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# Findings From a Nursing Student CPR Study

*Implications for Staff Development Educators*

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This article reports a secondary data analysis of a year-long study with 606 nursing students involving brief monthly CPR practice with voice-activated manikins versus no practice. Findings indicate that even with monthly practice and accurate voice-activated manikin feedback, some students could not perform CPR correctly. Implications of these findings for staff educators are discussed.

Chances of patient survival of a cardiac event are improved with the rapid implementation of high-quality CPR (Perkins et al., 2008). Satisfactory completion of a basic life support (BLS) course is required for nurses working in hospitals, and in many cases, an advanced cardiac life support (ACLS) course is now also required (Carpico & Jenkins, 2011). Hospital educators spend significant amounts of time in training and maintaining biennial BLS courses for hospital nurses and other healthcare providers. Nursing students, arguably the most novice of CPR providers, are also required to complete a BLS course successfully prior to beginning hospital-based clinical experiences (Gombotz, Weh, Mitterndorfer, & Rehak, 2006).

Clinical experience in and of itself does not enable healthcare providers to maintain or increase competency in BLS or ACLS (De Regge, Calle, De Paepe, & Monsieurs, 2008; Jensen et al., 2009). Smith, Gilcreast, and Pierce (2008) found that only 63% of nurses (44% were working in critical care or emergency departments/operating rooms) could pass BLS at 3 months after course completion and only 58% at 12 months. A recent study found that 52% of cardiac arrests documented in intensive care settings had frequent CPR deficiencies, for example, too shallow compression depth, compression rate of less than 100 per minute, and too high ventilation rate (Abella et al., 2005). It may be that providers are not developing sufficient skill during CPR training. In one study, CPR instructors were able to accurately assess mouth-to-mouth ventilations but were not accurate in assessing hand placement or compression depth (Lynch, Einspruch, Nichol, & Aufderheide, 2008). Smith et al. suggested several variables that might affect skill retention, among them instructor variations, skill complexity, and lack of practice. Instructor inattention to CPR quality and a general lack of rigor during CPR skill training have been cited as reasons for lack of provider skill after course completion (Arshid, Lo, & Reynolds, 2009; Perkins et al., 2008). However, the number of nurses who are unable to perform *any* compressions or ventilations correctly according to American Heart Association (AHA) guidelines has not been previously reported in the literature.

This article reports secondary study findings documenting the number of participants who were unable to perform compressions or ventilations with bag valve mask (BVM) correctly, as defined by the AHA, at any point during a study on retention of CPR skills.

## METHODS

Ten schools of nursing participated in a year-long study (Kardong-Edgren, Oermann, Odom-Maryon, & Ha, 2010;

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The American Heart Association (AHA) and Laerdal Medical Corporation supplied manikins and supplies for the study, free of charge to the study sites. These organizations funded the entire study through a grant to the National League for Nursing (NLN). The NLN coordinated the project with the funding provided for the Principal Investigator (M. O.) and research team. Members of the NLN, AHA, and Laerdal Medical Corporation worked with the investigators who designed the study. These organizations were not involved in the collection, data analysis, interpretation of data, or writing, or submission of the manuscript. Site coordinators and investigators were responsible for study implementation and uploading of data. The investigators were completely responsible for analysis of data and interpretation and for writing and submitting this manuscript for publication. No restrictions were placed on the statistical analysis or publication of the findings by the NLN, AHA, or Laerdal Medical Corporation.

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Oermann, Kardong-Edgren, & Odom-Maryon, 2011). Four schools used the HeartCode BLS (HC) with voice-activated manikin (VAM) course, and six used instructor-led (IL) courses (assignment of course instruction type was randomly chosen) to document initial CPR competency. Two of the IL schools used Resusci-Anne manikins (Manikin A), and the other three used a blue hard molded plastic CPR manikin (Manikin B). All participants successfully completed an initial CPR course. To then enter the study, all students completed a 9-minute study pretest (3 minutes each of compressions, ventilations with BVM, and single rescuer CPR) on a Resusci-Anne SkillReporter manikin.

