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Training Frequency and Anxiety: Do CPR Manikins Lend to Delivering High-Quality CPR?

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This is to certify that the doctoral dissertation by

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has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

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2019

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Abstract

Cardiopulmonary resuscitation (CPR) manikins are an educational technology tool employed to train nurses to perform high-quality CPR during real-life cardiac arrest events. However, a gap exists between CPR skills learned in training and those used in real life. The purpose of this quantitative study was to examine how CPR feedback and anxiety in registered nurses affect CPR performance on a manikin. Distributed practice and attentional control theory served as the foundations for this study. The research questions addressed the influence of demographic factors, real-time CPR feedback, and simulated hospital noises on CPR performance using CPR manikins. The study included a randomized longitudinal experimental design. Data were collected from 120 nurses via a demographic questionnaire, the Cognitive and Somatic Anxiety Questionnaire, and CPR compression performance feedback via a Zoll R Series defibrillator. Data analysis involved a repeated measures ANOVA or a regression analysis. Findings indicated that participants' age predicted CPR performance. Receiving real-time CPR feedback led to a statistically significant improvement in performance, and the introduction of hospital noises did not predict CPR performance. Findings may be used to enhance individual performance of CPR, which may benefit society through improved patient care during cardiac arrest.

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Dedication

I dedicate this project to the nurses who took time out of their busy workday to help a PhD candidate examine a topic in the hopes of advancing CPR training knowledge at a global level. Their interest in the topic and passion for delivering high-quality care were obvious. If it were not for their selfless actions and their participation in the study, this project would not have been realized.

Acknowledgments

I would like to thank Dr. Tyrrell and Dr. Marrapodi for their guidance, direction, and inspiration on this project. Even during the ups and downs of writing a dissertation, their support was unwavering. I feel blessed to have worked with such fine scholars who pushed me to be the best I could be. I would also like to acknowledge Dr. Lynn E. Shaffer for her help with the statistical analysis and Toni Williams who edited this manuscript.

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Chapter 1: Introduction to the Study

Simulation manikins are computerized machines that can run predefined scenarios, connect to a network, and be programmed (Damewood, 2016). Damewood (2016) described simulation as an active and engaging learning method in which learners can apply prior knowledge and practice without harming real people and that can provide an opportunity for reflection on performance. Through simulation-based training, learners can practice and master skills, which reduces patient risk, before employing the skills in real life (Naik & Brien, 2013). Educators in the health care field have been incorporating the use of simulation manikins to enhance cardiopulmonary resuscitation (CPR) training since 1960 (Laerdal Medical, 2016a; Rosen, 2013). Therefore, using simulation manikins for training nurses to perform CPR is particularly important when considering the critical nature of a cardiac arrest event.

Gagne (1974) posed the question, “How can the things of learning best be employed to promote learning?” (p. 3) when employing educational technologies. Cardiopulmonary resuscitation manikins are an educational technology. However, Neumar et al. (2015) reported that a learning gap exists related to performing high-quality CPR when using CPR manikins for training. The fact that a learning gap exists when employing CPR manikins for training purposes, which have included manikins since the 1960s, can lead to questioning the benefit of using CPR manikins for CPR training.

Lowyck (2014) indicated that defining a clear link between learning theories and the use of educational technologies is futile. Lowyck described a state that exists related to a need for improving conceptual frameworks, which leads to creating valid theories for use in the educational technology field. Using educational technology is a teaching method, but there is no guarantee that learning will occur when employing technology (Lowyck, 2014). However, “smaller units of analysis, where (partial) learning theories, models, and principles are connected to specific technological tools” (Lowyck, 2014, p. 7) could lead to a greater understanding of why a learning gap still exists with regard to using CPR manikins for training.

The topic of this study was understanding how CPR training leads to, or does not lead to, the performance of high-quality CPR. I also sought to determine whether anxiety was a factor in being able to perform high-quality CPR. According to Neumar et al. (2015), high-quality CPR leads to better patient outcomes if an individual survives the cardiac arrest event. This research may contribute to the medical community by providing a greater understanding of how CPR training and anxiety affect CPR performance during cardiac arrest events. This study may serve to enhance the knowledge of nurses who provide CPR and improve patient outcomes among those who sustain cardiac arrest, both of which contribute to positive social change.

Chapter 1 includes a brief history of simulation technology related to CPR training, an overview of CPR training effectiveness, and a discussion of why anxiety can affect CPR performance. This chapter also includes the purpose, problem statement, research questions, nature of the study, and hypotheses. I also provide definitions of terms, assumptions, limitations, scope, delimitations, study significance, and a summary.

Background

Educators have used modern simulators in the health care field for about 50 years (Rosen, 2013). Simulation-based training equipment is more realistic than it was in the 1960s, and the improvements in simulation equipment have led to enhancements in patient safety, increased procedure and task proficiencies, and improved communication and team working skills (Spooner, Hurst, & Khadra, 2012). Spooner et al. (2012) noted that educators use simulation-based training to deploy educational content in a controlled environment, in addition to using it for standardized performance assessment.

Revealed on March 17, 1967, SimOne was the first computer-based simulator (Rosen, 2013). Although the simulator was used primarily for anesthesiology training, it served as a prototypical device for many subsequent health care simulation manufacturers (Rosen, 2013). In 1960, Laerdal released Resusci Anne®, which was the first manikin created for practicing mouth-to-mouth resuscitation (Laerdal Medical, 2016a; Rosen, 2013). The Harvey® simulator, introduced in 1968, could replicate heart sounds in the correct locations, pulses, and respirations (Rosen, 2013). The technological innovations of these early simulators evolved into higher fidelity CPR training manikins.

The ability of trained providers to deliver high-quality CPR is vital to attaining optimal patient outcomes after cardiac arrest (Christenson et al., 2009; Neumar et al., 2015). Neumar et al. (2015) reported that components of high-quality CPR include adequate chest compression rate, adequate chest compression depth, allowing for complete chest recoil between compressions, minimizing interruptions to compressions, and avoiding excessive ventilations. However, no clear training relationship exists between practice and delivery of CPR for care to ensure the CPR is of high quality (Neumar et al., 2015).

It is difficult for nurses to retain high-quality CPR skills without repetitive training (Montgomery, Kardong-Edgren, Oermann, & Odom-Maryon, 2012; Oermann, Kardong-Edgren, & Odom-Maryon, 2011). The American Heart Association (2018) has two technology-driven methods through which nurses can renew their CPR certification: HeartCode® and Resuscitation Quality Improvement® (RQI). RQI has a repetitive training method designed to enhance CPR skills acquisition. However, researchers have not yet published studies in which they have examined the training routine of RQI for licensed registered nurses.

Indicators of poor retention of CPR skills and priorities for nurses exist in the literature (Sullivan, 2015). If CPR skills degrade in less than 6 months after training (Oermann et al., 2011; Sutton et al., 2011), the rate of degradation calls into question the benefits of current manikin training technologies on nurses' ability to learn high-quality CPR skills. Simulation-based activities can provide educators and leaders of health care organizations with the assurance that learners have the opportunity to learn procedures that do not occur frequently in a clinical setting (Stephenson, 2015). However, it is imperative to understand factors that can influence nurses' ability to perform quality CPR, thereby helping to enhance CPR psychomotor skills training (Roh & Issenberg, 2014). Roh and Issenberg (2014) pointed to "individual beliefs, attitudes, skills experiences, and knowledge" (p. 675) as factors that can influence nurses' behavior regarding CPR. However, situations that require performance of CPR in a hospital setting can lead to high stress and anxiety for care providers (Sullivan, 2015).

Because real-life cardiac arrest situations that require the need for nurses to perform CPR are high-stress and anxiety producing (Sullivan, 2015), it is important to understand whether these factors have an effect on performing high-quality CPR. Al-Ghareeb, Cooper, and McKenna (2017) found that anxiety encountered during simulation-based learning activities could lead to enhanced or poor individual performance. CPR manikins provide user feedback aimed at developing psychomotor skills. However, CPR training sessions for purposes of obtaining or renewing certification do not include anxiety-producing factors, such as chaos in the room during a cardiac arrest situation. Although CPR manikin training technologies have developed in the area of providing performance feedback, other factors exist that may limit the benefit of CPR manikin training (Al-Ghareeb & Cooper, 2016; Tellson, Qin, Erwin, & Houston, 2017). Current manikin technology combined with current training methods may not lead to nurses being able to perform high-quality CPR performance in real life.

Neumar et al. (2015) reported a gap between CPR training methods and delivering high-quality CPR during cardiac arrest events. Research on the benefits of proper CPR performance has shown correctly performed CPR significantly improves patient survival rates from cardiac arrests (Neumar et al., 2015). The current study was necessary to contribute to the research related to CPR simulation-based training. Gaining further understanding of the factors that enhance or diminish CPR performance may improve patient outcomes from cardiac arrests.

Problem Statement

No clear relationship exists between current CPR training methods employed for practicing CPR and the subsequent performance needed to deliver high-quality CPR during real-life cardiac arrest events. Neumar et al. (2015) indicated researchers have reported that inadequate compression rate and depth are common resuscitation errors that can reduce the likelihood of patient survival. Studies on the effects of CPR manikin-based training on CPR performance outcomes have shown repetition in simulation-based CPR practice is beneficial for maintaining CPR psychomotor skills (Oermann et al., 2011; Sutton et al., 2009).

Understanding factors that can influence nurses' ability to perform high-quality CPR may help to enhance CPR psychomotor skills training (Roh & Issenberg, 2014). Situations that require the performance of CPR in a hospital setting can lead to high stress and anxiety for care providers (Sullivan, 2015). Current CPR training methods do not routinely include anxiety-producing components. However, incorporating anxiety-producing components may enhance the value of simulation training (Khalaila, 2014). This study addressed this problem through the examination of CPR skills performance over time while introducing an anxiety-producing factor.

Purpose of the Study

The purpose of this quantitative study was to examine the impact of CPR performance feedback and hospital noises, as measured by the Cognitive and Somatic Anxiety Questionnaire (CSAQ; Appendix B) on the CPR performance of medical and surgical acute care registered nurses working in a hospital setting. Simulation CPR manikins are an educational technology used to enhance CPR performance. Lee and Oh (2015) reported that learning that incorporates simulation can allow students to scrutinize their technical skills and can also benefit cognitive and psychomotor learning domains. Cook, Brydges, Zendejas, Hamstra, and Hatala (2011) indicated that "technology-enhanced simulation training in health professionals' education is consistently associated with larger effects for outcomes of knowledge, skills, and behaviors" (p. 978). The 2015 American Heart Association guidelines included a recommendation to use feedback devices to learn the psychomotor skills of performing CPR (Neumar et al., 2015). The CPR simulation manikins used in the current study provided learner feedback aimed at improving performance.

The dependent variable in this study was CPR performance by nurses on a CPR manikin. I measured the dependent variable by applying specially designed training pads for the Zoll R Series defibrillator on a CPR manikin, which measured performance metrics according to American Heart Association CPR guidelines (see Neumar et al., 2015). The 2015 American Heart Association guidelines for acceptable CPR included a compression rate of 100–120 compressions per minute and a compression depth of 2 to 2.4 inches. The independent variables were CPR feedback (provided by a Zoll R Series defibrillator) and anxiety score (as measured by the CSAQ). To examine the effect of time on CPR performance, the exercise was repeated twice: 30 and 60 days after the baseline measurement. I collected performance data for each participant at all three events.

Research Questions and Hypotheses

Research Question 1: How do the participants' demographic factors of age, gender, and years of experience as a nurse relate to medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin?

$H_0$1: The participant demographic factors of age, gender, and years of experience as a nurse does not predict a medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin.

H_A1: The participant demographic factors of age, gender, and years of experience as a nurse does predict a medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin.

Research Question 2: What is the difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving any performance feedback?

$H_0$2: There is no difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time

CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving performance feedback.

H_A2: There is a difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving performance feedback.

Research Question 3: How does the introduction of hospital noises during CPR performance (as measured by the CSAQ) and real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin?

H_03: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and CPR performance scores (provided by a Zoll R Series defibrillator/CPR feedback device) does not predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin.

H_A3: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and CPR performance scores (provided by a Zoll R Series defibrillator/CPR feedback device) predicts medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin.

Research Question 4: What is the difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance?

$H_0$4: There is no difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance.

H_A4: There is a difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance.

Research Question 5: How does the introduction of hospital noises during CPR performance (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a

CPR training manikin at 30 days and 60 days (postbaseline) when compared to baseline performance?

*H_0*5: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) does not predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin at 30 days and 60 days (postbaseline) compared to baseline performance.

*H_A*5: The introduction of hospital noises during CPR performance scores (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predicts medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin at 30 days and 60 days (postbaseline) compared to baseline performance.

Theoretical Frameworks for the Study

Distributed practice and attentional control theory served as the two frameworks for the study. Distributed practice, which asserts learning occurs over time with repeated sessions, helps to enhance learning of CPR skills (Oermann et al., 2011). Studies on the distributed practice framework date back to its inception by Ebbinghaus in 1885 (Kupper-Tetzel, 2014). Ebbinghaus (1913/2011) noted that learning is better when educators repeat and disperse content over time compared to a single time or massed learning approach. Current research supports distributed practice as a framework that benefits learner outcomes (Gerbier & Toppino, 2015; Kupper-Tetzel, 2014). The distributed practice framework has been shown to be beneficial for learning paired word associations and complex motor skills (Gerbier & Toppino, 2015; Kupper-Tetzel, 2014).

The act of performing high-quality CPR includes both cognitive and motor components (Neumar et al., 2015). Delivering high-quality CPR appropriately and consistently can result in saving lives (Neumar et al., 2015). Based on the distributed practice effect, nurses should improve their ability to deliver high-quality CPR through repetition in training. Prior studies supporting the benefits of repetition in CPR training included nursing students as participants or took place in laboratory settings; therefore, findings may not generalizable to the real world (Oermann et al., 2011; Roh & Issenberg, 2014).

Attentional control theory served as another theory on which the study was grounded. An assumption of attentional control theory is that anxiety affects attentional processes involved with the human stimulus-driven and goal-directed functions, which is central to gaining insight into the effect of anxiety on performance (Eysenck, Derakshan, Santos, & Calvo, 2007). An assertion of the theory is that anxiety interrupts the balance between the human stimulus-driven and goal-directed attentional systems. The effect of anxiety on these two attentional systems is an increase in the stimulus-directed system and a decrease in the goal-directed system (Eysenck et al., 2007).

According to Sullivan (2015), "recognizing and responding to a cardiac arrest in the hospital setting is a high stress, high anxiety event for all healthcare providers" (p. 1). The goal of performing high-quality CPR may become a lower subconscious cognitive priority when a nurse is experiencing anxiety. Although simulation is an effective tool for learning technical and nontechnical health care skills to improve patient safety (Naik & Brien, 2013), simulation conditions need to be as realistic as possible to facilitate a meaningful learning experience.

Nature of the Study

The study involved a randomized longitudinal experimental design to answer the research questions. The variables included one dependent variable and two independent variables. The dependent variable was CPR performance by nurses as measured by a Zoll R Series defibrillator. There were two independent variables: receiving or not receiving CPR performance feedback and being subjected or not being subjected to a simulation of intensive care hospital noises. Medical and surgical acute care registered nurses were randomly assigned to one of three groups (control, which did not receive CPR feedback or be subject to hospital noises at 30- and 60-day measurement periods), Treatment Group 1 (which did not receive CPR feedback but was subjected to hospital noises at 30- and 60-day measurement periods), and Treatment Group 2 (which received CPR feedback and was subjected to hospital noises at 30- and 60-day measurement periods). R version 3.4.3 was used to analyze the data obtained from the Zoll R Series defibrillator (see Zoll Medical Corporation, 2017) and the CSAQ (see Calvo, Alamo, & Ramos, 1990). Depending on the hypothesis tested, I used either a two-way repeated measures analysis of variance (ANOVA) or regression analysis. I also collected demographic data via a survey and examined the data for any relationships with the dependent variable.

Definitions

Variables

Dependent variable: A measurement of CPR performance by acute care registered nurses obtained from a Zoll R Series defibrillator.

Explanatory variable: Demographic factors collected via a survey related to age, gender, and years practicing as a registered nurse.

Independent Variable 1: Receiving or not receiving CPR performance feedback while performing CPR on a CPR manikin.

Independent Variable 2: Having or not having a loud audio clip of intensive care unit hospital sounds played while performing CPR on a CPR manikin.

Terms

CPR feedback device: A device that provides feedback to the individual performing CPR. The aim of the feedback is to deliver CPR performance that is consistent with the 2015 American Heart Association guidelines (Zoll Medical Corporation, 2017).

High-fidelity simulation: A simulator that provides a realistic learning experience (Tichon & Diver, 2012).

High-quality CPR: Performance of CPR in accordance with the 2015 American Heart Association guidelines, which include proper chest compression rate and depth (Neumar et al., 2015).

Assumptions

There were certain assertions in this study that I could not confirm but that I believed to be true. I assumed the self-reported data collected from the demographic questionnaire and the CSAQ were true. I also assumed the participants performed CPR on the manikins to the best of their knowledge and ability. All equipment used in this study functioned accurately to measure CPR compressions and provide CPR feedback. Additionally, I assumed a normal distribution for the statistical analysis of data. The rationale for making these assumptions related to the study design. I could not control for the assumptions listed by making minor modifications to the research design. Therefore, I made the assumptions to preserve the integrity of statistical hypotheses testing (see Frankfort-Nachmias & Leon-Guerrero, 2018).

Scope and Delimitations

The scope of this study included licensed registered nurses working in acute care medical and surgical nursing hospital units. Participants included males and females with varying levels of nursing experience and nursing education. All participants worked for one of two community hospitals, and I assumed they were able to perform CPR for 2 minutes. There were approximately 650 nurses working as medical and surgical nurses at the two hospitals. I needed a minimum of 108 participants to ensure an adequate sample for the statistical analysis. I delimited the sample to a single nursing specialty (medical and surgical acute care nursing), which helped to eliminate the variability that might have occurred if I had included nurses from other nursing specialties who might have had more experience performing CPR and working in chaotic situations. I excluded registered nurses working in areas outside of the acute care medical and surgical areas, such as adult intensive care units or emergency departments.

Limitations of the Study

The primary limitation in this study related to generalizing findings to registered nurse populations working in areas outside of acute care medical and surgical nursing. Although this was a limitation, it was also a strength in that variability within the sample population was more controlled. Confounds related to the participants, such as gender and age, could have affected their performance during the data collection phase.

To address potential variability related to the participants, I performed statistical analyses on the demographic factors. These analyses revealed findings that presented limitations related to the population for this study. However, the study design included random assignment, which assumes a normal distribution that should have mitigated demographic factors as a limitation.

Significance of the Study

The significance of this study related to improving how educators use CPR manikins to train nurses to deliver high-quality CPR during real-life cardiac arrest events. I examined the CPR performance gap between training and practice to determine how to employ educational technologies from an educational perspective. Understanding factors that affect CPR psychomotor performance, such as CPR training manikins and anxiety, may lead to practice changes that positively influence how educators use CPR manikins as an educational technology for CPR training. Additionally, improvements in the use of CPR training technologies may lead to enhanced nursing knowledge, better CPR performance, and improved patient care. This study contributed to positive social change through examination of factors that affect individual performance, which may benefit society through improved patient care during cardiac arrest events.

Summary

This chapter included an overview of the gap that exists in transitioning current CPR training to practice. A brief review of the current literature revealed support for the existence of the gap examined in this study. The theoretical frameworks of distributed practice and attentional control theory served as the foundation to explain the impact of the variables on the dependent variable. I employed a randomized longitudinal experimental design and limited the population to a single nursing specialty to control for variation that could have skewed results if the study had included different nursing specialties. Findings may provide new knowledge in the field of health care educational technology and effect positive social change. Chapter 2 includes an in-depth review of literature related to simulation use for CPR training and to the theoretical frameworks for this study.

