cates are staff with RQI Partners, LLC. All other authors report no conflicts of interest.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jcjq.2019.08.010.

Lorna Rozanski Dudzik, DNP, RN, APN, is Assistant Professor, College of Nursing and Health Sciences, Lewis University, Romeoville, Illinois, and AHA Instructor and Get With The Guidelines®–Resuscitation Data

Abstractor, Edward Hospital, Naperville, Illinois. **Debra G. Heard, PhD**, is Consultant, American Heart Association, Dallas. **Russell E. Griffin, MBA, LP, FP-C**, is Vice President, Strategic Research and Innovation, RQI Partners, LLC, Dallas. **Mary Vercellino, MSN, RN, ACNS-BC, CWON**, is Clinical Nurse Specialist–Diabetes, Clinical Education, Edward Hospital and Health Services, Naperville. **Amanda Hunt, MS, BSN, RN**, is System Manager, Simulation and Training, Edward-Elmhurst Health, Naperville. **Adam Cates** is Impact Manager, RQI Partners, LLC, Chicago. **Maureen Rebholz, EdD, MSN, RN**, is Director of Education, Illinois Valley Community Hospital, Peru, Illinois. Please address correspondence to Lorna Rozanski Dudzik, lornardudzik@lewisu.edu, lornadudz@yahoo.com.

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