Participants ($n$ = 606) from both courses were then randomized into a group that practiced CPR skills with VAM technology for 6 minutes a month (2 minutes each of compressions, ventilations with BVM, and single rescuer CPR) for up to 1 year or a group that did no further practice until the posttest. Participants in both groups (monthly practice and no practice) were assigned a randomized posttest time at 3, 6, 9, or 12 months. The posttest was the same as the pretest, a 9-minute skills performance (3 minutes each of compressions, ventilations with BVM, and single rescuer CPR) on a Resusci-Anne SkillReporter manikin.

VAMs provide computer-generated voice coaching based on compressions and ventilations as the trainee practices CPR on the manikin. For example, the manikin may guide the trainee to "compress faster," "check hand placement," or "ventilate more slowly." Depending on a participant's randomly assigned posttest month (3, 6, 9, or 12 months from baseline), a posttest assessment (test-out) that mirrored the baseline assessment was then performed using a Resusci-Anne SkillReporter manikin.

## Outcomes

The primary outcomes examined were based on the 2005 AHA guidelines for CPR, which defined *correctly performed compressions* as compressions with an adequate depth of between 38 and 51 mm, correct hand position, and complete chest release. *Correctly performed ventilations* (using a BVM) were defined by the AHA as ventilations between 500 and 800 ml with an inflation rate <800 ml per second and the airway open during the inflation part of the ventilation (AHA, 2005). All three parameters for a correct compression or ventilation had to be met for the action to be counted as one without errors. Using the AHA definitions, two dichotomous outcomes were constructed: one outcome to identify participants who were unable to perform any compressions correctly and one outcome to identify those unable to perform any ventilations correctly.

## Data Analysis

The percentage of the total compressions and ventilations performed without errors from the posttest assessment were compared using a mixed linear model analysis including group (monthly practice or no practice), posttest month (3, 6, 9, and 12), and a Group × Posttest Month interaction term as main effects. Pretest CPR data and course/manikin type (HC, IL-Manikin A, and IL-Manikin B) were included in the model as a covariate. The main study findings and further details about the analytic methods have been published elsewhere (Kardong-Edgren et al., 2010; Oermann et al., 2011).

To examine the dichotomous outcomes (yes or no) examining the inability of participants to perform any compressions correctly or to perform any ventilations correctly, the same model was examined using generalized estimating

**TABLE 1 Comparisons of CPR Skill Performance for 606 Nursing Students by Monthly Practice Group**

| | Monthly Practice | | | No Monthly Practice | | | Mixed Linear Model[a] | |
|---|---|---|---|---|---|---|---|---|
| | | Pretest | Posttest | | Pretest | Posttest | | |
| CPR Skill[b] | *n* | *M* (*SD*) | *M* (*SD*) | *n* | *M* (*SD*) | *M* (*SD*) | *F*(*df1*, *df2*) | *p* |
| Percentages of compressions performed without errors | 302 | 37.3 (34.5) | 49.2 (33.2) | 303 | 33.2 (33.7) | 39.7 (34.8) | 8.74 (1,592) | .003 |
| Percentage of ventilations performed without errors | 301 | 31.5 (31.4) | 48.0 (32.3) | 303 | 34.5 (33.5) | 36.7 (33.7) | 15.98 (1,590) | <.0001 |

[a]Value of *p* for practice group effect from a mixed linear model using posttest CPR skill as outcome, group (monthly practice or no practice), posttest month (3, 6, 9, or 12), Group × Posttest Month interaction term as main effects, and including pretest CPR skill and course type (HC, IL-Manikin A or IL-Manikin B) as covariates.
[b]Correctly performed compressions are compressions with an adequate depth of between 38 and 51 mm, correct hand position, and with complete chest release. Correctly performed ventilations are ventilations between 500 and 800 ml with an inflation rate of <800 ml per second and an open airway during the inflation part of the ventilation (AHA, 2005).

equations (logistic model). All significance testing was done at .05 level (two sided). The SAS software (Version 9.1) FREQ, MIXED, and GENMOD procedures were used.