Chapter 2: Literature Review

In the executive summary to the American Heart Association's updated 2015 cardiopulmonary resuscitation and emergency cardiovascular care guidelines, Neumar et al. (2015) indicated the ideal training method and frequency for retaining cardiac resuscitation skills to train health care professionals who perform CPR require further examination. Since 2000, the American Heart Association has published new CPR guidelines or has revised previous CPR performance recommendations (Neumar et al., 2015). Because real-life CPR training on patients is not ethical or feasible, educators employ CPR manikins and high-fidelity patient simulators to meet mass CPR training needs. Neumar et al. recommended conducting additional educational research with a focus on the long-term retention of psychomotor and behavioral CPR skills in a simulated learning environment.

High-quality CPR is vital to attaining optimal patient outcomes following cardiac arrest (Christenson et al., 2009; Neumar et al., 2015). Neumar et al. (2015) noted that components of high-quality CPR include adequate chest compression rate, adequate chest compression depth, allowing for complete chest recoil between compressions, minimizing interruptions to compressions, and avoiding excessive ventilations. However, no clear training link exists to ensure high-quality CPR can be performed during cardiac arrest events, although automated technology feedback devices can help individuals learn the psychomotor skills of performing CPR (Neumar et al., 2015).

Through the American Heart Association (2018), two technology-driven methods emerged for nurses to renew their CPR certification: HeartCode® and RQI®. Companies such as Laerdal, CAE, and Gaurmad adopted the American Heart Association's CPR guidelines for health care professionals to build or update simulators for CRP training and assessment. These simulators provide real-time CPR performance feedback, including depth, rate, and chest recoil (CAE Healthcare, 2016; Gaumard Scientific, 2016; Laerdal Medical, 2016b). It is difficult for nurses to retain high-quality CPR skills without repetitive training (Montgomery et al., 2012; Oermann et al., 2011). However, the problem of which method or methods may be best to enhance knowledge retention related to performing high-quality CPR remains unclear. Another issue that remains unclear is whether anxiety plays a role in influencing a person's ability to perform high-quality CPR. Examining how training method and anxiety affect CPR quality among nurses may lead to improvements in patient care outcomes. Chapter 2 includes an in-depth and extensive literature review related to manikin use for CPR training and the theoretical frameworks employed in this study.

Purpose of the Study

The purpose of this quantitative study was to examine how CPR feedback and anxiety affect CPR performance in registered nurses over time. Simulation CPR manikins are an educational technology used to enhance CPR performance. Lee and Oh (2015) reported that learning that incorporates simulation can allow students to scrutinize their technical skills and can also benefit cognitive and psychomotor learning domains. The 2015 American Heart Association guidelines include a recommendation to use feedback devices to learn the psychomotor skills of performing CPR (Neumar et al., 2015). When connected to the Zoll R Series defibrillator, the CPR simulation manikins used in this study provided learner feedback aimed at improving performance.

Literature Search Strategy

The databases accessed for the literature review included the use of three multiple-database search engines. My literature review included relevant material from four different disciplines: education, psychology, nursing, and medicine research. The databases searched first were educational research databases, which included ERIC and Education Research Complete. Examined next were the nursing and medical databases, which included CINAHL and MEDLINE. The final search involved the military and government collection and a psychology database, which included PsycARTICLES, PsycBOOKS, PsycCRITIQUES, PsycEXTRA, and PsycINFO. Searching the PsycTESTS database resulted in identifying the cognitive anxiety instrument used for this study.

The scope of the literature review was publication years 2012 to 2017. However, to identify seminal work related to the theoretical frameworks, I expanded the search to include relevant literature dating back to 1913. All journal articles referenced were peer-reviewed articles. Verification of peer-review status involved using Ulrich's Periodicals Directory or a journal's website. Key search terms included *CPR training*, *CPR manikin*, *CPR mannequin*, *high-quality CPR*, *CPR psychomotor*, *CPR simulation*, *technology-enhanced simulation*, *military simulation*, *aviation simulation*, *pilot training*, *flight simulator*, *police simulation training*, *high-risk low-frequency events*, *distributed practice*, *cognitive anxiety*, and *forgetting*.

Theoretical Frameworks

Distributed practice and attentional control theory served as the two frameworks for the study. Supporters of distributed practice assert that learning occurs over time with repeated sessions and claim that it helps to enhance learning CPR skills (Oermann et al., 2011). Studies on the distributed practice framework date back to its inception by Ebbinghaus in 1885 (Kupper-Tetzel, 2014). Ebbinghaus (1913/2011) noted that learning is more effective when educators repeat and disperse content over time compared to a single educational session. Current research supports distributed practice as a framework that benefits learner outcomes (Gerbier & Toppino, 2015; Kupper-Tetzel, 2014). The distributed practice framework is beneficial for learning paired word associations and complex motor skills (Gerbier & Toppino, 2015; Kupper-Tetzel, 2014).

The act of performing high-quality CPR includes cognitive and motor components (Neumar et al., 2015). Delivering high-quality CPR appropriately and consistently can result in saving lives (Neumar et al., 2015). Based on the distributed practice effect, nurses should improve their ability to deliver high-quality CPR through repetition in training. Prior studies supporting the benefits of repetition in CPR training included nursing students as participants or took place in laboratory settings; therefore, findings may not be generalizable to the real world (Oermann et al., 2011; Roh & Issenberg, 2014).

Attentional control theory served as another theory on which the study was grounded. An assumption of attentional control theory is that anxiety affects attentional processes involved with the human stimulus-driven and goal-directed functions, which is central to gaining insight into the effect of anxiety on performance (Eysenck et al., 2007). An assertion of the theory is that anxiety interrupts the balance between the human stimulus-driven and goal-directed attentional systems. The effect of anxiety on these two attentional systems is an increase in the stimulus-directed system and a decrease in the goal-directed system (Eysenck et al., 2007).

According to Sullivan (2015), "recognizing and responding to a cardiac arrest in the hospital setting is a high stress, high anxiety event for all healthcare providers" (p. 1). The goal of performing high-quality CPR may become a lower subconscious cognitive priority when a nurse is experiencing anxiety. Although simulation is an effective tool for learning technical and nontechnical health care skills to improve patient safety (Naik & Brien, 2013), simulation conditions need to be as realistic as possible to facilitate a meaningful learning experience.

Distributed Practice Supports Learning

Research supports using a distributed practice approach to learning rather than a single-session or massed education approach (Abe, Kawahara, Yamashina, & Tsubio, 2013; Abelsson, Lindwall, Suserud, & Rystedt, 2017; Kupper-Tetzel, 2014; Taylor, Dixon-Hardy, & Wright, 2014). Distributed practice, also referred to as *spaced practice*, is effective for learning different content, such as word pairs, math problems, foreign languages, and motor skills (Gerbier & Toppino, 2015). Distributed practice theory provides support for using repetition in learning to gain the psychomotor skills associated with performing high-quality CPR.

Distributed practice research promotes the benefits of repetition in learning in different fields of study, including health care. Gallicchio, Cooke, and Ring (2016) conducted an exploratory test–retest design study in which 12 right-handed male recreational golfers participated. According to psychomotor efficiency, which was also the framework for this study, motor proficiency develops through practice and allows physiological alterations that include amplifying pertinent motor processes and diminishing nonpertinent motor processes (Gallicchio et al., 2016). Gallicchio et al. measured the golfers' putting performance and conscious processing employing three measures: frequency of successful putts out of 50 putts, putting performance errors, and electroencephalogram activity (brain activity). Using a paired-sample *t* test to examine changes in performance and conscious processing in the test and retest phases, Gallicchio et al. found putting performance improved significantly from the test to retest condition $t(11) = 2.18$, $p = .05$, $r^2 = .301$. Additionally, Gallicchio et al. reported conscious processing decreased between the two conditions $t(11) = 2.59$, $p = .03$, $r^2 = .378$. These results provided support for using repetition to improve the psychomotor skill of putting.

Kupper-Tetzel (2014) conducted a literature review of 85 empirical studies related to using distributed practice for learning. Distributed practice has led to learning improvements with verbal tasks, math skills, complex motor skills; distributed practice can also reduce forgetting and promote long-term knowledge retention. Although Kupper-Tetzel described a clear benefit to the strong learning outcomes associated with using distributed practice, a unified theory for explaining the positive impact on learning does not exist. Kupper-Tetzel noted that current theories researchers use to attempt to explain the distributed practice effect cannot define an optimal time for spacing learning repetition cycles. Additionally, much of the research on distributed practice takes place in a controlled environment, which limits how the approach can apply in the real world. Although this review provided support for using the disturbed practice approach in my study, it also presented a clear limitation related to the generalizability of learning outcomes obtained in a lab and the application of knowledge in real-life situations.

Taylor et al. (2014) analyzed the data from 1,007 general aviation fixed-winged accidents in the United Kingdom from January 2005 to December 2011. Accident reports obtained from the Air Accidents Investigation Branch website (Aircraft Owners and Pilot Association, 1997–2011) provided information on flight experience, age, and pilot license type (commercial versus private). Flight experience included three categories: currency (which was flying time during the previous 28 days and flying time during the previous 90 days), type of experience (which related to the flight time on a specific type and model of aircraft), and total experience (total flight time to date). After reviewing accident data reports and cross-referencing them with the surveys, Taylor et al. reported a significant finding for pilots who lost control of the aircraft during landing related to flight time during the previous 28 and 90 days. Taylor et al. provided recommendations for repeated simulation practice to help mitigate loss-of-control accidents. The study was relevant to the importance of repetition and ongoing training to maintain pilot competency to fly a plane.

Abe et al. (2013) examined the use of simulation-based education to improve cardiovascular competency in critical care nurses. The study took place at an Asian university hospital with 24 nurses who represented four different nursing specialties: surgery, critical care, internal medicine, and pediatrics. The nurses' training methods included lectures, cardiovascular-related procedure training, and simulations based on cardiovascular situations with debriefing during and after a simulation session. The study included two 12-member teams, and all participants performed in two of the four simulation sessions (a repeated simulation design) that occurred over the course of 1 day. Individuals completed self-assessment performance rubrics related to the achievement level acquired during the simulation, a teamwork inventory scale, and feedback from observers and the instructor.

Abe et al. (2013) reported that all groups had low mean rubric scores across all initial simulation scenarios. However, mean rubric scores increased in the second simulation and as participants completed more simulations. Although Abe et al. did not report statistical testing for this finding, they did report that, with consecutive repeated simulations and debriefings, self-ratings moved from a level of competence to competency. Instrument score analysis revealed significant findings on two of the subscales: (a) attitudes of the superior, which was a measure of superiors or leaders (i.e., a charge nurse) at work providing proper advice to those with less experience (i.e., a new nurse to practice; $p < .001$, Cronbach's α before training 0.90 and after training 0.91) and (b) less job satisfaction ($p < .01$, Cronbach's α before training 0.78 and after training 0.85). The results of this study showed support for incorporating a repeated simulation design into simulation-based learning activities in nursing.

Abelsson et al. (2017) examined the benefits of employing simulation-based learning for preparing prehospital care nurses to provide trauma care. A convenience sample of 63 nurses who possessed a bachelor's degree and prior prehospital care experience constituted the study population. Abelsson et al. used a two-group pretest–posttest design with repeated simulation training for the treatment group. The realistic simulation scenarios included receiving a call from an emergency dispatcher; access to a witness who saw the accident; use of a moulaged manikin, which means the manikin was made up to have simulated injuries; and facilitator feedback regarding the patient's condition. The study took place over a 6-month period, with the treatment group participating in simulation scenarios every 8 weeks and the control group receiving simulation training only at the beginning and end of the study period. Although the results did not show a consistent beneficial link between repetition and learning for trauma care assessment or tasks, Abelsson et al. concluded that repeated simulation training could have a strong effect on learning certain aspects of trauma-related care. Even considering the study limitations (sample size and inconsistency of care actions performed during the simulations), the fact that some learning improvements developed in the treatment group demonstrates support of a simulation-based approach.

The distributed practice approach to learning exists in different fields ranging from aviation to sports to health care. Researchers have reported the benefit of using learning repetition to enhance cognitive knowledge and psychomotor skills (Abe et al., 2013; Abelsson et al., 2017; Kupper-Tetzel, 2014; Taylor et al., 2014). Even though studies reviewed in this chapter do not include distributed practice as a theoretical framework, the researchers of all the studies discussed describe a method that incorporates repetition in learning, which has roots in distributed practice. Although employing the distributed practice approach to learning was beneficial, there are limitations with the method related to the optimal time spacing between learning sessions (Kupper-Tetzel, 2014). Furthermore, individual factors may influence how effective the distributed practice approach is on learning. Even considering the limitations, employing the distributed practice approach in my study was supported because of the empirical evidence found related to enhanced learning and performance with practice (Abe et al., 2013; Abelsson et al., 2017; Kupper-Tetzel, 2014; Taylor et al., 2014).

Anxiety and the Impact on Learning

The second theoretical framework providing a foundation for this study was attentional control theory. As noted previously, attentional control theory assumes that anxiety affects attentional processes that comprise the human stimulus-driven and goal-directed functions, and this framework is central to gaining insight into the effect of anxiety on performance (Eysenck et al., 2007). Therefore, anxiety may cause individuals to react differently by being more reactive versus outcome focused. Based on this theory, anxiety could be a factor influencing individuals' ability to deliver high-quality CPR. The focus of the studies examined in this section was on the relationship between anxiety and the impact on learning outcomes.

Flinn et al. (2015) employed a between-subjects experimental design to study the effects of stress on learning a laparoscopic surgical skill in 40 first through fourth-year medical students. All participants received the same training on how to use laparoscopic tools (surgical instruments) to cut a circle out of a piece of gauze and were assigned to one of four conditions; control (*n* = 10), observed (*n* = 10), encouraged (*n* = 10), and criticized (*n* = 10). In each condition, participants repeated the task over the course of 1 hour while being timed and assessed for task accuracy, as a professional actor, portrayed as a laparoscopic surgical expert, provided positive or negative feedback to the participants based on the treatment condition. The actor did not observe or provide feedback to the control group. Flinn et al. collected data on three objective measures of stress and one subjective measure of stress prior to treatment, 20 minutes into treatment, 40 minutes into treatment, and posttreatment. Although analysis of the stress assessment tool did not yield significant findings, post hoc analysis of the task performance data showed a significant difference in task performance scores between the encouraged condition and the criticized condition, with the criticized condition having the lowest task scores. This study shows how a stress-related condition can adversely impact performance on a surgical procedure. Thus, it is important to understand if environmental stressors exist that can adversely affect performance when performing a skill such as CPR.

Caffey, Crane, and Ireland (2016) conducted a study in which they examined 119 paramedic students' levels of anxiety related to pharmacology concepts and simulations using a pre- and post- Likert-type scale questionnaire. Caffey et al. recruited participants from a university semester-long pharmacology class and measured participants' feelings about learning different pharmacology concepts and perceived levels of anxiety when reviewing simulated cases studies based on real-life events. At the end of the semester course, the results showed high levels of anxiety on topics related to calculating medication concentrations, recalling medication-related information specific to their practice, and understanding prescribed patient medications. Caffey et al. concluded pedagogical tools, such as mnemonics and concept maps, could increase learner confidence on the topic. The relevance of this study to my study points to the way certain subjects or topics may be more stress evoking than others related to learning, thus affecting learning outcomes. For example, certain aspects of performing CPR may be more stress evoking to individuals, such as when a patient's ribs crack during the act of performing compressions.

Hordacre, Immink, Ridding, and Hillier (2016) examined the effects of anxiety and psychological stress on perceptual-motor learning in 36 adult participants by examining how manipulated stress conditions affect learning. Hordacre et al. used a pretest–posttest design and random assignment to compare a control group and a treatment group on a mental arithmetic task. The treatment group received a more complex task, which Hordacre et al. reported as causing high levels of stress and anxiety. The control group completed the task at a lower level of complexity, and thus faced a lower level of stress and anxiety. After completing the pretest math task, both groups completed training on a timed fine motor task, followed by an assessment of performance on the timed motor task during the posttest measurement period. Results showed the treatment group performed more accurately on the fine motor test, which indicated that heightened levels of stress and anxiety prior to training can enhance performance. Thus, introducing stress prior to CPR training may enhance CPR performance.

Lee and Cha (2017) explored nurses' experience of performing CPR on patients in a university medical center emergency department. Seventeen registered nurses responded to an online advertisement to participate in the study. Lee and Cha employed a naturalistic paradigm to describe the phenomenon of interest. Participant interviews, which were recorded and transcribed verbatim, lasted between 40 and 90 minutes. During interviews, participants responded to questions related to performing CPR. Four themes emerged, of which three (pressure from the urgency of the CPR, becoming sharp tempered in addressing personnel during CPR, and keeping psychological conflicts of CPR patient care to oneself) included stress, tension, and anxiety components related to performing CPR. Although the Lee and Cha noted that analysis of interview data did not clearly indicate whether education can reduce CPR-related anxiety, they emphasized that repetition with CPR training can enhance CPR performance. The three themes that emerged, which included stress, tension, and anxiety components related to performing CPR, helped to inform my study related to selecting anxiety as a factor that can affect CPR performance.

Al-Ghareeb et al. (2017) conducted a meta-analysis to understand the influence of anxiety on undergraduate health professionals during simulation-based learning activities and the instruments used to measure anxiety. Criteria for selection included articles between 1986 and 2016 in leading journals. Al-Ghareeb et al. found anxiety could lead to enhanced or poor performance during simulation-based learning activities, which included the use of different instruments to measure anxiety. The results of this meta-analysis indicated anxiety can have a positive or negative effect on learning outcomes

(Al-Ghareeb et al., 2017). Thus, anxiety experienced by individuals learning or performing CPR could affect how well or poor they perform the CPR.

Using a biophysical challenge framework, Vine et al. (2013) examined the effect of participants' motor performance on a laparoscopic surgical task completed by 52 final-year medical students inexperienced in the task. Vine et al. used a pretest–posttest design to measure visual attention control and motor performance in a challenge condition versus a threat condition (psychological stressors verbally introduced to the participants during task completion). Vine et al. measured cardiovascular measurements, task performance, and eye gaze measurements. The results of a regression analysis revealed significant differences on task performance and less eye gaze, which indicates interruptions to attentional processes may be less frequent when participants view the task as a challenge versus a threat (Vine et al., 2013). If individuals view CPR as a threatening task because they are not comfortable performing the task, they may not perform as well. The results of this study provide some insight into how anxiety may enhance or diminish CPR performance.

Although health care was the primary focus of the studies on anxiety and performance discussed to this point, researchers have examined other professionals, such as police officers, who also need to perform in stressful situations. Renden et al. (2014) employed attentional control theory to provide a theoretical foundation for examining the anxiety levels of 13 police officers while performing three different tasks. Participants performed the tasks during a low-anxiety and a high-anxiety situation. Renden et al. measured anxiety, mental effort, heart rate, and performance scores for each participant.

The results of the study showed significant performance decreases, which included exhibiting behaviors to avoid the situation, in the high-anxiety state compared to the low-anxiety state (Renden et al., 2014). These results support the theory that high-anxiety situations affect attentional systems, which is relevant to understanding the effects on CPR performance during cardiac arrest care.

The studies reviewed on anxiety indicated how placing individuals in stressful situations affects learning and motor performance (Al-Ghareeb et al., 2017; Caffey et al., 2016; Flinn et al., 2015; Hordacre et al., 2016; Renden et al., 2014; Vine et al., 2013). Cardiac arrest situations are typically stressful, which is important to note, as individuals perform CPR during these stressful situations. Individual performance may improve (Hordacre et al., 2016) or may decrease (Renden et al., 2014; Vine et al., 2013) during stress conditions. However, according to Al-Ghareeb et al. (2017) and Hordacre et al. (2016), anxiety may increase or decrease performance based on individually related factors. As it remains uncertain how anxiety-related factors affect individual performance during CPR, understanding anxiety related to learning CPR is important. Additionally, if anxiety interrupts an individual's normal attentional control processes during the act of performing CPR in a real-life situation, providing CPR training in a more real-to-life stressful situation may lead to better CPR performance.

Simulation Use in Non-Health-Care Industries

The use of simulation as an educational technology occurs in industries outside of health care. For example, educators use simulation-based learning in high school education (Berk et al., 2014), higher education (Drury-Grogan & Russ, 2013), the construction industry (Tichon & Diver, 2012), and law enforcement (Stanyon, Goodman, & Whitehouse, 2014). Studies from these respective fields provided support for simulation as a learning technology, which was important to my study because the evidence supports the use of simulation technology as being beneficial for learning purposes.

Berk et al. (2014) explored simulation as a method to promote interest in the science, technology, engineering, and mathematics (STEM) fields, using self-efficacy (Bandura, 1977) as the theoretical foundation. A convenience sample of 30 alumni of Harvard Medical School's MEDscience course between 2008 and 2012 responded to a structured phone survey. During the 13-week MEDscience course, each student participated in hands-on medical simulation with a simulation manikin, used problem-based learning skills, and partook in classroom didactic sessions. Berk et al. reported 63% of the participants enrolled in additional science or health classes as a result of their simulation experience. Berk et al. recommended using simulation and classroom education to promote STEM educational and career choices in high school students. The result of the study provided support for using simulation as an educational technology.

Drury-Grogan and Russ (2013) explored the reactions of 51 junior-college-level students to a business communication simulation as part of the business communication curriculum. Experiential learning theory (Kolb, 1984) was the theoretical foundation for the study. Drury-Grogan and Russ divided the participants into 10 groups, and each group completed a series of eight table-top modules in which participants sat around a table and reacted to scenarios during a 3-hour session. Postsimulation debriefings took place in which participants recorded their learning outcomes in a written questionnaire. Drury-Grogan and Russ transcribed and coded responses for analysis using NVivo. Analysis revealed that participants described four outcomes achieved as a result of the simulation experience: improved teamwork, insights into how the real business world works, how to maintain composure, and how to enhance communication skills. The findings supported using simulation for business education and provided an effective, safe learning environment for students. The findings provided support for my study with respect to demonstrating the validity of simulation as an effective learning methodology and creating an environment in which individuals can practice CPR without harming patients.

Tichon and Diver (2012) used a semistructured interview approach to report on using simulation as a method for teaching entry-level heavy machinery operators. Fifty-six construction trainees participated. A high-fidelity simulator, which is a simulator that provides a highly realistic learning experience, provided an experience that replicated the use of heavy equipment. Participants received 1.5 days of high-fidelity simulation training over a 6-week period, as part of their training. A usability and use evaluation, based on a model developed by Lucas and Thabet (2008) provided the foundation for the analysis. Tichon and Diver reported simulation-based training could provide beginners with the opportunity to practice and gain the skills, attitudes, and behaviors required to become equipment operators. The findings indicated high-fidelity simulation can be useful for heavy equipment training.

Stanyon et al. (2014) conducted a mixed method, quasi-experimental, pretest–posttest study to determine the effectiveness of simulation-based experiences for police officers learning about mental illness. Stanyon et al. administered questionnaires related to mental illness knowledge to 51 Canadian police officers. The design included three groups, of which two received mental illness education: a control group ($n = 18$, no mental illness education), a face-to-face education group ($n = 16$), and a simulation-based education group ($n = 17$). An unbalanced two-way ANOVA revealed the two treatment groups performed significantly better than the control group on the pretest–posttest measure ($F = 17.55$, $p < .004$). Stanyon et al. coded and analyzed qualitative data collected during the focus groups using NVivo. The qualitative analysis participants agreed that additional mental illness education could lead to an increase in their confidence, and the simulations were realistic for those in the simulation group. Stanyon et al. concluded simulation is an effective method for training police officers in the area of mental illness.

Examining simulation-related studies from fields outside of health care provided evidence of the wide acceptance and benefit of this educational approach. Berk et al. (2014), Stanyon et al. (2014), and Tichon and Diver (2012) employed approaches in which they presented learning content using technology-based simulation to participants over time. The findings are important as they served as support for the theoretical foundation of distributed practice employed in my study. Additionally, the results of these studies showed simulation-enhanced learning (Berk at al., 2014; Stanyon et al., 2014; Tichon & Diver, 2012) and increased confidence (Stanyon et al., 2014). In addition to reporting the benefits of simulation-based learning, Drury-Grogan and Russ (2013) found the simulation environment as a safe place for learning. This important finding indicated that simulation-based learning can minimize learner anxiety during practice, which leads to improved learning when compared to performing during real-life situations.

Simulation Use in the Health Care Industry

Within the field of health care simulation-based learning activities are being used in different disciplines as a form of educational technology. Educators can use simulation technology to deliver educational content in a controlled, safe, and low-risk environment compared to using real patients (Berndt, 2014; Gardner et al., 2016; Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014; Singh et al., 2013; Stephenson, 2015). Even though there are stated benefits for employing simulation technologies for learning (Berndt, 2014; Cook et al., 2011, 2013; Gardner et al., 2016; Hayden et al., 2014; Khalaila, 2014; Kim, Park, & Shin, 2016; Lee & Oh, 2015; Singh et al., 2013; Stephenson, 2015; Sullivan et al., 2015; Ward et al., 2014), limitations related to using simulation equipment do exist (Beischel, 2013; Coffey at al., 2015; Lin et al., 2016; Maloney & Haines, 2016; Singh et al., 2013). However, the limitations of using simulation-based technologies have not greatly affected their acceptance and expanded use within the field of health care education and institutions of higher learning within which simulation has gained wide acceptance.

During the eighth annual meeting of the Consortium of the American College of Surgeons Accredited Education Institute, a multidisciplinary panel gathered to discuss the benefits of simulation for such events as disaster training, disease outbreaks, war, and mass casualty events. The panel reported the benefits of simulation-based education to prepare for such high-risk situations that do not occur frequently. Gardner et al. (2016) noted researchers have shown that simulation-based experiences have appropriately prepared surgeons with the knowledge and skill to practice safely and direct their teams effectively in high-risk situations. Gardner et al. described high-risk situations as complex, rapidly changing, ambiguous situations that could result in a need to manage information overload, adverse physician conditions, performance pressures, time limitations, situations disposed to error, and problems associated with working with a team of diverse people. Simulation can help health care professionals cope with high-risk situations more effectively (Gardner et al., 2016). Because cardiac arrest situations are high risk, simulation should better prepare care providers to perform CPR skills.

Berndt (2014) conducted a meta-analysis, which included 17 English-only articles published between 2007 and 2011. Berndt sought to provide evidence for using simulation as an educational method for teaching safety-related skills to prelicensure nursing students. The Rating System for the Hierarchy of Evidence (Melynk & Fineout-Overhold, 2005) served as the method for critically evaluating the articles. Berndt found using simulation as an educational method to be more effective than traditional lecture alone. This review validated the use of simulation as an educational method for teaching patient-safety-related skills to prelicensure nursing students, who were the participants in my study.

Ward et al. (2014) examined the perceived self-confidence of 41 speech-language pathologists on their tracheostomy management skills. Ward et al. recruited participants from public health settings who self-reported minimal to no tracheostomy skills. Each participant completed a tracheostomy-related prereading and attended a 1-day simulation training, which included partial task training and immersive simulation scenarios. The focus of the pretest–posttest design that took place immediately after the training and 4 months posttraining was analyzing the use of technology-enhanced simulation as an educational method for tracheostomy management training. A repeated ANOVA that included a post hoc analysis showed an increase in the level of confidence of the speech-language pathologists related to tracheostomy care ($p < .05$). Furthermore, Ward et al. reported the level of confidence did not go down at the 4-month mark. Although Ward et al. did not state a specific theoretical framework for the study, the results provide support for using simulation-based training to learn the task of performing CPR, while maintaining confidence up to 4 months posttraining,

Hayden et al. (2014) examined how learning transferred from the simulation laboratory to clinical practice in a two-part longitudinal, multiple-site study. Hayden et al. employed the NLN Jeffries Simulation Framework to ensure consistency in the simulation scenarios and Debriefing for Meaningful Learning© (Dreifuerst, 2010) to maintain uniformity in the debriefing process. Part 1 of the study included 666 nursing student participants recruited from 10 prelicensure registered nursing programs (associates or baccalaureate level) in the United States, randomly assigned to one of three groups. The control group used up to 10% of its clinical hours for simulation, the first treatment group used 25% of its clinical hours in a simulation lab, and the second treatment group used 50% of its clinical hours in a simulation lab. Outcome measures assessed knowledge, competency, critical thinking, and perceptions of meeting learning needs. No statistically significant differences existed between the control and the treatment groups related to clinical competency ($p = 0.688$), comprehensive nursing knowledge ($p = 0.478$), and National Council Licensure Examination (NCLEX®) pass rates ($p = 0.737$; Hayden et al., 2014).

Part 2 of the study included 266 participants recruited from Part 1 of the study (Hayden et al., 2014). Specifically, the second part of the study involved examining a manager's perspective on participants' readiness for practice (participants' manager responded to the survey) and the participants' self-assessment readiness for practice. Hayden et al. employed an electronic survey method to collect data from the nurse and manager participants at 6 weeks, 3 months, and 6 months after the participants started their first registered nursing position. No statistically significant differences existed during the survey time frames for managers' ratings on readiness for practice ($p = .706$, $p = .511$, $p = .527$) or self-assessment ratings on readiness for practice ($p = .35$, $p = .216$, $p = .033$) as new registered nurses (Hayden et al., 2014).

The lack of statistical significance in Parts 1 and 2 of Hayden et al.'s (2014) study bears relevance to the benefits of simulation-based learning for prelicensure nursing students. Hayden et al. did not find a difference in NCLEX® pass rates between the different groups. The results indicated simulation-based experiences prepared students' content knowledge similarly to unit-based clinical experiences. In Part 2 of the study, Hayden et al. noted no difference in readiness for practice or self-rating scores between the groups, which indicated simulation was as effective as unit-based patient care for preparing new graduate nurses for clinical practice. Hayden et al. deduced that high-quality simulation could replace up to 50% of the usual clinical hours in prelicensure nursing programs. Therefore, simulation-based clinical learning experiences are as valuable as real-life experiences for prelicensure student learning. Relating these results to my study shows high-quality CPR simulations could be as effective for learning CPR as learning during real-life situations.

Cook et al. (2011) completed a meta-analysis in which they sought to explain the difference between learning outcomes for studies in which researchers employed technology-enhanced simulation and those who did not. Cook et al. followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (Liberati et al., 2009) for their analysis and identified 609 studies for inclusion. All included studies included a focus on simulation use for training health professionals (at any stage of practice) compared to a nonintervention control group. The studies also had to include learning outcomes related to knowledge or skills acquisition, behavior changes, or effect on patient care. The results of the analysis showed simulation training leads to enhanced knowledge, skills, and behaviors in healthcare professionals (Cook et al., 2011, p. 978). The results of the study provided support for using CPR training to enhance knowledge, skills, and behaviors for those who need to perform CPR.

Cook, Brydges, Zendejas, Hamstra, and Hatala (2013) conducted a meta-analysis of quantitative studies to examine the benefits of mastery learning using simulation-based medical education. Cook et al. employed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (Liberati et al., 2009) for their analysis and identified 82 studies for inclusion. Technology-enhanced simulation, which includes manikins, refers to a tool or device used to replicate a part of clinical care that learners physically interact with for teaching or assessment purposes (Cook et al., 2013). Cook et al. posited mastery learning incorporated educational methodologies that included intellectual interactivity, feedback, learning repetition, and a greater amount of learner time spent on the learning activity. The analysis revealed mastery learning incorporating technology-enhanced simulation yielded improved learning outcomes for process-related skills compared to not using a mastery learning model. Because the act of performing CPR is a process-related skill, and current CPR training includes the components of mastery learning, it would stand to reason simulation-based learning would enhance the skills of those professionals needing to perform CPR.

Khalaila (2014) examined the influence of simulation-based learning on reducing anxiety for a convenience sample of 61 second-year baccalaureate nursing students enrolled in a Middle Eastern college. Khalaila used a pretest–posttest longitudinal design and measured student anxiety prior to and after a simulation exercise using the 20-item State-Trait Anxiety Inventory developed by Spielberg (1983). During a 3-month period in which the participants partook in their first hospital-based clinical experience, they completed two simulation days comprised of two to three daily simulation exercises that were each 90-minutes long. Analysis revealed a significant decrease in anxiety for the nursing students following simulation completion. The results of the study supported how simulation-based learning experiences can reduce anxiety prior to clinical practice. This related to my study in that I expected CPR training would help to reduce anxiety during training.

Lee and Oh (2015) conducted a meta-analysis to assess the effects of high-fidelity simulation on cognitive, affective, and psychomotor learning outcomes. Lee and Oh used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (Liberati et al., 2009) and identified 26 studies for their review. Nursing students at varying levels of academic progression comprised the sample of 26 studies. The results of the meta-analysis showed high-fidelity simulation may have positive effects on the acquisition of high-level cognitive skills and clinical skills. Although the analysis did not support the development of knowledge as a result of simulation, it did show simulation-based experiences allow nursing students to scrutinize their technical skills critically (Lee & Oh, 2015). This finding is relevant to my study, as using CPR manikins for CPR training allows individuals to evaluate and improve their own performance. Therefore, improved performance during simulation-based training should lead to better CPR skill performance in real-life situations.

Kim et al. (2016) examined quantitative studies to determine effect size for simulation-based education and compared the effect sizes based on simulation fidelity level. Kim et al. focused their meta-analysis on studies in nursing education and identified 40 studies for inclusion. Results showed simulation-based learning in nursing education is an effective teaching modality with an effect size of 0.70, and effect sizes were highest for high-fidelity simulation (0.86) and medium-fidelity simulation (1.03).

Kim et al. also reported an effect size of 1.03 for achieving psychomotor outcomes with high-fidelity simulation. This meta-analysis supported the use of CPR manikins in my study for achieving high levels of CPR performance during training sessions.

Although the support for employing simulation technology for teaching professionals and students within the health care field is well documented (Berndt, 2014; Cook et al., 2011, 2013; Gardner et al., 2016; Hayden et al., 2014; Khalaila, 2014; Kim et al., 2016; Lee & Oh, 2015; Stephenson, 2015; Sullivan, et al., 2015; Ward et al., 2014), researchers have also introduced factors that can influence simulation technology effectiveness and use (Beischel, 2013; Coffey et al., 2016; Lin et al., 2016). Thus, it was important for me to consider how variables, such as cost, simulation preparation, learners' readiness to learn, learners' physical abilities, and body mass index, affect simulation goals and outcomes.

Zendejas et al. (2013) conducted a meta-analysis on the economics of using simulation-based learning for physician education. Zendejas et al. identified 59 studies in which the researchers reported cost as an element in the study. The analysis revealed the most frequently cited cost (42 out of 59 studies) related to simulation-based education was simulator cost. These results indicated that cost is a factor related to using simulation equipment. Although the study showed improved learning outcomes when using simulation-based learning, the return on investment for simulation equipment purchases is not that clear (Zendejas et al., 2013). Therefore, simulation equipment cost is a consideration as it relates to learners having access to CPR manikin equipment for practicing CPR skills. Although the cost of the CPR manikins in my study was not a factor, because the equipment did not need to be purchased, using a CPR training approach that includes repetition could be cost prohibitive for organizations needing to purchase many manikins.

Beischel (2013) conducted a mixed-methods study to test a hypothesized model that evaluated learning variables on anxiety and cognitive learning outcomes with high-fidelity simulation learning situations. One hundred twenty-four baccalaureate-level nursing students enrolled in an entry-level nursing course at a Midwestern university comprised the sample. Divided into groups of five to six, participants completed presimulation questionnaires, assigned coursework, and a high-fidelity simulation experience. Of the variables examined related to the participants, readiness to learn, possessing a strong auditory–verbal learning style, and having sufficient preparation for the simulation activity directly influenced anxiety. However, having hands-on and strong auditory–verbal learning styles influenced learning outcomes. Beischel did not find that anxiety affected cognitive learning outcomes. Beischel highlighted how different variables can adversely affect the simulation learning experience, which is relevant to understanding potential confounds in my study.

Coffey et al. (2015) conducted a pilot study that compared manikins and simulated patients (individuals who act as patients) for the purposes of educating and assessing health care workers. Coffey et al. compared verbal interaction (with a manikin or simulated patient) and procedural-related touch (touching a manikin or simulated patient) using two different scenarios for the high-fidelity manikin simulation situation and simulated patient situation. Two teams of three people, who comprised a convenience sample recruited from a hospital in the United Kingdom, participated in the study. Each team completed four scenarios, with each scenario repeated in the two simulated conditions. The results indicated participants interacted more with the simulated patient than with the simulation manikin. The use of a simulated patient in this study enhanced the realism of the situation, which led to more authentic verbal interactions and appropriate procedure-related touch. Although the sample in the study was a limitation, the results showed manikin technologies may be inadequate for certain types of learning needs that involve patient care. Thus, using simulation manikins for learning CPR could be a limitation for enhancing high-quality CPR performance.

Lin et al. (2016) studied factors that affected emergency medical technicians' ability to perform high-quality CPR. Using a Laerdal Resusci Anne® manikin, 95 participants recruited from two different county fire departments participated in the study. Lin et al. focused on individual differences and found significant differences related to emergency medical technicians' board certification levels, body mass index, and exercise frequency. A post hoc analysis of data obtained from a prior study (using the same participant group) showed significant differences with body mass index and exercise frequency related to being able to perform high-quality CPR on a manikin (Lin et al., 2016). The results contradicted the notion that practicing CPR on a simulator leads to enhanced CPR performance (Kim et al., 2016). The findings from Lin et al. indicated individual differences (such as body mass index and exercise frequency) are important factors to consider when evaluating a person's ability to perform high-quality CPR. Therefore, an important consideration for my study was that using CPR manikins to practice CPR may have an inherent limitation related to reaching a level of being able to deliver high-quality CPR performance.

To address limitations related to the ability to perform high-quality CPR, an individual can use mechanical chest compression devices to deliver continuous chest compressions. Bonnes et al. (2016) conducted a meta-analysis to compare the benefits of mechanical versus manual CPR with prehospital post-cardiac-arrest clinical outcomes. Twenty studies comprised the sample for the analysis, and Bonnes et al. concluded clinical outcomes did not differ between using manual versus mechanical CPR compression. Using a mechanical device would minimize human limitations related to high-quality CPR performance (such as CPR performance fatigue or inconsistency with CPR compression rate and depth). However, given the lack of improvement between mechanical CPR compressions and human-performed CPR compressions on patient outcomes (Bonnes et al., 2016), the results further supported my examination of two variables (repetition of CPR practice and anxiety) that may affect high-quality CPR performance.

Gardner et al. (2016) noted simulation is a useful method for preparing health care professionals to deal with high-risk situations. The notion of training for high-risk situations directly relates to cardiac arrest events, which are high risk. Researchers have shown that simulation is effective for building skills (Berndt, 2014; Gardner et al., 2016; Hayden et al., 2014; Lee & Oh, 2015; Stephenson, 2015; Ward et al., 2014) and knowledge (Cook et al., 2011; Gardner et al., 2016) for health care professionals and students. Enhanced confidence, skills, and psychomotor performance are important proficiencies to possess when performing CPR.

Although some researchers showed limitations with simulation-based learning (Beischel, 2013; Coffey et al., 2016; Lin et al., 2016; Maloney & Haines, 2016), Hayden et al.'s (2014) results provided support for simulation-based learning being on par with actual clinical care experience for nursing students. However, Stephenson (2015) indicated that, without regularly practicing CPR skills, performance can decline. Therefore, even with the empirical support for employing simulation technology, a single simulation learning session will not result in long-term knowledge. While practicing CPR on CPR manikins should result in enhanced psychomotor performance, the specific frequency in which one must practice for maintaining CPR skills remains unknown.