## RESULTS

### Compression Data

Monthly practice improved CPR performance by decreasing the percentage of compressions that had errors (see Table 1). Immediately after successful completion of the BLS course, the monthly practice group ($n$ = 302) performed an average of only 37.3% ($SD$ = 34.5%) of compressions without errors in the study pretest. With practice, their skill improved: at posttest the monthly practice group performed nearly half ($M$ = 49.2%, $SD$ = 33.2%) of their compressions correctly. Note that the posttest mean represents the grand mean from all posttest groups (3, 6, 9, and 12 months). In the no practice group ($n$ = 303), at pretest students performed only 33.2% ($SD$ = 35.7%) of all compressions correctly; that increased slightly at posttest ($M$ = 39.7%, $SD$ = 34.8%). Adjusting for pretest CPR skill differences and course type, the difference in mean percentage of compressions performed correctly at posttest between practice groups was statistically significant (49.2% compared with 39.7%, $p$ = .003). The difference in mean percentage of compressions performed correctly between course/manikin group at posttest (HC: $M$ = 50.1, $SD$ = 34.5; IL-Manikin A: $M$ = 37.6, $SD$ = 33.3; IL-Manikin B: $M$ = 41.0, $SD$ = 33.7) was also marginally statistically significant ($p$ = .05).

Although practice improved students' ability to perform compressions, the numbers of students who were not able

**TABLE 2 Nursing Students' Inability to Correctly Perform Compressions and/or Ventilations by Monthly Practice Group and Course/Manikin Type**

| | Monthly Practice | | | No Monthly Practice | | | |
|---|---|---|---|---|---|---|---|
| Outcome[a] | Total No. of Students | Pretest n (%) | Posttest n (%) | Total No. of Students | Pretest n (%) | Posttest n (%) | Practice Group $p^b$ |
| Inability to perform any compressions correctly: | | | | | | | |
| All students | 302 | 59 (20) | 18 (6) | 303 | 73 (24) | 47 (16) | .0004 |
| Course/manikin[c] | | | | | | | |
| HC | 133 | 10 (7) | 5 (4) | 132 | 11 (8) | 13 (10) | |
| IL-Manikin A | 55 | 13 (24) | 6 (11) | 53 | 9 (16) | 9 (17) | |
| IL-Manikin B | 114 | 36 (32) | 7 (6) | 118 | 53 (45) | 25 (21) | |
| $p^d$ | | <.0001 | .19 | | <.0001 | .05 | |
| Inability to perform any ventilations correctly: | | | | | | | |
| All students | 301 | 95 (32) | 37 (13) | 303 | 91 (30) | 76 (25) | <.0001 |
| Course/manikin[c] | | | | | | | |
| HC | 133 | 21 (16) | 15 (11) | 132 | 13 (10) | 21 (16) | |
| IL-Manikin A | 55 | 16 (29) | 7 (13) | 53 | 14 (26) | 17 (32) | |
| IL-Manikin B | 113 | 58 (51) | 15 (13) | 118 | 64 (54) | 38 (32) | |
| $p^d$ | | <.0001 | .89 | | <.0001 | .006 | |

[a]Table data correspond to the number (%) of students unable to correctly perform any compressions or unable to correctly perform any ventilations by practice group and course/manikin type.
[b]Value of $p$ for practice group effect from final logistic GEE model including posttest CPR skill as outcome, practice group (monthly practice or no practice) as main effect, and including pre-CPR skill and course type (HC, IL-Manikin A, or IL-manikin B) as covariates. Posttest differences in means among the three course and manikin types were not statistically significant for either the compression or ventilation outcomes.
[c]Course type HeartCode BLS (HC), instructor-led (IL) courses using Resusci-Anne manikins (Manikin A) or a blue hard molded plastic CPR manikin (Manikin B).
[d]Value of $p$ from Likelihood ratio chi-square test comparing three course type groups at pretest and posttest separately.

to perform *any* compressions correctly for the practice and no practice groups were surprisingly large (see Table 2). Immediately after completion of the CPR course, students completed the study pretest. One hundred thirty-two (23%) of the 605 students, 59 (20%) in the monthly practice group and 73 (24%) in the no practice group, could not perform *any* compressions correctly as per the AHA definitions. At the posttest for the monthly practice group, this number decreased to 18 (6%) students who still could not perform *any* compressions correctly. Forty-seven (16%) students in the no practice group could not perform any compressions correctly at posttest ($p$ = .0004).