Simulation Manikins: An Education Technology

The use of simulation technology for educational purposes has roots in the field of aviation (Rosen, 2013; Singh et al., 2013). While the first modern-day simulator for aviation dates to 1929 (Singh et al., 2013), educators in the field of health care only started to use simulation in 1967 (Rosen, 2013). The health care field was slower to adopt simulation use for educational purposes compared to the aviation industry, but mounting evidence supports the benefits of using simulation manikins as an educational technology for health care students and professionals (Al-Ghareeb & Cooper, 2016; Bingham, Sen, Finn, & Cawley, 2015; Johnson et al., 2016; Spooner et al., 2012; Tellson et al., 2017). However, some evidence shows that using CPR manikins for CPR training has limitations (Buléon et al., 2016; Kirkbright et al., 2014; Wanner, Osborne, & Greene, 2016; Wee et al., 2014).

Tivener and Gloe (2015) conducted a mixed methods study to understand the effects of high-fidelity CPR simulation on knowledge, confidence, and emotions of athletic training students. Twenty students enrolled in an accredited midwestern athletic training program comprised the sample. All subjects participated in one high-fidelity CPR simulation and filled an observer roll for two additional simulations. The pretest–posttest results showed significant improvements in CPR knowledge and self-confidence. Tivner and Gloe also found participants had a high level of anxiety, fear, and nervousness prior to and after completing the simulation scenario. Although Tivener and Gloe concluded high-fidelity simulation is an effective method for training athletic training students, an anxiety-related component existed in the pretest and posttest data collection phases. Therefore, Tivener and Gloe's study helped to inform my study related to high-fidelity simulation use and, from a design perspective, related the inclusion of anxiety as a variable.

Johnson et at. (2016) investigated the benefit of feedback from automated CPR feedback devices on CPR compression rate and depth during 2-minute CPR retraining sessions. Employing a repeated measures design, 150 participants performed CPR compressions on a Laerdal QCPR simulation manikin, which recorded compression rate and depth. A convenience sample obtained from an Australian university hospital included individuals who possessed basic life support certification and were either licensed registered nurses, nursing students, or medical students. Participants completed a

2-minute session and received performance feedback before completing a second 2-minute training session. Johnson et al. found performance feedback significantly improved performance between the two training sessions. Johnson et al.'s study supported the idea that feedback on CPR performance leads to improved CPR performance. This study was relevant to my research because it helped to inform my study design.

Cheng et al. (2015) examined 324 health care providers' perceptions of their own CPR quality during a simulated cardiac arrest. Randomized into one of four different groups, two groups included those who received just-in-time training with or without real-time visual CPR feedback. The other two groups did not receive just-in-time training with or without real-time visual (control group) CPR feedback. Participants included nurses, medical students, resident physicians, and attending physicians. Cheng et al. found that real-time CPR feedback either alone or in combination with just-in-time training significantly improved perceptions of CPR depth. Participant perceptions improved, but actual accuracy of the perceptions was poor. The results showed CPR performance perceptions did not accurately relate to CPR performance, which was important to my study because I used a real-time CPR feedback device in my study.

Wanner et al. (2016) examined the benefits of using a homemade CPR mannequin and online video-based training on CPR skills. Twenty-four participants recruited from a college of osteopathic medicine in the northeastern United States enrolled in the study. Twelve participants possessed a current CPR certification, and the other 12 participants had never been CPR trained. Participants viewed a 6-minute online video and practiced on a manikin they replicated at home, according to researcher guidelines, using a towel, toilet paper roll, and t-shirt. Wanner et al. employed a parallel design with pretest and posttest CPR skills evaluation for the study. Although the results showed improvements in some skills among both groups, chest compression depth for both groups did not improve. Even though Wanner et al. created a low-cost, low-fidelity CPR manikin to mitigate cost, chest compression depth is an important component of high-quality CPR and the results reinforced the benefits related to using real-time higher cost CPR feedback manikins or devices to learn CPR skills.

Al-Ghareeb and Cooper (2016) conducted a literature review to explore studies that identified impediments and enablers for using high-fidelity simulation manikins in undergraduate nursing education. Using the Critical Appraisal Skills Programme criteria (Public Health Resource Unit, 2012), 21 studies met the criteria for inclusion in the review. Al-Ghareeb and Cooper identified common themes between the studies and found simulation is effective for knowledge acquisition, development of critical thinking skills, and improving student satisfaction with learning. Al-Ghareeb and Cooper also identified impediments to simulation use, which broadly included lack of time to use technology, lack of technology training, lack of financial support for equipment purchases, and increased workload as a result of incorporating technology into the educational curriculum. Although this review provided support for the learning benefits related to simulation technology, it also called out potential limitations that can adversely affect learner use. The conclusions in the review were relevant to my study in that simulation is an effective method for teaching. However, there were also impediments that could affect widespread use of manikin technology for CPR training, such as lack of time to use technology and lack of funding to purchase simulation equipment.

Bingham et al. (2015) examined 149 pharmacy students' ability to retain advanced cardiac life support knowledge and skills with the use of high-fidelity simulation mannequins. Participants recruited from a pharmacy program in Pennsylvania, and randomly assigned to 36 teams comprised of five to six people each, took part in a simulated cardiac arrest situation. Bingham et al. used a checklist to evaluate the students' skills and manikin survival or death during the simulation scenario, during which proper care resulted in manikin survival. Twenty-three of the 149 pharmacy students had participated in an advanced cardiac life support training course 120 days prior to the study. A facilitator, who portrayed the role of a physician, created an emergency-like situation through verbal interactions with the team during the simulation. Although the authors did not find significant differences between the groups, they noted manikin survival was 37% higher for the groups that had a student with prior advanced cardiac life support training. The results relating to enhanced manikin survival provide supported for a simulation-based approach for using repetition with CPR training, which is the approach used in my study.

Tellson et al. (2017) examined the use of three CPR manikins (normal size, obese size, morbidly obese size) on health care providers' ability to perform high-quality CPR. CPR manikins, which are described as normal sized adult, tend to mimic the common size of a female body. Tellson et al. created obese and morbidly obese manikins based on the body casts of individuals who met body mass index criteria for the two categories.

The participants included 61 health care professionals who were from a hospital in Texas. Each participant performed 60 compressions (two cycles of 15 compressions) on each manikin at a rate of 100 compressions per minute, with a depth of 2 inches, and a 5-second pause between each cycle. The manikins provided performance measurements for each participant and results showed CPR performance on the normal manikin was significantly better than both the obese (p = .0001) and morbidly obese manikins (p = .0001). Tellson et al. indicated about 70% of adults in the United States are overweight, which is important to note when determining whether CPR training manikins are adequate to prepare care providers for providing CPR in real life.

Buléon et al. (2016) examined the impact of continuous CPR chest compression cycles over a 10-minute period on CPR manikins with and without the use of a CPR feedback device. Sixty health care professionals, recruited from a university medical center-based emergency ambulance service, comprised the study group. Buléon et al. employed a Laerdal Resusci Anne® and CPRmeter as a CPR manikin and CPR feedback device, respectively. The CPRmeter, which is a small puck-like device that goes over the CPR compression point on the manikin's chest, provides real time chest compression feedback to the individual performing CPR. Using a randomized crossover study design, the results showed the average rate of proper chest compressions was significantly better in the group that received real-time feedback from the CPRmeter. This finding brings into question the benefit of manikin use for high-quality CPR training, in that real-time CPR feedback may have a greater impact on CPR performance than practicing on a manikin.

The results of this study were important considerations for my study, as they indicated that frequency for CPR practice on CPR manikins may not affect CPR performance.

Kirkbright et al. (2013) conducted a systematic review and meta-analysis of studies related to CPR performance by health care providers who used audiovisual feedback devices in simulated and actual cardiac arrest situations. Kirkbright et al. identified 17 studies in which the researchers used manikins and three studies in which the researchers used actual patients. Although the results showed chest-compression quality can be closer to American Heart Association CPR guidelines by using real-time audiovisual feedback devices, Kirkbright et al. noted significant clinical heterogeneity existed between the studies, which was a limitation for the study. The goal of performing high-quality CPR is to perform in accordance with American Heart Association guidelines. Therefore, the analysis showed the delivery of CPR performance is more consistent when using CPR feedback devices, which results in high-quality CPR chest compressions. This analysis supported the finding of Buléon et al. (2016), which indicated that real-time CPR feedback devices provide more consistent CPR performance versus CPR training alone. Kirkbright et al.'s findings highlighted the notion that frequency of CPR manikin training alone may not lead to individuals being able to perform high-quality CPR.

In another study by Wee et al. (2014), the use of an automated external defibrillator provided CPR feedback to participants when performing CPR on a CPR manikin. A Zoll E Series Defibrillater provided performance feedback to the 209 registered nurses and health care assistants recruited from a Singapore dialysis company who enrolled in the study. Participants performed five cycles of 30 chest compressions at a rate of 90 to 110 compressions per minute. The results showed CPR feedback devices significantly enhanced chest compression depth and chest compression rate for participants. Wee et al. concluded CPR feedback devices enhance CPR performance during training; however, more research is necessary related to generalizing these results to patient care outcomes. The study supported the results from Kirkbridget et al. (2013) and Buléon et al. (2016) that indicated real-time CPR feedback devices provide more consistent performance of high-quality CPR.

Yeung, Davies, Gao, and Perkins (2014) examined the effectiveness of different CPR feedback devices and compression prompt devices on CPR chest compression quality. One hundred one participants, recruited from an intermediate life support course in England, completed the study. The devices compared in the study were a simple metronome (a device that provides auditory compression rate tones), a pressure sensor with a metronome device (provides real-time compression depth feedback and an auditory rate tone), and an accelerometer device integrated into a Phillips MX CQPR defibrillator (a device that uses a pressure meter to provide visual feedback on CPR compression rate and depth). Participants randomly assigned to the control or one of the three device groups completed 2 minutes of CPR on a Laerdal Resusci Anne Advanced SkillTrainer® manikin to establish baseline performance. The participants rested for 1 hour and then performed 2 minutes of CPR with their assigned prompt or feedback device (the control group performed CPR on the manikin without any CPR performance device). Yeung et al. found the pressure-sensing devices statistically improved compression depth and the devices with auditory feedback significantly reduced the compression rate at baseline to the desired rate of 100 during treatment phase. These results highlighted the importance of using compression-sensing feedback equipment in my study to measure CPR performance.

Although mounting evidence shows real-time CPR feedback devices can enhance CPR performance (Buleon et al., 2016; Kirkbright et al., 2013; Wee et al., 2014; Yeung et al., 2014), Sheak et al. (2015) examined the benefit of end-tidal carbon dioxide monitoring (waveform capnography to measure blood flow) in relationship to CPR quality. Data collected for the study (using Philips MRx QCPR Defibrillators with carbon dioxide monitoring and event recording) originated from hospitals and prehospital care providers throughout the United States. Five hundred eighty-three cardiac arrest situations occurring in a prehospital or hospital setting met criteria for inclusion in the analysis. Sheak et al. found that CPR chest compression depth significantly predicted an increase in end-tidal carbon dioxide levels, thus providing another CPR physiological measure to gauge CPR performance. These findings are important as an individualized patient-focused method for ensuring the delivery of high-quality CPR. The CPR technology in my study did not include end-tidal carbon dioxide monitoring; however, the results of Sheak et al.'s study may help to highlight limitations with CPR educational technology and generalizability to real-world practice.

Research supports the use of simulation manikins as an educational technology for learning CPR-related skills and for other health-care-related knowledge (Al-Ghareeb et al., 2016; Bingham et al., 2015; Spooner et al., 2012; Tellson et al., 2017). However, simulation technology specifically related to learning CPR skills does have limitations (Buleon et al., 2016; Kirkbright et al., 2013; Wanner et al., 2016; Wee et al., 2014; Zendejas et al., 2013). The results from Buléon et al. (2016), Kirkbright et al. (2013), and Wee et al. (2014) showed the sole use of CPR manikins does not lead to health care providers being able to deliver high-quality chest compressions during CPR. These studies showed real-time CPR assist devices are more effective for health care providers to perform high-quality CPR compared to using manikin technology alone. Thus, CPR simulation manikins and CPR training may not provide an adequate learner experience for health care professionals, which leads to the performance of high-quality CPR.

Evidence for a Distributed Practice and Manikin Use to Learn CPR Skills

Employing simulation technology with variable practice schedules for learning CPR skills is well supported (Aqel & Ahmad, 2014; Kwon, Kwon, & Lee, 2016; Niles et al., 2017; Nori, Saghafinia, Motamedi, & Hosseini, 2012; Oermann et al., 2011; Sullivan et al., 2015; Sutton et al., 2011). These researchers employed simulation manikins that incorporate American Heart Association CPR guidelines to ensure training meets accepted real-life practice guidelines. Although many of the studies reviewed do not directly reference the distributed practice framework, the notion of using repetition in practice to enhance learning is foundational to distributed practice.

Oermann et al. (2011) examined the effects of monthly CPR practice on nursing students' CPR psychomotor skills at 3-, 6-, 9-, and 12-month intervals. The participants were 606 beginning nursing students from diploma, associate degree, and baccalaureate nursing programs at 10 different schools. Oermann et al. randomly assigned participants to two groups: the control group received the American Heart Association basic life support provider course, with no additional CPR training during the course of the study, and the experimental group used the HeartCode™ American Heart Association basic life support provider course with voice-activated CPR feedback manikins. Oermann et al. employed a Laerdal Resusci Anne SkillReporter® CPR manikin to obtain CPR performance metrics for both groups.

An independent *t* test and Chi-square test provided the analysis of between-group demographic variables between the control and experimental groups (Oermann et al., 2011). The CPR outcome measures showed the control group's ability to deliver appropriate compression depth significantly decreased between 9 and 12 months (p = .004). Oermann et al. (2011) reported CPR skills could improve with monthly practice compared to the group that did not practice monthly. The findings in Oermann et al.'s study provided support for using a monthly repeated-practice approach for learning CPR skills.

Sutton et al. (2011) investigated the effectiveness of brief CPR training on CPR skills retention for hospital pediatric providers (nurses and medical residents). Using a Laerdal voice feedback manikin and a Philips external monitor defibrillator, Sutton et al. randomly assigned 74 participants to one of four conditions: a control group, instructor-only training (no manikin technology used), automated defibrillator monitor feedback only, and automated defibrillator monitor feedback combined with instructor training. Sutton et al. used a pretest–posttest longitudinal design and conducted sessions, with CPR performance measured at baseline, 1 month, 3 months, and 6 months. Each session included a 60-second CPR pretraining evaluation, a 120-second CPR training session, and a 60-second posttraining evaluation. The results showed retention of CPR skills more likely improved with the training sessions at the 3-month (95% confidence interval [CI]: 1.1–4.5; p = .02) and 6-month (95% CI: 1.4–6.2; p = .05) marks. The study, which was the first study completed on this topic, showed how brief training can aid in retaining CPR skills, which provided support for using CPR manikins and the distributed practice approach in my study.

Roh and Issenberg (2014) conducted a single-group posttest study to examine CPR skills quality and whether relationships exist between CPR psychomotor skills with self-efficacy and CPR knowledge. Participants included 124 second-year nursing students partaking in an emergency department clinical rotation. Roh and Issenberg noted six identical CPR training sessions, comprised of 20 or 21 participants per session, received training during the data collection phase. Resuscitation self-efficacy assessment included two items from a nursing instrument, and CPR knowledge assessment employed a 10-item questionnaire. Roh and Issenberg used CPR manikins to measure CPR quality in terms of American Heart Association metrics and guidelines. Of the 124 participants, only one correctly performed five CPR cycles. No significant findings were noted for CPR psychomotor quality among students. However, there were significant findings for nursing students who performed chest compressions correctly with reported self-efficacy (r = -.238, p = .008) and for self-efficacy and CPR knowledge (r = .303, p < .004). Although compression skills were not significantly related to knowledge (r = -.060, p =

.510), the results emphasized the need to understand factors that may affect the performance of high-quality CPR.

Nori et al. (2012) studied the retention of CPR cognitive knowledge and the psychomotor skills of nurses following a CPR training course. Nori et al. employed a quasi-experimental design and measured the knowledge and psychomotor skills of 112 nurse participants at four different points in time: before training, at the end of training, 10 weeks posttraining, and 2 years posttraining. All participants received a 2-hour didactic training and 100 minutes of applied training on manikins. A 20-question multiple choice questionnaire provided the CPR knowledge measure, and a CPR observant checklist assessed psychomotor skills. Nori et al. used a repeated measures ANOVA design to compare the mean scores during the four different measurement periods. Before reporting results, Nori et al. noted 70 nurses did not complete the last stage of measurement due to being transferred to other hospitals, which is a limitation related to interpreting the data obtained 2 years posttraining. Nori et al. reported significant differences between the stages of measurement for both the cognitive knowledge and psychomotor skills components ($p < .004$ for both variables). However, mean scores for the variables measured decreased during the third and fourth measurement periods, as compared to pretest and immediate posttraining scores. The results of the study supported the importance of repetition to develop CPR cognitive knowledge and CPR psychomotor skills.

Kwon et al. (2016) completed a study in which they compared the effect of massed learning and distributed practice approaches on motor sequential learning in healthy adults. Kwon et al. employed a pretest–midtest–posttest longitudinal design and compared 30 participants randomly assigned to one of two groups. A computer-based software program that involves using visual cues to measure response time and response accuracy measured participants' response time and response accuracy to a computer-based serial reaction task (participants reacted to visual number cues and had to select an appropriate response based on the task). The results showed a distributed practice learning schedule is more effective for motor skill learning compared to a massed learning approach. The findings lent support for the distributed practice framework employed in my study, in that practice over time leads to better motor performance compared to a single learning session. Furthermore, as performance of CPR involves recalling learned motor skills, Kwon et al.'s study provided support for CPR training that occurs in smaller sessions over time, which I employed in my study.

Aqel and Ahmad (2014) used experiential learning theory as a foundation to examine the use of high-fidelity simulators on 90 second-year University of Jordan nursing students' CPR knowledge, skills, acquisition, and retention. To participate, students could not have any prior experience performing CPR on a patient or CPR during a high-fidelity simulation. Participants were randomly assigned to one of two pretest–posttest groups control group received a 4-hour American Heart Association class consisting of a PowerPoint presentation and a CPR manikin demonstration. The treatment group received the same content as the control group but included high-fidelity simulation CPR training. Aqel and Ahmad used *t* tests to examine the differences between groups and reported no significant differences in baseline CPR knowledge between the groups ($p = .53$). However, significant differences existed between the groups for CPR knowledge ($t = -6.94$, $p < .004$) and skills ($t = -5.44$, $p < .004$) in the posttest condition, which indicates high-fidelity simulation enhances the acquisition and retention of CPR knowledge and skills. Aqel and Ahmad also found a significant difference for knowledge retention 3 months posttraining ($t = 8.05$, $p < .004$), and both groups experienced a significant loss of skills retention 3 months posttraining ($t = -7.05$, $p < .004$). The study provided support for using high-fidelity CPR manikins to train for cardiopulmonary arrest, indicated that CPR skills degradation occurs at 3 months, and more frequent CPR training could provide a foundation for maintaining CPR skills.

Sullivan et al. (2015) conducted a randomized simulation-based study to examine effectiveness and frequency of in situ training related to in-hospital cardiac arrest. Sixty-six non-intensive-care nurses, randomly divided into four groups, completed the study. The four groups included a control group and groups that received training every 2 months, 3 months, and 6 months. Sullivan et al. focused on the timeliness of initiation of chest compressions and successful defibrillation after the initial call for help. A Kruskal-Wallis test, using a Dunn/Bonferroni adjustment for significant findings, showed a greater frequency of training yielded a decreased time to initiate chest compressions and defibrillation for in-hospital cardiac arrest ($p < .004$). However, no significant differences between the 2-month group and the 3-month group showed frequency of training as being frequent enough to maintain CPR skills. Sullivan et al.'s findings provided support for how repeated practice improved two specific components of responding to a cardiac arrest situation (decreased time to initiate chest compressions and defibrillation) and indicated a 3-month period is suitable for spacing CPR training sessions.

Niles et al. (2017) examined the effectiveness of brief training sessions on CPR manikins using a quasi-experimental longitudinal study with 37 nurses working at an acute care children's hospital in Philadelphia. Only nurses CPR certified within the preceding 6 months participated in the study and any individuals who had exposure to using real-time audiovisual CPR feedback were excluded. A Laerdal Resusci Anne provided feedback on chest compression depth, compression rate, compression release, and proper CPR hand placement. Participants completed a baseline CPR assessment and then chest compression training every 2 to 3 months, for a total of 12 months, using manikin feedback to reach high-quality CPR performance criteria. The results indicated chest compression quality significantly improved at the 6-month mark over baseline, and there was no difference between measurements at the 6-month and 12-month marks. This study serves as evidence that brief CPR training that occurs every 2 to 3 months, using a CPR manikin with feedback enhances chest compression quality. The finding that briefly repeated CPR training using CPR training manikins can lead to improved CPR performance was relevant to my study.

CPR is a task that requires cognitive knowledge and psychomotor skills to perform it correctly. However, Roh and Issenberg (2014) did not find a significant difference between CPR knowledge and CPR skill in nursing students, whereas Nori et al. (2012) reported a significant increase in CPR knowledge and skill with repeated learning for licensed nurses. Therefore, cognitive knowledge may not be an important factor in being able to perform CPR skills correctly.

Some researchers specifically addressed the frequency of repetition to learn the psychomotor skills of CPR (Aqel & Ahmad, 2014; Kwon et al., 2016; Niles et al., 2017; Nori et al., 2012; Oermann et al., 2011; Sullivan et al., 2015; Sutton et al., 2011). However, even with repetition in CPR training, knowledge and psychomotor skills degrade over time (Aqel & Ahmad, 2014; Niles et al., 2017; Nori et al., 2012; Oermann et al., 2011). The degradation in CPR psychomotor skills over time indicates the need to understand specific training intervals for maximizing CPR skills retention, even though studies show monthly CPR practice can enhance psychomotor performance (Oermann et al., 2011; Roh & Issenberg, 2014).

Some studies involved student nurse participants and not licensed registered nurses (Aqel & Ahmad, 2014; Oermann et al., 2011; Roh & Issenberg, 2014), which is a potential limitation, in that licensed nurses may not have the time available to practice any skill on a monthly basis, unless mandated to do so by their employer. Practicing on a monthly basis for every type of situation a nurse may encounter, whether a common occurrence (such as listening to normal lung sounds) or not so common (such as cardiopulmonary arrest), would be cost and time prohibitive. Therefore, even with employing a distributed practice approach to learning, it may not be realistic to operationalize monthly training to meet the vast array of educational needs of nurses.

Finally, in some of the studies reviewed, the researchers acknowledged financial support from the Laerdal Corporation (Buléon et al., 2016; Niles et al., 2017; Oermann et al., 2011; Sutton et al., 2011). While the authors ethically declared the potential conflict, the results provide support for the company to sell a product that incorporates repetition to maintain CPR certification. Future studies should be independent from any simulation company funding.

Syntheses of Literature Themes

The purpose of this section is to identify the major themes in this chapter. Neumar et al. (2015) stated a gap exists between CPR training and the ability of individuals to perform high-quality CPR in real life. Therefore, researchers need to examine factors that potentially affect CPR performance to address the gap between CPR training and performance. Major themes in the literature related to CPR training and transference of skills to practice include the frequency in which individuals need to practice CPR, the use of CPR training manikins for training nurses, and how anxiety affects learning.

The gap identified by Neumar et al. (2015) highlights how the lack of a relationship between practicing a skill and being able to perform that skill at a later time creates a fundamental problem for CPR training. Typically, individuals will obtain an initial CPR certification and then recertify every 2 years to maintain their certification. While the American Heart Association released a new method for maintaining CPR certification (RQI®), which is based on 90-day recertification cycles, there is no research that indicates this approach works (independent of other interventions). However, RQI® was launched February 2015 (American Heart Association, 2018). Thus, the reason there is no literature to reference could stem from the newness of the approach. From a distributed practice framework perspective, increasing the frequency of certification training cycles should translate to enhancing CPR performance (Abe et al., 2013; Abelsson et al., 2017; Kupper-Tetzel, 2014; Taylor et al., 2014).

CPR skills are one of many types of skills needed by nurses to maintain a proficient level of readiness. Nurses need to be able to respond to a broad range of clinical problems, some of which are rarely or never encountered during daily practice. Training for events that do not occur frequently may occur yearly or even less frequently. Research in the area of massed learning shows this approach is not effective for knowledge acquisition (Kwon et al., 2016). Although studies show repetition of CPR practice leads to enhanced CPR performance and skills (Aqel & Ahmad, 2014; Kwon et al., 2016; Niles et al., 2017), the recommended frequencies to practice vary (Niles et al., 2017; Oermann et al., 2011). The lack of specificity for CPR training frequency leads to a need for a better understanding of the optimal time frame for repeating CPR training to maintain CPR skills.

Research supports the use of simulation approaches for learning in the non-health-care- and health-care-related fields (Aqel & Ahmad, 2014; Tichon & Diver. 2012). Simulation-based learning approaches are effective for preparing health care professionals for high-risk situations (Gardner et al., 2016). Hayden et al. (2014) described simulation-based learning as equivalent to actual clinical experience for nursing students. The CPR studies reviewed in this chapter included CPR manikins for examining different variables, such as time, that potentially affect CPR performance. Oermann et al. (2011) and Sutton et al. (2011) conducted the first CPR-related studies with CPR manikins that employed a distributed practice framework.

CPR training-related studies often take place in simulated environments that do not replicate the stress and chaos that can occur during real-life cardiac arrest situations. Sullivan (2015) described the cardiac arrest situation in the hospital setting as high anxiety and stress producing. Introducing anxiety into motor learning training sessions is beneficial (Hordacre et al., 2016). Lee and Cha (2017) reported anxiety was a theme that emerged related to the performance of CPR by nurses in their study. However, no researchers identified studies that incorporated an anxiety-producing variable into CPR training. Therefore, a CPR-training perspective warrants examining how the introduction of anxiety-producing variables affect performance during CPR training.

Summary

Researchers have documented the use of simulation for enhancing learning outcomes in fields outside health care (Berk et al., 2014; Stanyon et al., 2014; Tichon & Diver, 2012). Within the field of health care, researchers have documented the benefits of employing simulation-based technology for teaching health career students and professionals (Aqel & Ahmad, 2014; Berndt, 2014; Cook et al., 2011; Gardner et al., 2016; Hayden et al., 2014; Lee & Oh, 2015; Stephenson, 2015; Ward et al., 2014). The distributed practice framework supports the evidence that practicing CPR can lead to better performance (Aqel & Ahmad, 2014; Kwon et al., 2016; Niles et al., 2017; Nori et al., 2012; Oermann et al., 2011; Sullivan et al., 2015; Sutton et al., 2011). However, the frequency in which one must practice the skill of performing high-quality CPR to maintain proficiency is as often as every month (Oermann et al., 2011). In the absence of practicing CPR, skills diminish as early as 3 months (Aqel & Ahmad, 2014). The focus of studies on the topic is nursing students or medical students (Aqel & Ahmad, 2014; Oermann et al., 2011; Roh & Issenberg, 2014); thus, the findings may not generalize to licensed registered nurses.

Neumar et al. (2015) clearly indicated a gap exists between practice and real-life CPR use. I believe this gap exists as a result of the different factors that can influence CPR performance by health care professionals. The most optimal practice schedule for maintaining CPR skills is still unknown, and evidence exists to support the benefit of real-time feedback devices during simulated cardiac arrest situations (Buléon et al., 2016; Kirkbright et al., 2013; Wee et al., 2014), which could negate the need for more frequent CPR training. Evidence also shows an individual’s physical abilities have an impact on CPR performance (Lin et al., 2016), which does not directly affect learning a skill. Therefore, it is important to recognize factors that may positively or adversely affect CPR performance and focus training efforts on performance factors that can improve through education.

According to Sullivan (2015), cardiac arrest situations are high-stress and anxiety-evoking events for health care providers. Therefore, it is important to understand how anxiety affects learning CPR and being able to perform CPR skills. Introducing anxiety-producing factors during a simulation activity may enhance (Hordacre et al., 2016) or diminish the learning outcomes (Renden et al., 2014; Vine et al., 2013). Because it is not a requirement to practice CPR under stress conditions to maintain a CPR certification, changing practice conditions warrants specifically examining anxiety as a factor in learning CPR.

My research involved examining the knowledge gaps related to the frequency required to maintain CPR skills and the ways an anxiety-producing factor affects learning CPR skills when using CPR manikins. I focused on licensed registered nurses who do not typically encounter cardiac arrest situations during their daily work activities. Thus, augmenting research knowledge related to learning CPR skills, so high-quality CPR can be delivered by nursing professionals, who typically do not perform CPR on patients. A longitudinal repeated measures design was suitable, and a discussion on the methodologies appears in Chapter 3.

Chapter 3: Research Method

The purpose of this quantitative study was to examine the impact of CPR performance feedback and hospital noises, as measured by the CSAQ, on the CPR performance of medical and surgical acute care registered nurses working in a hospital setting. Simulation CPR manikins are an educational technology used to enhance CPR performance. Lee and Oh (2015) reported that when learning incorporates simulation, students can scrutinize their technical skills and improve their cognitive and psychomotor learning domains. Cook et al. (2011) stated that "technology-enhanced simulation training in health professionals' education is consistently associated with larger effects for outcomes of knowledge, skills, and behaviors" (p. 978). The 2015 American Heart Association guidelines includes a recommendation to use feedback devices to learn the psychomotor skills of performing CPR (Neumar et al., 2015). The CPR simulation manikins in the current study provided learner feedback through a Zoll Series R defibrillator.

This chapter includes a description of the research methods, variables, and rationale for employing the approach used for this study. Also presented is the methodology related to the population studied. Descriptions of data collection and data analysis, threats to validity, and ethical procedures are also included in this chapter.

Research Design and Rationale

This study included a randomized longitudinal experimental design. The rationale for selecting the research design related to addressing the research questions. A research design becomes a blueprint that researchers use to address problems and provides guidance during the stages of investigation (Frankfort-Nachmias, Nachmias, & DeWaard, 2015). The design choice (see Figure 1) was also consistent with the research presented in Chapter 2. The quantitative approach selected allowed a statistical comparison between the groups and over time. Data gathered from CPR manikin performance using the Zoll Series R defibrillator and from the CSAQ required analysis to determine whether relationships between the variables existed.

Exploration of the other major research approaches, which are qualitative and mixed methods, revealed that these methods were not appropriate for this study. Researchers employ a qualitative approach when they seek to collect data based on field research or observation in a natural setting (Frankfort-Nachmias et al., 2015). A mixed-methods approach includes more than one method or data type (Patton, 2002). Because I examined relationships between variables and between groups, the quantitative design was appropriate. The study included only one approach and data type; therefore, a mixed-methods approach was not appropriate.

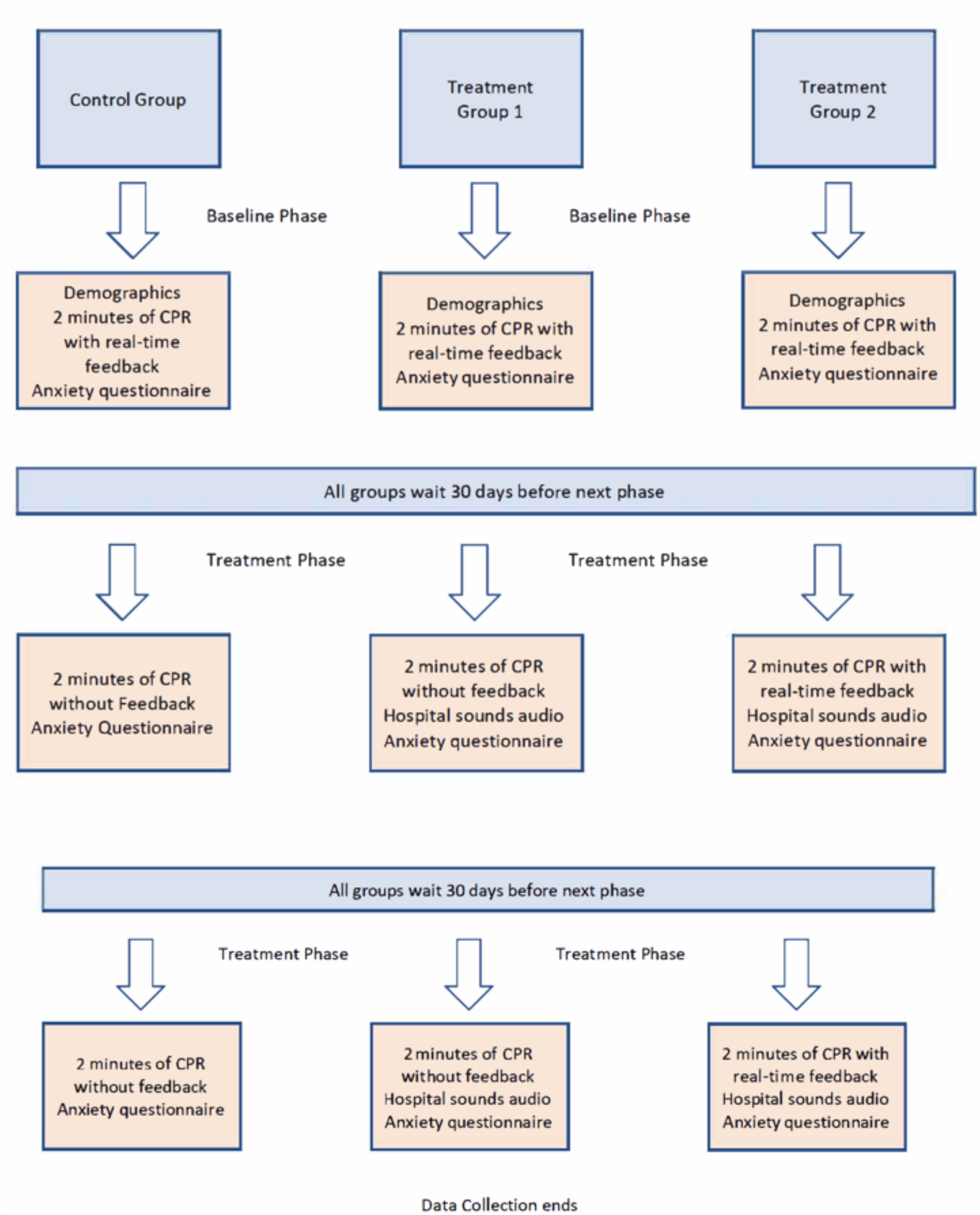


Figure 1. The three-group longitudinal design employed for this study.

The study variables included one dependent variable and two independent variables. The dependent variable was CPR performance by nurses on a CPR manikin. Measuring the dependent variable involved applying specially designed training pads for the Zoll R Series defibrillator to a CPR manikin to measure performance metrics according to the 2015 American Heart Association CPR guidelines. The guidelines for acceptable CPR include a rate of 100–120 compressions per minute and a compression depth of 2 to 2.4 inches. The participants who received CPR performance feedback could look at the defibrillator monitor to determine whether their CPR performance was meeting the American Hospital Association CPR guidelines. Participants who received CPR performance feedback received auditory prompts to adjust CPR rate or compression depth to meet American Heart Association CPR guidelines.

The independent variables were CPR feedback (provided by a Zoll R Series defibrillator) and the use of a hospital-noises audio rendering. I played the audio-rendered portion of a simulated cardiac arrest situation video developed by researchers from the Kaiser Permanente School of Anesthesia (2016) loudly (at a maximum volume using an Acer computer and Logitech 5-150 external speakers) for treatment groups to evoke a realistic environment in which nurses perform CPR (see Appendix A for permission to use the video/audio rendering). To examine the effect of time on CPR performance, I repeated the exercise two additional times and collected the performance data at 30 and 60 days after measuring the baseline. The rationale for repeating the exercise at 30 and 60 days related to the distributed practice framework that posits that learning occurs over time with repetition (see Gerbier & Toppino, 2015).

There were two potential constraints with this design choice. The first constraint related to participant attrition throughout the study. Because this study took place over 60 days, it was possible that all participants might not have completed the study. The second constraint related to the possibility of equipment failure during the measurement periods of the study. Failure of the CPR manikin, Zoll Series R defibrillator, or audio player could have adversely affected data collection and subsequent results.

Methodology

The population for this study included licensed medical and surgical acute care registered nurses working at one of two community hospitals that were part of a single state health care system located in the Northeastern United States. All participants had registered nurse licensure in the state, which was employer verified through the employment process to work at the hospital. I limited the sample to medical and surgical acute care nurses who had a current basic life support certification and who had not performed CPR on a patient or CPR manikin within the 90 days preceding their initial participation in the study. Limiting the sample as described reduced the test–retest effect.

The study included a simple random sampling strategy that afforded every individual in the population the chance of being selected for the study and for any participant group. The population of medical and surgical acute care nurses at the two hospitals was approximately 650. Limiting the sample to a specific population of nurses, specifically medical and surgical acute care nurses, reduced the selection threat to internal validity. For example, if other nursing specialties, such as critical care nurses, had participated in the study, it would have been hard to discern whether performance differences were due to training or prior experience.

Data collection took place in a room at the hospital that I reserved. Data collection included completing the surveys and CPR performance. When individuals agreed to be a participant, they created a unique identifier and completed the first round of data collection. I also informed the participant that data collection would occur 30 days and 60 days later in the same area where the first phase of data collection occurred.

The baseline measurement phase ended after achieving the desired sample size for the study. The subsequent measurement phases (30 days postbaseline and 60 days postbaseline) occurred over a 4-day period during scheduled blocks of time. Participants were permitted to show up to complete a phase at any point during the scheduled times. The estimated time for each individual to complete a measurement phase was 5–7 minutes, which included spending 2 minutes of CPR on the manikin and completing the CSAQ. Approximately 5 additional minutes were necessary during the first measurement phase to complete a demographic questionnaire. To help participants remember their scheduled session, I sent e-mail reminders to the participants if the participant wanted to receive an e-mail. No association existed between the e-mail address and any data collected during the study.

The tool used to calculate the sample size for this study was G*Power 3.1 (see Faul, Erdfelder, Lang, & Buchner, 2009). The input parameters for the analysis were.25 (effect size), .05 one-tailed (α level), 0.80 (power), and 0.5 (correlation among repeated measures). A priori power analysis revealed the total sample size for this study was 108 participants. Using .80 as the level for the power in the sample size analysis is typical for the quantitative method used in this study (see Campbell & Thompson, 2002; Cohen, 1992). The sample size selected was 120 participants to allow for participant attrition over the course of the study. Increasing the sample size above the minimum value of 108 helped to preserve the statistical integrity of the study by allowing up to an 11% attrition rate.

I recruited participants at the hospital site. Communications to potential participants included announcements made verbally at staff huddles and nursing department meetings and the distribution of flyers. There was no obligation to participate in the study, and participation would not affect participants' employment in any way. All participants received a random assignment to one of the three groups (control, Treatment Group 1, or Treatment Group 2) after completion of the baseline phase. The control group did not receive CPR performance feedback and were not subject to the loud audio clip. Treatment Group 1 did not receive CPR feedback but was subject to the loud audio clip. Treatment Group 2 was subject to the loud audio clip during CPR performance and received CPR feedback.

All participants who agreed to participate in the study signed an informed consent document at the time they agreed to participate and prior to any research activities commencing. Each participant received a copy of the signed consent form. However, fewer than 10 participants kept the consent form, and most indicated they did not want a copy. I collected the consent forms at the time the participants signed them. The informed consent form included a statement related to the option to withdraw from the study at any time without consequence. If a participant started the study and wanted to withdraw prior to the last measurement phase, I engaged the participant to determine whether any change was possible to the schedule to maintain the participant's continued participation.

I collected data via a paper-and-pencil demographic questionnaire, the CSAQ (see Appendix C), and CPR compression performance feedback via a Zoll R Series defibrillator. At the completion of the study, I asked all participants if they had any questions or concerns regarding the study. I informed participants that I would communicate results in the aggregate and would not reference any individual-level data. I shared the aggregate results by e-mail to any participant who provided an e-mail address on a form completed separately from any study data.