The numbers of students not able to perform any compressions correctly after the CPR course (pretest) also differed by course/manikin type [HC: 21 (8%), IL-Manikin A: 22 (20%), IL-Manikin B: 89 (38%), $p$ < .0001]. The magnitude of the differences in students' inability to perform compressions correctly at posttest between course/manikin groups varied by monthly practice and no practice (see Figure 1). Monthly practice using the VAM improved the performance of students assigned to the IL course to a similar level as the HC group at posttest: 5 (4%) students in the HC group, 6 (11%) students in the IL-Manikin A group, and 7 (6%) students in the IL-Manikin B were not able to perform compressions correctly at posttest, $p$ = .19 (see Table 2). In comparison, for the no practice group at posttest, 9 (17%) students in the IL-Manikin A group and 25 (21%) students in the IL-Manikin B group were not able to perform any compressions correctly compared with only 13 (10%) students in the HC group, $p$ = .05.

## Ventilation Data

As seen in Table 1, similar to the compression data, differences were found between practice groups for the mean percentage of BVM ventilations performed correctly. At pretest, the monthly practice group performed an average of 31.5% (*SD* = 31.4%) of their ventilations correctly; that mean increased to 48.0% (*SD* = 32.3%) at posttest after monthly practice. For the no practice group, the pretest mean was 34.5% (*SD* = 33.5%) and posttest mean was 36.7% (33.7%). Adjusting for pretest of CPR skill differences and course/manikin type, the difference in the mean percentage of ventilations at posttest performed correctly between practice groups was also statistically significant (48.0% compared with 36.7%, $p$ < .0001). The difference in mean percentage of ventilations performed correctly at posttest between course/manikin group (HC: $M$ = 46.7, *SD* = 33.0; IL-Manikin A: $M$ = 36.8, *SD* = 32.5; IL-Manikin B: $M$ = 40.1, *SD* = 34.0) was not statistically significant ($p$ = .69).

Consistent with trends observed for the compression data, after completion of the CPR course (pretest), the number of students who were not able to perform *any* ventilations correctly as per the AHA definitions for both groups was

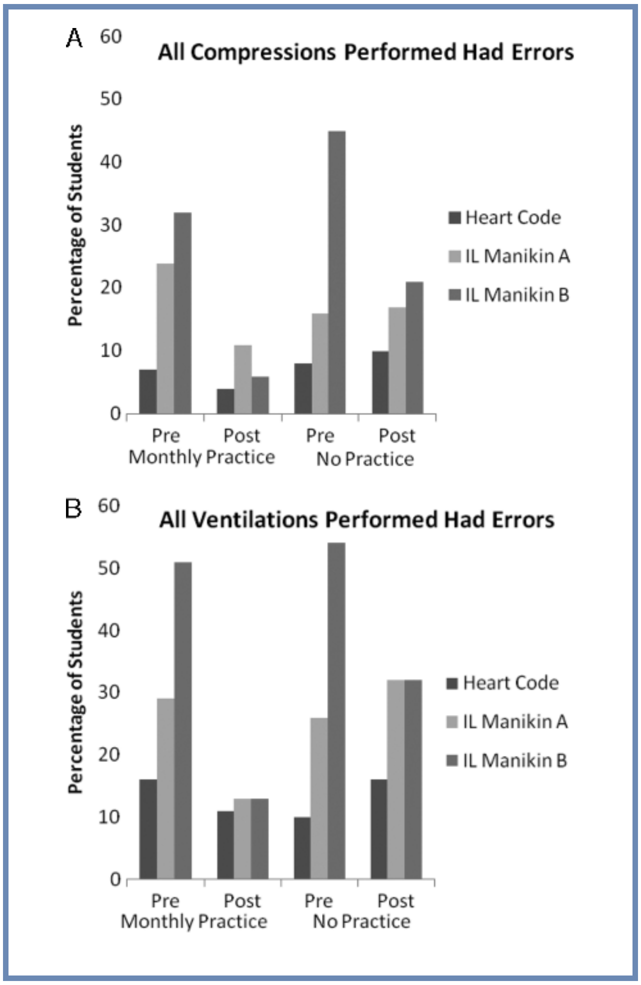


**FIGURE 1** Percentage of students who could not perform any compressions and/or ventilations by practice group and course type: HeartCode BLS, instructor-led (IL) using Resusci-Anne manikins (Manikin A), or a blue hard-molded plastic CPR manikin (Manikin B).

also larger than anticipated: 186 (31%) of the 604 students [95 (32%) in the monthly practice groups and 91 (30%) in the no practice group] could not perform any ventilations correctly. After monthly practice, 37 (13%) students could not perform any ventilations correctly compared with 76 (25%) students in the no practice group at the same testing point ($p$ < .0001; see Table 2).