After receiving institutional review board (IRB) approvals, I began recruitment and data collection. Ninety-four nurses consented to participate, and I received dissertation committee approval to start Phase 1. However, despite reminders sent to participants, only eight of 50–60 nurses showed up to participate during the first three data collection sessions. I stopped data collection due to the low participation rate. I received verbal communications from the hospital president, chief nursing officer, and two staff educators advising that the hospital was extremely busy during the Phase 1 data collection time. I also heard from participants via e-mail or verbally that they had forgotten to show up during the day they signed up to participate. Based on these issues, I proposed and submitted modifications to participant recruitment and data collection methods for approval by the two IRBs.

Modifications to the study protocol included changing the criteria for participant inclusion to 30 days (from 90 days) for the length of time since last performing CPR on a patient or for recertifying CPR, including an additional questionnaire used in Phases 2 and 3 regarding CPR performance (see Appendix C), using a room on or near the nursing units in which the participants were working, incorporating a second hospital (from the same health system) in the sample, revising the informed consent to include the requested study modifications, and distributing a new flyer for the additional facility for collecting data. I also appeared on the nursing units to remind participants about data collection on the data collection days.

I requested modifications to the study protocol as a means to increase the rate in which individuals participated in the data collection phases of the study. One of the modifications included the addition of a second hospital site, which increased the potential participant pool to 650. Additionally, moving data collection onto the unit in which the participants were working made it easier for the nurses to take a quick break from their daily routine to participate. Furthermore, my presence on the unit served as a direct reminder to the participants at the postbaseline data collection times about their continued participation.

After receiving approval from both IRBs to proceed with the study by employing the new procedures, I started to recruit participants again. The new population of participants included some individuals who signed up for the initial study. I recruited participants and collected Phase 1 data after an individual consented to being in the study. By implementing a rolling calendar approach for scheduling postbaseline data collection, I was able to collect data on different nursing units at different times and maintain a schedule for when postbaseline data collection would occur for participants by unit. By employing the new protocol methods, I obtained a sample size of 120 for Phase 1.

Additionally, I placed a portable table against a wall for stability and placed two nonslip pads under the table legs nearest to the participant to minimize table movement and to ensure a consistent height for placement of the CPR manikin. To minimize the movement of the manikin during compressions, I placed a nonslip pad under the manikin on the table. Figure 2 is a picture of the table and the setup of the equipment used.

Figure 2. Setup showing the CPR manikin, portable table, nonslip material under the CPR manikin and front table legs, and Zoll Series R defibrillator on the table.

Instrumentation and Operationalization of Constructs

I developed and used a demographic questionnaire for collecting information from all participants (see Appendix C). Collecting demographic data allowed me to gather descriptive data of the individual factors of participants that might have had an effect on the dependent variable. The study involved using the CSAQ (Calvo et al., 1990) to measure the anxiety level of participants just after performing CPR on a manikin. The anxiety survey contained 20 items divided into the cognitive anxiety and somatic anxiety subscales, with 10 items each (Calvo et al., 1990). The factor loadings for the cognitive anxiety subscale ranged from .51 to .82, and the factor loadings for the somatic anxiety subscale ranged from .56 to .87 (Calvo et al., 1990). The alpha coefficient for internal consistency was .88 for the cognitive subscale and .86 for the somatic subscale; in addition, the correlation between the cognitive and the somatic subscales was .66 (Calvo et al., 1990).

According to Frankfort-Nachmias et al. (2015), factors values range from 0 to 1.0, with 1.0 being the highest amount of variance accounted for in the model. Thus, with subscale coefficients of .88 and .87, 88% and 87% of the variance was accounted for in the cognitive anxiety subscale and in the somatic subscale, respectively. I received permission from the publisher, Elsevier, to employ the questionnaire (see Appendix D).

The CSAQ, a self-report instrument, was suitable for this study because it provided a general measure of cognitive and somatic anxiety. Calvo et al. (1990) validated the initial instrument with 156 participants during an evaluative aptitude test. Calvo et al. created their scale based on 14 validated instruments, which resulted in 46 items, and removed all 13 items that had a correlation of .30 or lower on the trait scale of the State-Trait Anxiety Inventory (Spielberger & Diaz-Guerrero, 1975). The remaining 33 items were subject to factor analyses with varimax rotations. I retained two final factors with eigenvalues greater than 1.5, which accounted for 60% of the total variance, and I identified the final subscales of cognitive anxiety and somatic anxiety.

Researchers used the CSAQ (Calvo et al., 1990) in subsequent studies for measuring self-reported levels of cognitive and somatic anxiety. Calvo and Cano-Vindel (1997) administered the questionnaire to 136 undergraduate students to assess the relationship between participants' trait anxiety and emotional reactivity while being subject to an evaluative stress task. Calvo and Cano-Vindel reported the alpha levels at .88 for the cognitive subscale and .86 for the somatic subscale, and they found a significant relationship existed between trait anxiety and scores on the CSAQ ($p < .001$). Additionally, a relationship existed between trait anxiety (during the stress condition) and higher levels of cognitive and somatic distress for the participants ($p < .001$).

In another study, Calvo and Miquel-Tobal (1998) employed the CSAQ to measure self-reported levels of cognitive and somatic anxiety in 78 undergraduate students. Calvo and Miquel-Tobal examined if participants low or high in trait and test anxiety reported higher levels of self-reported cognitive and somatic anxiety. The alpha level for the cognitive scale was .88, and the alpha level was .86 for the somatic scale (Calvo & Miquel-Tobal, 1998). Levels of self-reported cognitive and somatic anxiety were higher for participants high in trait and test anxiety ($p < .01$ for the cognitive scale and $p < .02$ for the somatic scale).

Researchers had used the CSAQ in past research to assess self-reported levels of cognitive and somatic anxiety for participants (Calvo & Cano-Vinel, 1997; Calvo & Miquel-Tobal, 1998). In both studies, significant relationships existed between the cognitive and somatic scales and the other variables. Due to the prior use of the CSAQ to assess participant levels of cognitive and somatic anxiety under a stress induced condition, the questionnaire was suitable for assessing participants' cognitive and somatic anxiety levels in the present study.

The variable manipulated during the treatment phases was whether a participant received CPR performance feedback from a Zoll R Series defibrillator. The Zoll R Series defibrillator included a CPR performance measurement capability based on American Heart Association CPR guidelines. This defibrillator includes visual and auditory feedback for the user related to compression rate and compression depth. Participants who received CPR performance feedback from the Zoll R Series defibrillator were able to evaluate and change their performance during CPR compressions. Those participants who did not receive CPR feedback were not able to see the Zoll monitor and could not hear any audio cues as I had turned them off. The other treatment variable related to whether participants heard a loud audio clip of intensive-care-unit-type hospital noises during CPR performance. The audio clip introduced typical sounds heard during a hospital cardiac arrest situation to add a level of realism to the training simulation.

The dependent variable for this study was CPR performance by nurses. I obtained the dependent variable measurement during the initial trial (baseline) and at two additional trials 30 and 60 days postbaseline. The Zoll Series R defibrillator measured CPR performance and provided a report on CPR performance metrics that was downloadable to a jump drive. I analyzed the Zoll report as performance related to the percentage of correct compressions delivered (between 100 and 120 compressions per minute) and the percentage of correct compressions delivered (at a depth of between 2 and 2.4 inches).

The study involved collecting and screening data from the CSAQ (Calvo et al., 1990) and CPR performance metrics (from the Zoll R Series defibrillator) for completeness. Incomplete data resulted in removing the participant from the analysis if a statistical correction was not possible. All data analysis took place using R Version 3.4.3 (The R Foundation, 2017).

Research Questions and Hypotheses

Research Question 1: How do the participants' demographic factors of age, gender, and years of experience as a nurse relate to medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin?

$H_0$1: The participant demographic factors of age, gender, and years of experience as a nurse does not predict a medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin.

H_A1: The participant demographic factors of age, gender, and years of experience as a nurse does predict a medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin.

Research Question 2: What is the difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving any performance feedback?

$H_0$2: There is no difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving performance feedback.

H_A2: There is a difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving performance feedback.

Research Question 3: How does the introduction of hospital noises during CPR performance (as measured by the CSAQ) and real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin?

$H_0$3: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and CPR performance scores (provided by a Zoll R Series defibrillator/CPR feedback device) does not predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin.

H_A3: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and CPR performance scores (provided by a Zoll R Series defibrillator/CPR feedback device) predicts medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin.

Research Question 4: What is the difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance?

H_04: There is no difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance.

H_A4: There is a difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance.

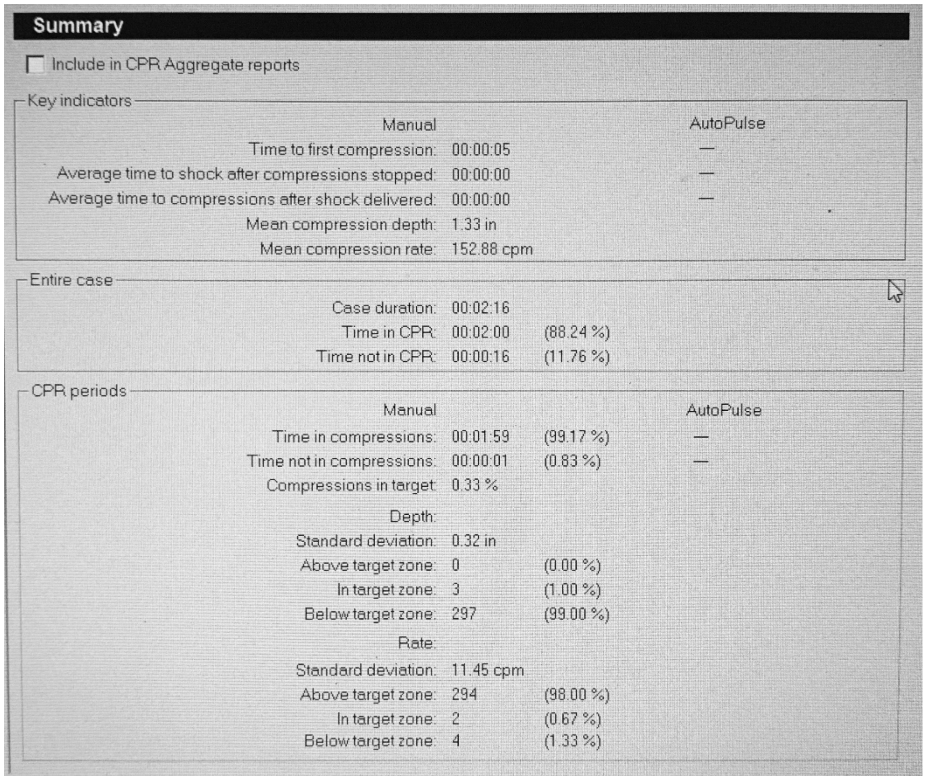
Research Question 5: How does the introduction of hospital noises during CPR performance (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin at 30 days and 60 days (postbaseline) when compared to baseline performance?

$H_0$5: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) does not predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin at 30 days and 60 days (postbaseline) compared to baseline performance.

H_A5: The introduction of hospital noises during CPR performance scores (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predicts medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin, at 30 days and 60 days (postbaseline) compared to baseline performance.

After the explanatory analysis of the demographic data was complete, I described the results and reported the information in Chapter 4. The purpose of this analysis was to determine whether the demographic factors predicted CPR performance. The data in the table include data ranges and percentages for categorical data. The data obtained from the CSAQ were suitable for analysis and reporting as separate cognitive anxiety and somatic anxiety scores. Because this questionnaire provided interval data on a 5-point Likert-type scale a mean score was calculated. The CSAQ data, which is reported in Chapter 4, showed the scores at the different measurement times. CPR performance metrics obtained from the performance report showed measurements obtained for each participant via a downloadable report from the Zoll R Series defibrillator reported as a percentage of correctly delivered chest compression depth and a percentage of correctly delivered chest compression rate. The data obtained from CPR performance appear in Chapter 4.

The three statistical tests employed for this study were a two-sample independent *t* test, a regression analysis, and a two-way repeated measures ANOVA. The *t* test provided an analysis that led to an answer to Research Question 1. Researchers use a *t* test to examine the "significance of a difference between means" (Frankfort-Nachmias et al., 2015, p. 412). The two-way repeated measures ANOVA led to an answer to Research Questions 2 and 4. A regression analysis addressed Research Questions 1, 3, and 5.



Summary

☐ Include in CPR Aggregate reports

Key indicators

	Manual	AutoPulse
Time to first compression:	00:00:05	—
Average time to shock after compressions stopped:	00:00:00	—
Average time to compressions after shock delivered:	00:00:00	—
Mean compression depth:	1.33 in	
Mean compression rate:	152.88 cpm	

Entire case

Case duration:	00:02:16	
Time in CPR:	00:02:00	(88.24 %)
Time not in CPR:	00:00:16	(11.76 %)

CPR periods

	Manual		AutoPulse
Time in compressions:	00:01:59	(99.17 %)	—
Time not in compressions:	00:00:01	(0.83 %)	—
Compressions in target:	0.33 %		
Depth:			
Standard deviation:	0.32 in		
Above target zone:	0	(0.00 %)	
In target zone:	3	(1.00 %)	
Below target zone:	297	(99.00 %)	
Rate:			
Standard deviation:	11.45 cpm		
Above target zone:	294	(98.00 %)	
In target zone:	2	(0.67 %)	
Below target zone:	4	(1.33 %)	

Figure 3. A sample of CPR performance feedback provided by the Zoll R Series defibrillator, which measured CPR performance for all participants. Reprinted from *Rescuenet code review getting started guide: Software version 5.8.1 or newer, May 16, 2017*, by Zoll Medical Corporation. Retrieved from https://www.zoll.com/ medical-products/data-management/rescue-net-fire-ems/code-review. Copyright 2017 by Zoll Medical Corporation. Picture taken by researcher.

According to Frankfort-Nachmias and Leon-Guerrero (2018), researchers use a two-way repeated measures ANOVA or examining the effect of two or more treatments on a dependent variable over time. Additionally, Frankfort-Nachmias and Leon-Guerrero noted researchers use regression analysis when examining how independent variables affect a single dependent variable. This study included three different analyses: the demographic analysis, a two-way repeated measures ANOVA, and regression analysis. I interpreted the results for the *t* test by assessing the significance of mean scores and obtained an *F* statistic for the ANOVA, which was the ratio of within-group to between-group variance. Regression coefficients show the strength of the relationship the independent variable has on the dependent variable (Frankfort-Nachmias & Leon-Guerrero, 2018).

Threats to Validity

Researchers need to identify potential threats to validity to rule out the threats and minimize or eliminate the potential invalidation that variables have on causal relationships (Frankfort-Nachmias et al., 2015). The two categories of potential threats to validity discussed were external validity and internal validity. Frankfort-Nachmias et al. (2015) indicated external validity refers to the extent to which a researcher draws conclusions that generalize to larger populations and different settings. Internal validity refers to the ability to eliminate potential factors under study that account for changes in dependent variable outcomes (Frankfort-Nachmias et al., 2015).

Frankfort-Nachmias et al. (2015) described two main issues with external validity: representativeness of the sample and reactive arrangements. The participants did not work in a critical care area or emergency department and thus did not typically need to care for or work with patients who require cardiac arrest care. Although generalization of the results to other nursing specializations (such as critical care) is a limitation, it is not a limitation related to generalizing the results to other medical and surgical acute care nurses. While reactive arrangements were a limitation in this study, being able to study CPR performance in a controlled, live clinical situation was not possible. Therefore, this study as well as others (Oermann et al., 2011; Roh & Issenberg, 2014) took place in simulated or laboratory settings.

I identified diffusion of treatment, experimental mortality, and testing as the three primary potential threats to internal validity in this study. To address the potential diffusion-of-treatment threat, I informed the groups not to discuss the study. The design mitigated the potential testing threat because the measurement periods were 30 days apart. Furthermore, recruiting a higher number of participants than identified in the power analysis addressed the experimental mortality threat, so dropping out would not affect the results.

Additionally, the participants worked in an acute care hospital, which may limit generalizability to non-hospital-based care providers who need to perform CPR. As the focus was hospital-based nurses, discussion regarding the results took place in the context of the population studied. Lastly, content experts at the American Heart Association evaluate CPR practices and can change them in the future. If guidelines were to change, which would be beyond my control, the results of this study may not generalize to future standards.

Ethical Procedures

The vice president of nursing at each hospital provided a letter of commitment and each participant provided consent to participate prior to their participation in the study. The Walden University (Approval no. 12-24-18-0451066) and the Catholic Health System (Approval no. CHS/IRB/1839) IRBs approved the study. Participation in the study was strictly voluntary, and participants were able to withdraw at any time without any consequences. I maintained participant confidentiality at all times. The consent form remained separate from survey forms and CPR performance reports. I stored all survey information at a private and locked location. Participants did not receive compensation for their participation and their participation did not affect their employment in any way. Data shared with the organization was done in the aggregate.

Data collection occurred through two different primary methods: survey related (demographics questionnaire and CSAQ) and CPR performance on manikins. Because this was a longitudinal study, I used unique identifiers for each participant. Data collected only included the unique identifier and did not refer to individual names. To preserve the integrity of the data collection process over time, all participants received a blank card on which to write down their number and seal it in an envelope. Therefore, participants who asked me for their unique identifier received the envelope with their identifier. Participants would only open their envelope if they forgot their identifier. At the end of the study, I shredded all envelopes.

The CSAQ (Calvo et al., 1990) data only referenced the unique participant identifier. I entered all data into a Microsoft Excel spreadsheet and stored them on my personal computer at home. The spreadsheet included data collected from the CSAQ and CPR performance. Furthermore, the spreadsheet only included the unique identifier. Survey and data information will remain stored for at least 5 years at my residence.

Summary

This study involved using a quantitative method to examine the impact of CPR performance feedback and anxiety on CPR performance using CPR manikins in medical and surgical acute care nurses. I used a repeated measures design to examine the potential effects of the two variables over time. Participants consented to participating in the study prior to starting any study-related data collection. Participants received a random assignment to one of three groups: control, Treatment group 1, or Treatment Group 2. Study participation required individuals to complete 2 minutes of CPR on a CPR manikin, complete a demographic questionnaire, and complete the CSAQ. Walden University and Catholic Health System IRBs approved the study and I treated all participants in accordance with accepted ethical research standards. The results of this study are in Chapter 4.

Chapter 4: Results

The purpose of this study was to examine the impact of CPR performance feedback and hospital noises, as measured by the Cognitive and Somatic Anxiety Question, on CPR performance in medical and surgical acute care registered nurses working in a hospital setting. The focus was using the research questions and hypotheses to examine the impact of treatments on nurses' ability to perform high-quality CPR on a manikin. The research questions and hypotheses follow.

Research Questions and Hypotheses

Research Question 1: How do the participants' demographic factors of age, gender, and years of experience as a nurse relate to medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin?

$H_0$1: The participant demographic factors of age, gender, and years of experience as a nurse does not predict a medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin.

H_A1: The participant demographic factors of age, gender, and years of experience as a nurse does predict a medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin.

Research Question 2: What is the difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving any performance feedback?

$H_0$2: There is no difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving performance feedback.

H_A2: There is a difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin while either receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) or not receiving performance feedback.

Research Question 3: How does the introduction of hospital noises during CPR performance (as measured by the CSAQ) and real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin?

$H_0$3: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and CPR performance scores (provided by a Zoll R Series defibrillator/CPR feedback device) does not predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin.

H_A3: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and CPR performance scores (provided by a Zoll R Series defibrillator/CPR feedback device) predicts medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin.

Research Question 4: What is the difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance?

H_04: There is no difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance.

H_A4: There is a difference in medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR manikin, while either receiving or not receiving real-time CPR feedback (provided by a Zoll R Series defibrillator/CPR feedback device) at 30 days and 60 days (postbaseline) compared to baseline performance.

Research Question 5: How does the introduction of hospital noises during CPR performance (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards (as measured by a Zoll R Series defibrillator) on a CPR training manikin at 30 days and 60 days (postbaseline) when compared to baseline performance?

$H_0$5: The introduction of hospital noises during CPR performance (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) does not predict medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin at 30 days and 60 days (postbaseline) compared to baseline performance.

H_A5: The introduction of hospital noises during CPR performance scores (as measured by the CSAQ) and receiving or not receiving real-time CPR performance feedback (provided by a Zoll R Series defibrillator/CPR feedback device) predicts medical and surgical nurses' ability to perform CPR in accordance with American Heart Association national standards on a CPR training manikin, at 30 days and 60 days (postbaseline) compared to baseline performance.

Chapter 4 provides statistical results from this study. The chapter includes a detailed description of the data collection process, discrepancies in data collection, and the time frame for collecting data. The chapter also includes challenges to the data collection process and a chapter summary.

Data Collection

Although I encountered initial challenges related to recruiting participants, modifications to the recruitment process were submitted and approved by the IRBs. Collecting data on a nursing unit involved focusing on specific nursing areas at a given time for recruitment. This approach led to me being present on a nursing unit during each data collection phase, which made it easier for nurses to step away from their care duties. My presence also served as a physical reminder that data collection was taking place. It took 30 days to complete Phase 1 of data collection, and the sample size achieved was 120. I noted on a personal calendar when data collection occurred on a given nursing unit and at which hospital.

The time frame for data collection was 90 days, 60 of which occurred during summer months. Phase 2 of data collection yielded a sample size of 80, and Phase 3 resulted in a sample size of 60. For the participants working 12-hour shifts, data collection occurred at least 2.5 hours into a shift regardless of it being a day shift (7:00 a.m. to 7:00 p.m.) or night shift (7:00 p.m. to 7:00 a.m.). For participants working 8-hour shifts, I coordinated data collection times with scheduled department meetings.

The population in this study included registered nurses working in a medical or surgical nursing position at an acute care hospital. It is common for registered nurses working in these capacities in an acute care hospital to maintain a CPR credential as part of their employment. I assumed that the population in this study represented a broader group of nurses in the same practice area at other acute care hospitals.

Data Preparation

I conducted an ocular review of all data for completeness. There was no need to track down any missing data. After completing the review, I created category ranges for the following variables: years of experience as a nurse, average anxiety score, and average percentage correct score of compression rate and compression depth (as measured by the Zoll Series R defibrillator). The next steps involved entering the data into a Microsoft Excel spreadsheet for input into R Version 3.4.3 and using the participant code as a case number to track data across the study time frame.

I stored the CPR performance metrics on a removable flash storage card in the Zoll Series R defibrillator and uploaded the data obtained from the defibrillator to an Acer computer before deleting all data on the flash storage card. The data obtained from the storage card and uploaded onto the computer underwent analysis for CPR performance using a program called RescueNet Code Review, which was created by Zoll Medical Corporation. The program reported the data as a percentage of time of correctly performing compressions at a depth of 2 to 2.4 inches and a separate percentage of time of correct compression rate between 100 and 120 compressions per minute. I marked a 2-minute period of CPR performance time (from the start of compressions) for each time that performance was measured, using the RescueNet software. The software would then calculate the performance metrics as the percentage done correctly. Marking the 2-minute period was necessary for the software to analyze the period of performance.

Missing data occurred in responses to the anxiety questionnaire during the first phase of data collection. Participants either circled two responses to a single item or left an item blank. I eliminated items that contained missing data and based a mean anxiety score on the remaining completed items. For example, if a participant completed only 19 out of 20 survey questions, the score was based on 19 items. This occurred nine times and only during Phase 1. No participant missed more than two items on the questionnaire.

Administration of Treatments

The administration of the treatments occurred in rooms at each of the hospital sites reserved for the study. As described in the methods section, the setup for the manikin and Zoll Series R defibrillator was consistent for each data collection period. During the data collection period, I was the only person present with the participant in the room. I switched the settings on the Zoll Series R defibrillator to either provide feedback or not provide feedback during the administration of the treatment conditions. I used an Acer laptop computer connected via Wi-Fi to a free site-based service for streaming hospital noise audio via external speakers.

Treatment and Intervention Fidelity

After the first phase of data collection was complete, participant attrition resulted in 80 participants completing Phase 2 and 60 participants completing Phase 3. Discussions with participants revealed several reasons for the attrition. Although I did not compile qualitative data relating to the attrition, the reasons provided included an inability to continue due to medical reasons, lack of interest in continuing in the study, being too busy to leave the patient's bedside, and forgetting to participate in a data collection phase. Many of the participants worked 12-hour shifts and were off duty for 5–6 days at a time, which may have resulted in missing Phase 2 or 3 of data collection. There may have been other reasons for the attrition because in some cases participants did not show up for data collection and did not communicate with me.

Study Results

Descriptive Statistics

Phase 1 data collection ended with 120 participants. Females accounted for 111 (92.5%) of the participants. Phase 2 data collection ended with 80 participants, of whom 73 (91.1%) were female. The final phase of data collection ended with 60 participants, of whom 55 (93.2%) were female. All participants reported that they had a valid CPR card, had not been recertified or had not performed CPR on a patient in the preceding 30 days, and had worked in an acute care hospital setting. Seventy-eight participants (65%) were 45 years old or younger. A breakdown of participants' ages appears in Table 1.

Table 1

Age Ranges of Participants

Age range in years	*n*	%
≤ 25	23	19.2
26–35	30	25.0
36–45	25	20.8
46–55	15	11.7
56–65	26	21.7
+ 65	2	1.7

Note. n = 120.

Participants who reported 5 years of experience or fewer as a registered nurse composed the largest subcategory of 41 individuals (34.2% of the total sample). The second largest subcategory was 24 participants (20% of the total sample) who had 30 or more years of experience as a registered nurse. Table 2 provides a breakdown of participants' nursing experience levels.

Table 2

Years of Experience as a Nurse

Years of experience as a nurse	*n*	%
< 5	41	34.2
5–9	21	17.5
10–19	17	14.2
20–29	17	14.2
30 +	24	20.0

Note. *n* = 120.

Mean anxiety scores were grouped into ranges as shown in Table 3. The most common mean anxiety scores were reported for the range of 1.51–2.0, which was a low level of anxiety. Fifty individuals (41.7% of the sample) reported scores in the 1.51–2.0 range. Although the mean anxiety score could go as high as 5.0, no participants reported levels that exceeded 4.01. Table 3 provides the reported anxiety levels of all participants.

Table 3

Mean Anxiety Scores (at Baseline)

Mean anxiety scores	*n*	%
1.00–1.50	9	7.5
1.51–2.0	50	41.7
2.01–2.50	26	24.2
2.51–3.0	18	15.0
3.01–3.50	12	10.0
3.51–4.0	2	1.7
4.01–4.50	0	0.0
4.51–5.00	0	0.0

Note. *n* = 120.

The Zoll Series R defibrillator captured CPR performance data as two separate performance metrics, a percentage of CPR rate and a percentage of CPR depth, performed in accordance with American Heart Association guidelines. Addressing the research questions of this study related to CPR performance, involved calculating a single performance score of correctly performed CPR. The single performance score was an average comprised of the percentage CPR depth and CPR rate correctly performed on a manikin during a 2-minute session.

The basis for the performance ranges was approximately 10 percentage points. The range of 50–50.9% had the highest number of participants at 22 individuals or 18.3% of the sample. Table 4 includes additional findings related to all participants.

Table 4

Average Percentage Correct Performed for Compression Depth and Rate (at Baseline)

Correctly performed CPR compression depth and rate (as an average)	*n*	%
0–9.9	7	5.8
10–19.9	6	5.0
20–29.9	9	7.5
30–39.9	9	7.5
40–49.9	12	10.0
50–59.9	22	18.3
60–69.9	14	11.7
70–79.9	15	12.5
80–89.9	15	12.5
90–100	11	9.2

Note. n = 120.

Additional descriptive statistical information appears in Figures 4 and 5. Figure 4 is a graphic representation of CPR performance over the course of the study and by condition group. Figure 5 shows a scatter plot with a trend line comparing CPR performance to mean anxiety scores at baseline.

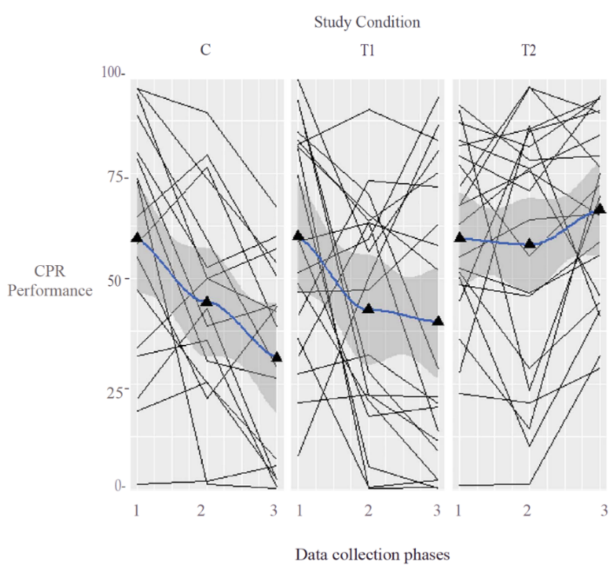


Figure 4. CPR performance, as a mean percentage of CPR depth and CPR rate, in accordance with American Heart Association CPR guidelines, by treatment group during data collection phases (baseline = 1, 30 days post baseline = 2, 60 days post baseline = 3).

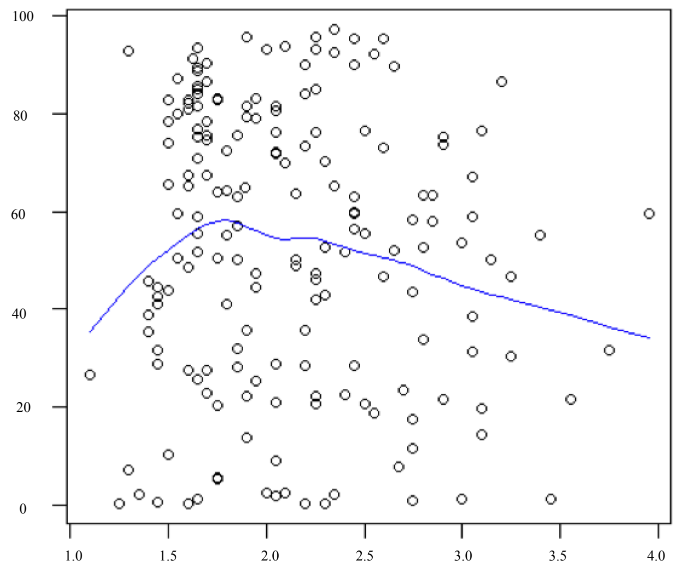


Figure 5. CPR performance of each individual during Phase 1 of data collection, with a trend line of mean anxiety scores.

Statistical Assumptions

An evaluation of the assumptions for each statistical method employed showed no violation of the analysis model. For each linear regression, I evaluated two major assumptions: the mean of the residuals was near or at zero and there was homoscedasticity of residuals. The plots (see Appendix E) show the spread of the residuals was even above and below a horizontal line, which indicated a linear trend. Additionally, the residuals are consistent with normal distribution. The models also conformed with the assumptions of homoscedasticity at each level of the predictor variable. Diagnostic plots testing the assumptions for the linear regressions are in Appendix E. For the repeated measures ANOVA, the Greenhouse-Geisser (epsilon = 0.858) and Huynh-Feldt (6.93) statistics confirmed there was no bias in the results due to sphericity.

Research Findings

The focus of Research Question 1 was the influence of the demographic factors of age, gender, and years of experience as a nurse on predicting CPR performance on a CPR manikin. Evaluating the data for this question involved employing a linear regression. The results of the analysis showed age group predicted CPR performance: for each increase in age group level, CPR performance dropped by an estimated 5.2 percentage points (p = .0007). Approximately 9.2% of the variance in CPR performance was explained by age group (R2 = .0922). However, gender (p = .7824) and years of experience as a nurse (p = .6262) did not predict participants' CPR performance after accounting for the effect of age. Therefore, I accepted the alternative hypothesis for age group and rejected it for gender and years of experience as a nurse. Table 5 shows the results of the linear regression analysis.

Table 5

Linear Regression of Demographic Factors with CPR Performance

Model and Factors	Estimate	*SE* (estimate)	*t*	*p*	R^2
CPR = age group + years as RN + sex[a]					
Age group	-5.8496	2.8518	2.051	.0425	
Years as RN	0.0842	0.3040	0.277	.7824	.0948
Sex	-4.1083	8.4129	-0.488	.6262	
CPR = age group[b]					
Age group	-5.191	1.500	-3.462	.0007	.0922

[a]*F* = 4.407, *df* = (3,116), *p* = .0089. [b]*F* = 11.99, *df* = (1,118), *p* = .0007.

The process to answer Research Question 2 involved employing a repeated measures ANOVA to examine if differences exist in medical or surgical nurses' ability to perform CPR on a CPR manikin when receiving or not receiving real-time feedback. The results of the analysis showed a statistically significant difference between participants who received CPR feedback and participants who did not, df (1,176), F = 11.35, p = .0009. Thus, I accepted the alternative hypothesis and rejected the null (see Table 6).

Table 6

Repeated Measures ANOVA Output for Research Question 2

Model and Factor	*df*	Sum square	Mean square	*F*	*p*
CPR = feedback + error[1]					
Feedback	1	8229	8229	11.35	0.0009
Residuals	176	127633	725		

The process to answer Research Question 3 involved examining if hospital noises played during CPR performance (as measured by the CSAQ), while receiving CPR feedback (provided by a Zoll Series R defibrillator), predicted CPR performance. The analysis involved employing a linear regression model to address this research question. The purpose of Phase 1 was to obtain baseline CPR performance data while receiving feedback. As this phase did not include hospital sounds, I used the data collected during Phase 2 for the analysis. The dummy variable created reflected when hospital noises were played or not played (as a yes/no variable). A second regression model included the mean anxiety scores as a measure of anxiety during the participants' CPR performance, as the underlying theory of introducing hospital noises was that the noises would induce anxiety.

The results of this analysis showed hospital noises played during CPR performance did not predict CPR performance (p = .4697). Additionally, the mean anxiety score did not predict CPR performance (p = .1118; see Table 7). I accepted the null hypothesis for this question.

Table 7

Linear Regression for the Relationship Between Hospital Noises and CPR Ability (at 30 Days)

Model and factor	Estimate	SE (estimate)	t	p	R^2
CPR = hospital noises + feedback					
Hospital noises	-5.683	7.821	-0.727	0.4697	0.062
Feedback	16.839	7.600	2.216	0.0297	
CPR = anxiety mean score + feedback					
Anxiety mean	-8.122	5.049	-1.608	0.1118	0.0863
Feedback	12.760	6.572	1.941	0.0559	

Note. Number of observations equals 80.
[a]F = 2.545, df (2,77), p = .0851. [b]F = 3.365, df (2,77), p = .0310.

The process to answer Research Question 4 involved examining the impact of time on performance of CPR at 30 and 60 days compared to baseline measurement. A repeated measures ANOVA provided the analysis for this question. The results of this analysis showed performance did not statistically significantly change at 30 or 60 days postbaseline, as indicated by the p value for the interaction term that tested for differing trends over time for those who received feedback versus those who did not (p = .1640). Although the variable feedback was significant (p = .0012) in the model, it was a fixed effect and did not relate to the research question addressing the change over time. The Greenhouse-Geisser (epsilon = 0.858) and Hynhd-Feldt (6.93) statistics showed corrections were not necessary due to sphericity. Thus, I accepted the null hypothesis and rejected the alternative hypothesis (see Table 8).

Table 8

Repeated Measures ANOVA Output for Research Question 4

Model and factor	*df*	Sum square	Mean square	*F*	*p*
CPR = feedback * time + error[1]					
Interaction between feedback and time					
Feedback	1	7881	7881	10.803	0.0012
Time	1	60	60	0.083	0.7742
Feedback * time	1	1425	1425	1.954	0.1640
Residuals	172	125469	729		

The process of examining Research Question 5 involved determining if hospital noises played during CPR performance (as measured by the CSAQ), while receiving CPR feedback (provided by a Zoll Series R defibrillator), predicted CPR performance at 30 days and 60 days postbaseline. The analysis involved employing a linear regression model to address this research question. I created a dummy variable to reflect when hospital noises were played or not played (as a yes/no variable). The regression model included the mean anxiety scores as a measure of anxiety related to the playing of hospital noises during the participants' CPR performance

The results of this analysis showed that receiving hospital noises being played during CPR performance did not predict CPR performance ($p = .0929$) at 30 days postbaseline. The mean anxiety score did not predict CPR performance over time ($p = .561$). Additionally, receiving feedback, regardless of being subjected to hospital noises or not, did not predict CPR performance ($p > .05$) at 30 days postbaseline. Even though feedback significantly predicted CPR performance in the model ($p = .0012$), it was a fixed effect and did not relate to the research question, which involved measurement over time. Table 9 provides the results for this analysis.

Table 9

Linear Regression Examining Relationship Between Hospital Noises and Change in CPR Ability (Baseline to 30 Days)

Model and factor	Estimate	SE (estimate)	*t*	*p*	R^2
CPR change = hospital noises + feedback[a]					
Hospital noises	-14.345	8.430	-1.702	.0929	.0514
Feedback	14.937	8.193	1.823	.0721	
CPR change = anxiety mean score + feedback[b]					
Anxiety mean	-3.275	5.605	-0.584	.561	.0201
Feedback	7.497	7.296	1.028	.307	

Note. Number of observations equals 80.
[a]$F = 2.085$, $df\,(2,770)$, $p = .1312$. [b]$F = 0.788$, $df\,(2,77)$, $p = .4584$.

The results of the analysis showed playing hospital noises during CPR performance did not predict CPR performance ($p = .4708$) at 60 days postbaseline. Furthermore, the mean anxiety score did predict CPR performance over time ($p = .025$). Anxiety score and feedback together accounted for 26.5% of the variance in CPR performance from baseline to 60 days ($R^2 = .265$). Receiving feedback, whether subjected to hospital noises or not, predicted CPR performance ($p < .005$). Table 10 shows the results for this analysis.

Table 10

Linear Regression Examining Relationship Between Hospital Noises and Change in CPR Ability (Baseline to 60 Days)

Model and factor	Estimate	SE (estimate)	t	p	R^2
CPR change = hospital noises + feedback[a]					
Hospital noises	7.112	9.795	0.726	.4708	.204
Feedback	26.941	9.315	2.892	.0054	
CPR change = anxiety mean score + feedback[b]					
Anxiety mean	15.284	6.637	2.303	.0250	.265
Feedback	32.306	7.809	4.137	.0001	

Note. Number of observations equals 60.
[b]$F = 7.305$, $df\,(2,57)$, $p = .0015$. [b]$F = 10.28$, $df\,(2,57)$, $p = .0002$.

I accepted the null hypotheses for the measurements at 30 days postbaseline. I accepted the null hypothesis related to the introduction of hospital noise for 60 days postbaseline. There was a significant finding for CPR feedback predicting CPR performance at 60 days postbaseline ($p = .0001$). However, this was a fixed effect and not related to the research question.

Summary

This study included five research questions on the factors being examined related to registered nurses, working in a medical or surgical area at one of two acute care hospitals, on their ability to perform CPR on a CPR manikin. For Research Question 1, I accepted the alternative hypothesis for age, which showed age had a positive impact on CPR performance. However, I accepted the null hypothesis for gender and years of experience as a nurse. Research Question 2 showed a statistically significant difference for nurses receiving feedback compared to those who did not; thus, I accepted the alternative hypothesis. Research Question 4 showed no difference in CPR performance over time, and I accepted the null hypothesis. Research Questions 3 and 5 did not yield any statistically significant findings; thus, I accepted the null hypotheses. Chapter 5 includes an interpretation of the results, limitations of the study, and recommendations for future research.