The number of students performing no ventilations correctly after the CPR course also differed by course/manikin type [HC: 34 (13%); IL-Manikin A, 30 (28%); IL-Manikin B, 100 (43%); $p$ < .0001]. Similar to the compression data, the magnitude of the differences in the students' inability to perform ventilations correctly at posttest among the course/manikin groups varied between the two practice groups (see Figure 1). With monthly practice and familiarity with the VAM, participants in the IL course improved their ability to perform ventilations: Only15 (11%) students in the HC group, 7 (13%) in the IL-Manikin A group, and 15 (13%) in the IL-Manikin B had errors in ventilations at posttest ($p$ = .89; see Table 2). In comparison, for the no practice group at posttest, 21 (16%) students in the HC group were not able to perform any ventilations correctly, compared with 17 (32%) students in the IL-Manikin A group and 38 (32%) students in the IL-Manikin B group ($p$ = .006).

To further understand the unexpectedly high percentage of students performing all compressions or all ventilations with errors, the researchers examined the relationship between lack of ability to perform compressions and lack of ability to perform ventilations. After CPR course completion, 57 (10%) of the 606 participants were unable to perform correctly either of these two skills (compressions and ventilation). For participants who completed monthly practice, the number of participants unable to perform either of these two skills decreased from 25 (8%) to 3 (1%) compared with the no practice group, which decreased from 32 (11%) to 17 (6%).

## DISCUSSION

Initial study findings suggested that, despite completion of a CPR course, a surprisingly large percentage of the student participants were unable to perform correctly *any* compressions or ventilations when measured using a Resusci-Anne manikin with SkillReporter software. This observation prompted evaluation of all study equipment, site coordinator training, and data collection methods. All of the equipment was found to be in working order, site coordinators completed standardized training, AHA instructors who taught the IL courses were all certified, and data were collected electronically using SkillReporter software and were also in working order. Further site evaluation indicated that three of six study sites with IL courses had significant numbers of participants who recorded no compressions or ventilations during the pretest after successful CPR course completion. These three IL site instructors taught and tested CPR course skills and check offs with a different brand of manikin (with hard blue molded faces and chest plates) before the study pretest with the SkillReporter manikins. Noordergraaf, Van Gelder, Van Kssteren, Diets, and Savelkoul (1997) found no difference in CPR skill performance between participants trained with the hard molded manikins used in part of this study and the Resusci-Anne manikins. Findings suggested significant performance differences by manikin type. A review of literature yielded one other early study that reported validity of CPR manikins (Tsitlik et al., 1983). Staff development educators may want to consider evaluating the reliability and validity of the equipment used to teach CPR based on these findings.

All other study sites had used Resusci-Anne manikins for CPR training, skills check offs, and the study pretests. In this study, 132 (22%) participants at pretest performed no compressions correctly, despite having just successfully completing a CPR course. The inability to perform compressions becomes even more important as the depth required by the AHA 2010 guidelines increased from 38 to 51 mm (Travers et al., 2010). It may be possible that student participants were unmotivated by the time they reached the study pretest. Having received CPR cards, the participants' extrinsic motivation for good performance might have been removed.

It is also possible that these participants were physically tired. Recent research demonstrated a significant decrease in ability to perform compressions after 2 minutes in lay provider CPR (Trowbridge et al., 2009; Vaillancourt, Midzic, Taljaard, & Chisamore, 2011). Barton, Barnes, and Bair (2010) found the mean time to less than adequate compression performance by providers because of fatigue was 150 seconds. Study participants completed 3-minute (180 seconds) pretest and posttest for compressions immediately after a CPR course, and students may have been tired. Staff development educators may want to suggest to code teams that research supports rotation out of the chest compression role in a code after 2 minutes based on these and other research findings.

With up to 12 months of practice, the number of participants in the IL-Manikin A and IL-Manikin B courses who were not able to perform any compressions correctly decreased from 24% to 11% (IL-Manikin A) and from 32% to 6% (IL-Manikin B). The number of participants who were not able to perform any ventilations correctly decreased from 29% to 13% (IL-Manikin A) and from 51% to 13% (IL-Manikin B), suggesting that the lack of skill mastered during the initial CPR course could be acquired with practice. Staff development educators may want to consider providing opportunities for brief monthly practice of CPR skills for all staff. This might be especially important on units that experience more than occasional opportunities for using CPR skills.

What remains concerning is that even with up to 12 months of VAM practice, 18 (6%) of student participants in the monthly practice group still performed no compression correctly, and 37 (13%) of the participants in the monthly practice group still performed no ventilations correctly. The largest number of nonperformer participants were assigned to the 3-, 6-, and 9-month practice groups; thus, they may not have gained the full advantage of 12 monthly practice sessions.

One hundred eighty-six monthly practice and no practice group participants, 31% of student participants, performed no BVM ventilations correctly. This occurred more often in the IL courses. This finding suggests that this skill was not mastered during the CPR courses. This might reflect a potential lack of rigor by CPR instructors in teaching and evaluating skills as reported by others (Arshid et al., 2009; Perkins et al., 2008). Staff development educators may want to encourage CPR instructors to pay particular attention to BVM skills, as this was the skill least mastered by all participants after the initial class. The improvement in compression and ventilation skill of participants in the

IL-Manikin B no practice group at posttest occurred because of the increased flexibility of the Resuci-Anne chest compared with the molded plastic face manikin, allowing an improvement in skills with the new manikin, again raising the question of the validity of CPR equipment used for training.

After 12 months of VAM practice with BVM ventilations, 37 (13%) participants in the monthly practice group still could not perform *any* ventilations successfully. Most of the study participants were women who often have smaller hands that make managing a BVM more difficult. Bauman et al. (2010) recently tested a smaller and more ergonomically correct BVM that made a significant difference in the participant's ability to ventilate. Seventy-six (25%) of the no practice group participants could not perform *any* ventilations correctly after 12 months, supporting findings of others that skills are lost long before the 2-year CPR renewal time (Abella et al., 2005; Smith et al., 2008).

This study was done with a relatively young and healthy group of student nurses. With an aging nursing work force, staff development educators may want to consider the fact that there may be nurses who cannot perform some or all aspects of CPR. The researchers do not propose solutions to this finding but suggest that it is better to know and acknowledge the problem than ignore it. Cason, Kardong-Edgren, Cazzell, Behan, and Mancini (2009) called for less concentration on carrying a current CPR card and more on the actual ability to perform high-quality CPR. However, this study demonstrated that many participants could not adequately perform CPR, raising questions about the preparation of experienced nurses to perform CPR. Does every healthcare provider actually *need* to be able to perform CPR? What should be done when someone cannot perform compressions or ventilations adequately and when technology allows detection of this inability? Is it possible that a healthcare provider CPR card, much like a driver's license, could carry restrictions (e.g., qualified to perform compression but not ventilations)?

There were some limitations to this study. Participants in this study were nursing students and not experienced practicing nurses. The study should be repeated with practicing nurses to validate the findings in this population. Participants who trained willingly in CPR every month for a year might be more motivated than the average student and not representative of the general population (Callahan, Hojat, & Gonnella, 2007.)

## CONCLUSION

This secondary analysis of data suggests that even with monthly practice and accurate VAM feedback, some people cannot perform the skills of CPR correctly. The findings raise serious questions about the current regulations regarding CPR courses. Does one need to only "complete a CPR course" or to be able to actually perform the skills of CPR? Technology now allows staff development educators to identify providers who cannot perform these skills. Increased instructor rigor during IL CPR classes is required to ensure that the basic skills of compressions and especially BVM are learned. The reliability and validity of manikins used for CPR training should be assessed to assure they provide accuracy in the simulation of the skills necessary to perform CPR.

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