Chapter 5: Discussion

A gap exists between CPR training and the ability to deliver high-quality CPR during real-life cardiac arrest events (Neumar et al., 2015). To address this gap, researchers have recommended training methods employing the use of educational technologies to enhance the individual performance of CPR (Neumar et al., 2015; Oermann et al., 2011; Sutton et al., 2009). However, the gap exists even when using CPR manikins that provide individualized performance feedback. The fact that CPR performance has not greatly improved with the use of manikins as an educational technology leads to questions regarding the benefit of such technology.

Using technology for an educational purpose does not guarantee learning occurs (Lowyck, 2014). Additionally, Lowyck (2014) noted the education technology field needs improved frameworks and more focused analysis related to the use of educational technologies to learn how to use technology for teaching purposes. Nurses and others who receive CPR training learn to perform CPR by practicing on a manikin while receiving performance feedback. The frequency at which this training occurs can vary from every 90 days to once every 2 years based on the different methods available for maintaining CPR credentials through organizations such as the American Heart Association.

Interpretation of the Findings

Researchers are actively employing simulation-based educational methods in different professional fields as a way to enhance skills performance and cognitive learning (Stephenson, 2015). In the field of health care, simulation provides a safe learning environment compared to learning on real patients and minimizes risk to patients (Drury-Grogan & Russ, 2013; Hayden et al., 2014; Kim et al., 2016). However, Neumar et al. (2015) indicated that further examination is necessary to determine ideal training methods and frequency for nursing professionals who perform CPR. The purpose of this study was to examine the impact of CPR performance feedback and hospital noises, as measured by the CSAQ, on the CPR performance of medical and surgical acute care registered nurses working in a hospital setting. The theoretical frameworks of distributed practice and attentional control theory served to ground this study.

Research Question 1

The findings of this study showed the demographic factor of age was a predictor of CPR performance. As the participant's age group got older, the corresponding CPR performance percentage decreased. With each increase in age group, there was a corresponding decrease of approximately 5% in the average CPR performance score. The finding indicated that, among younger nurses, CPR performance was most in accordance with CPR performance metrics.

The demographic factors of gender and years of experience as a nurse did not predict CPR performance. The fact that gender did not predict performance could be the result of the low population of male nurses (nine out of 120 participants) participating in the study. The fact that the population of participants primarily consisted of female nurses made gender a more difficult factor to examine in this study.

The variable years of experience as a nurse also did not predict CPR performance. This may be the result of examining a variable that was too broad. For example, age, which emerged as a significant predictor of CPR performance, may not directly tie into a nurse's years of experience. A person who entered the nursing profession later in life (such as in their 40s or 50s) would have less experience than someone who entered nursing in their 20s, which limited the influence of this variable as a factor affecting CPR performance by nurses.

Prior researchers (Aqel & Ahmad, 2014; Oermann et al., 2011; Roh & Issenberg, 2014) considered age to be a research variable. However, results from previous studies revealed that age was used to show similarities or differences between a control and a treatment group, but age was not examined as a performance predictor. Aqel and Ahmad (2014) employed nursing students in their study, and the participants' age ranged between 18 and 28 years. Roh and Issenberg (2014) reported the student participants' age range was 19–49, with a mean age of 22.2 $\pm$ 4.97 years. Oermann et al. (2011) reported the mean age between the control and treatments groups was similar (28.7 $\pm$ 9.7 years and 27.4 $\pm$ 8.2 years). The age range for my study was less than 25 years to over 65 years, and age served as a predictor variable of performance.

The focus of Research Question 1 was understanding the demographic factors related to CPR performance. Age was a predictor of CPR performance in my study, which is not consistent with prior research (see Aqel & Ahmad, 2014; Oermann et al., 2011; Roh & Issenberg, 2014). The reason that my results regarding age are not consistent with the studies mentioned is the analysis method employed to examine age (regression versus mean differences) and the fact that I had participants over the age of 65 years. Although the results are descriptive and not grounded in the theoretical frameworks employed for this study, the descriptive statistics provide a basis for understanding the population studied in addition to providing a potential limitation related to gender.

Research Question 2

There was a statistically significant difference between the participants who received CPR feedback (via the Zoll Series R defibrillator) and those who did not. This finding is consistent with prior research (Buléon et al., 2016; Niles et al., 2017; Wee et al., 2014) that indicated that participants who received CPR performance feedback had significantly better CPR performance compared to participants who did not receive CPR feedback. The results of my study underscored the importance of in-the-moment feedback in achieving the delivery of high-quality CPR during cardiac arrest events, as shown in previous studies (see Buléon et al., 2016; Niles et al., 2017; Wee et al., 2014).

Answering Research Question 2 involved using data obtained during Phases 1 and 2 of data collection. Given the nonsignificant findings, the distributed practice framework did not help to explain this outcome. These results were not consistent with prior research (see Aqel & Ahmad, 2014; Kwon et al., 2016; Niles et al., 2017; Nori et al., 2012; Oermann et al., 2011; Sullivan et al., 2015; Sutton et al., 2011) that showed CPR practice can lead to enhanced CPR performance.

The reason my study findings may not be consistent with prior research regarding performance over time (see Aqel & Ahmad, 2014; Kwon et al., 2016; Niles et al., 2017; Nori et al., 2012; Oermann et al., 2011; Sullivan et al., 2015; Sutton et al., 2011) may be the study design employed to examine CPR performance. My study involved a CPR feedback treatment condition, and previous studies (see Aqel & Ahmad, 2014; Kwon et al., 2016; Niles et al., 2017; Nori et al., 2012; Oermann et al., 2011; Sullivan et al., 2015; Sutton et al., 2011) did not. Additionally, the sample size employed in my study was not at the desired power level in the second phase of data collection. Therefore, my analysis may not have been sensitive enough to detect differences between the groups.

Research Question 3

The introduction of hospital noises as measured by the CSAQ did not yield significant results. This result may be due to the noises (as a variable) not causing anxiety or not being perceived by the participants as an anxiety-producing factor. Flinn et al. (2015) reported that their stress assessment tool did not yield significant findings; however, post hoc analysis showed significant differences in performance on laparoscopic tasks. Flinn et al. showed that stress could enhance performance on a task, which is a similar result to the descriptive finding in my study regarding anxiety. The descriptive results of how self-reported mean anxiety scores have a direct relationship with CPR performance initially, but transition to an inverse relationship as anxiety scores increase, are important to note.

This descriptive finding shows CPR performance is best at a certain level of perceived anxiety (mean anxiety score of approximately 1.75) related to the task of performing CPR on a manakin. Therefore, not enough anxiety (mean anxiety score of 1.50 or lower) or too much anxiety (mean anxiety score of 3.0 or higher) can adversely affect CPR performance on a manakin. This finding is consistent with McKenna (2017) who noted that anxiety during simulation learning activities could positively or negatively affect individual performance.

The theoretical framework of attentional control may help to explain why CPR performance diminishes as anxiety increases. The results of my study are consistent with prior research (see Flinn et al., 2015; McKenna, 2017) that indicated a stressor can affect performance on a task. However, given my descriptive result, the task of performing CPR may have been more of a stressor than the hospital noises introduced during the treatment phases.

Research Question 4

The focus of Research Question 4 was the impact of CPR feedback on CPR performance at 30 and 60 days compared to baseline. The results were not statistically significant; performance did not differ over time. Therefore, the effect of practicing CPR did not lead to improved CPR performance. The theory of distributed practice did not support these findings. However, the sample size limitation may have accounted for the reason performance did not change.

If the findings for this question were different, there would be a stronger theoretical argument for practicing CPR. However, the results of this study showed receiving CPR performance feedback did enhance performance, as discussed in the results to Research Question 1. The performance trend (see Figure 4) was consistent with other studies (see Buléon et al., 2016; Niles et al., 2017; Wee et al., 2014). Oermann et al. (2011) noted that the frequency at which a person must practice CPR to obtain the skills necessary to deliver high-quality CPR could be as often as every 30 days. The result of my study indicated that practicing CPR more frequently than every 30 days may lead to improved CPR performance outcomes for nurses.

Research Question 5

The focus of Research Question 5 was the impact of hospital noises on CPR performance at 30 and 60 days postbaseline while participants received or did not receive CPR feedback. The results were not statistically significant; the introduction of hospital noises did not predict performance. As noted in the discussion to Research Question 3, hospital noises were not anxiety producing for participants. The findings did indicate that CPR feedback predicted CPR performance, but as a fixed effect, not related to the research question stated.

The theoretical framework did not provide insights into the obtained results. Prior researchers had not sought to examine the use of hospital noises as a stressor or treatment leading to anxiety. If participants did not perceive the noise as an anxiety-producing factor, it would explain why the treatment had no impact on CPR performance. However, as noted in the discussion on Research Question 3, stressors can influence performance (Flinn et al., 2015; McKenna, 2017). Flinn et al. (2015) employed an actor portrayed as an expert to provide in-the-moment feedback to participants in the control group. If my study had included an approach like this, it would have been more invasive compared to a rendering of hospital noises playing during the performance of CPR on the manikin and may have created a more stressful situation for participants, potentially resulting in different findings for this research question.

Limitations of the Study

The primary limitation of this study related to sample size during Phases 2 and 3. Although the sample size was as desired for the first phase of data collection, attrition resulted in the loss of 40 participants during Phase 2 and a total of 60 participants by the conclusion of Phase 3. Using a purposeful sampling approach was a challenge as nursing schedules changed due to illness and a staffing decrease due to a low hospital census, which refers to nurses who do not come into work because hospital occupancy is lower than needed for the staff scheduled. Additionally, participants were sometimes scheduled for a number of days in a row and then would be off for 4 or more days at a time. The attrition observed limited results for data collection at 30 and 60 days.

An additional limitation of this study was the use of medical and surgical nurses. Nurses working in intensive care units and emergency departments also need to perform CPR on patients. Because this study did not include nurses from those nursing specializations, the results may not be generalizable to their population. Furthermore, the fact that only nine males participated was a limitation related to gender.

It is also possible that the hospital noises played during the two phases that included this treatment did not generate a level of anxiety. Sullivan (2015) noted that cardiac arrest situations can lead to stress. However, the introduction of noises may not have been enough to evoke a stressful or anxiety-related response. The act of performing CPR may have contributed more to the anxiety response than the introduction of hospital noises.

Recommendations

I employed a purposeful sampling approach while using a working registered nurse population in a time-based study. One recommendation is to double the sample size as a result of the power analysis. In this study, the attrition rate was 50% when comparing the baseline phase to the final phase. If the study had started with 216 nurses, a 50% attrition rate would have resulted in 108 participants, which would have satisfied the minimum sample level required for power analysis.

Given the challenge encountered during the first attempt to collect data, I recommend making it as easy as possible for nurses to get away from their work responsibilities to participate in a study. An effective option might involve collecting data on the unit in which the participants work and, if possible, making arrangements with nursing leadership to provide additional support during data collection periods. Incentivizing participants may also encourage participation.

When undertaking a study design like this with actively working registered nurses, I further recommend doing so with a research team. As I work full-time, it was challenging to juggle work and an intensive data collection schedule. If it were not for the flexibility of my employer with regard to my need to collect data, I may not have been successful with completing a time-based study.

Additional study recommendations include examining demographic factors such as age and gender. As CPR is a physical task, examining factors linked to physical capability may also warrant further review. This study did not have many males participating, so it could beneficial to open studies like this to other professionals who perform CPR at hospitals to recruit more male participants.

Although the results of the study did not find the introduction of hospital noises a significant predictor, the descriptive statistics related to mean anxiety scores and CPR performance during Phase 1 showed a potential relationship. Khalaila (2014) noted anxiety-producing factors can enhance simulation training. Another recommendation is that future research take place related to anxiety-producing factors and CPR training.

The final recommendation is that researchers spend less effort examining the benefits of the frequency of CPR training related to performing high-quality CPR and expanding research on other factors that affect CPR performance (such as age, physical capability, and receiving CPR performance feedback). Even if future researchers are able to identify an optimal frequency in which to practice CPR on a manakin, in real life other factors such as an individual's age, level of stress, and use of CPR performance feedback will have a greater impact on the quality of CPR performance. Therefore, I believe examining or exploring CPR training frequency alone will not lead to narrowing the CPR performance gaps that exists.

Implications

Positive Social Change

The implications of this study are positive social change as a result of enhancing knowledge in the educational technology field related to the performance of CPR. Social change as it relates to this study could occur at three different levels: the individual level, the organizational level, and at a global level. At the individual level, CPR knowledge and performance can improve, potentially leading to better prepared nurses and better patient outcomes. At an organizational level, the effects on the individual are amplified to create a broader effect on the community that a given hospital serves. Lastly, at a global level, the results may affect future research and CPR guidelines, which would serve to positively affect the care provided to individuals who suffered a cardiac arrest event.

Research Design Implications

As a result of this study, future researchers should use research designs that include a focus on licensed registered nurses and other hospital employees who perform CPR on patients in hospital settings. It would also be important to include different study variables, beyond training frequency, that may affect a person's ability to perform CPR. Lastly, using a qualitative inquiry with those who perform CPR in a hospital may reveal themes related to CPR performance not identified through quantitative research.

Recommendations for Practice

The final recommendation is that all individuals performing CPR should use CPR feedback devices when performing CPR. The results support recommending individuals who are younger perform CPR, which is a controversial finding. I further recommend that anyone who is not physically capable of performing CPR limit the time spent performing CPR or do not perform it at all.

Conclusion

I conducted this study to examine the CPR training gap through two different theoretical frameworks: distributed practice and attentional control theory. Researchers promoted CPR manikin use and training frequency to enhance CPR performance (Aqel &

Ahmad, 2014; Kwon et al., 2016; Niles et al., 2017; Nori et al., 2012; Oermann et al., 2011; Sullivan et al., 2015; Sutton et al., 2011). However, researchers had not studied the introduction of anxiety-producing components while performing CPR on a manikin.

Although researchers may continue to examine the gap that exists between CPR training and performance in real life, the gap may not be educationally related. The findings of my study indicate other factors such as age, anxiety level, and receiving CPR performance feedback have more of an impact on performance than repetition alone. Although this study did not include a qualitative approach, many participants reported to the researcher during the data collection phase how hard it was to perform 2 minutes of high-quality CPR. Thus, given the findings of this study, the CPR performance gap between CPR training and performance in real life may reflect physical ability rather than a lack of education.

Recent studies (Anderson, Sebaldt, Lin, & Chen, 2019; Smereka et al., 2019) continue to provide evidence that infrequent simulation-based CPR manakin training or simulation-based CPR manakin training without performance feedback is not enough to develop high-quality CPR skills. Anderson et al. (2019) found that monthly CPR training with real-time visual feedback is more effective compared to training every 3, 6, or 12 months. Smereka et al. (2019) reported that using a CPR feedback device during CPR training improved CPR chest compression depth and chest compression rate. Thus, researchers continue to examine the nature of using CPR performance feedback devices (Smereka et al., 2019) and training frequency (Anderson et al., 2019).

Many studies on CPR performance reviewed for the study included student populations (see Aqel & Ahmad, 2014; Oermann et al., 2011; Roh & Issenberg, 2014; Tivener & Gloe, 2015). My study included participants younger than 25 and older than 65 years of age. My study may include a more realistic population of nurses who perform CPR, compared to those in nursing school. Therefore, studies including a student nurse population may not generalize to the nursing workforce.

Although I would not dispute the fact that an individual needs to understand the correct form and hand placement for CPR, developing the proper frequency for training may be difficult to ever define. I know there are factors beyond regular CPR training that affect CPR performance on a CPR manakin. If a nurse is not physically capable of performing CPR, training once every 90 days for a few minutes is not going to fix that issue.

Even though researchers continue to try and define an optimal training frequency for CPR practice, the feasibility of being able to release hospital nursing staff to train as often as once a month is probably not realistic. After all, CPR training is just one of many types of training nurses may need to be able to provide care in care situations that do not occur frequently (such as stroke alerts and sepsis alerts). If nurses were to receive ongoing training for all potential but rare situations that may occur during a shift, more training time would be necessary in their work schedules.

As the results indicate, practicing on CPR training manikins alone will not prepare nurses to perform high-quality CPR on patients. Research should focus on factors beyond training to explain the gap in CPR performance. Introducing different theoretical frameworks and disciplines outside of the health care field may help to evaluate and examine the CPR performance gap.

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Appendix A: Permission to Use Audio Rendering

Dear Sandra:

I am a PhD-Candidate at Walden University in the field of Educational Technology. I am working on my dissertation and would like to ask for permission to use the audio portion of the below YouTube video as background noise for a treatment condition in my study. The study is focusing on CPR training. In return for permission to use, I would cite and reference the video in my study. Please feel free to email me or call [redacted] if you have any questions.

Thank you in advance.

Steve Marks, RN, MS, PhD-c

https://www.youtube.com/watch?v=dM1ODzynpng

Cardiac Arrest - Improved Management

www.youtube.com

Cardiac Arrest - Improved Management

RE: Request to use KPSA YouTube Video
[redacted]
Wed 7/11, 9:14 AMSteven Marks

Good Morning Steven, I have sent your request to Dr. [redacted] I am sure he will respond to you

[redacted]

[redacted]

[redacted]

From: Steven Marks [redacted]
Sent: Tuesday, July 10, 2018 4:02 PM
To: Sandra [redacted] [redacted]
Subject: Request to use KPSA YouTube Video

Caution: This email came from outside Kaiser Permanente. Do not open attachments or click on links if you do not recognize the sender.

[redacted]
Wed 7/11, 11:18 AMSteven Marks
Hi Steven,

Please use our trigger films to educate others. Take care. [redacted]

Get Outlook for iOS

Appendix B: Cognitive and Somatic Anxiety Questionnaire

Cognitive and Somatic Anxiety Questionnaire

Items					
Please circle the number from I to 5 for each of the 20 items to indicate: HOW YOU FEEL OR ARE REACTING AT THIS MOMENT					
(1) Not at all; (2) Slightly; (3) Somewhat; (4) Definitely; (5) Very much					
1. My hands feel moist (S).	1	2	3	4	5
2. I feel I am skilled at these tasks (C).	1	2	3	4	5
3. I experience a tingling sensation somewhere **in** my body (S).	1	2	3	4	5
4. I think I am failing at these tasks (C).	1	2	3	4	5
5. Hands feel unsteady (S).	1	2	3	4	5
6. I feel self-confident about my performance (C).	1	2	3	4	5
7. My fingers feel stiff (S).	1	2	3	4	5
8. I feel uneasy concerning the tasks (C).	1	2	3	4	5
9. My breathing rate is irregular and faltering (S).	1	2	3	4	5
10. I find it difficult to focus my attention on the tasks (C).	1	2	3	4	5
11. I feel aroused (S).	1	2	3	4	5
12. Thoughts irrelevant to task performance run through my mind (C).	1	2	3	4	5
13. My fingers tremble (S).	1	2	3	4	5
14. I think that other students are more skilled than I am (C).	1	2	3	4	5
15. My fingers are sweating (S).	1	2	3	4	5
16. I am worrying about my performance (C).	1	2	3	4	5
17. My stomach feels tense (S).	1	2	3	4	5
18. I think I will have a low outcome (C).	1	2	3	4	5
19. My heart is beating faster (S).	1	2	3	4	5
20. I cannot concentrate on the tasks (C).	1	2	3	4	5

Note. C = Cognitive Anxiety, S = Somatic Anxiety.

Appendix C: Demographics Questionnaire

Demographics Questionnaire Phase One

Participant ID __________________

Do you have a valid CPR certification?

Yes No

Have you performed CPR on a patient or for recertification within the last 90 days (circle response)?

Yes No

Do you work on an acute care, medical and surgical nursing unit (circle response)?

Yes No

Gender

Male Female

Age

< 25 26-35 36-45 46-55 56-65 65+

How many years have you been a nurse?

____

CPR Performance Questionnaire

Participant ID __________________

Have you performed CPR on a patient or for recertification within the last 30 days (circle response)?

Yes No

Appendix D: Permission to Use Cognitive and Somatic Anxiety Questionnaire

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Estimated size (number of pages)	225
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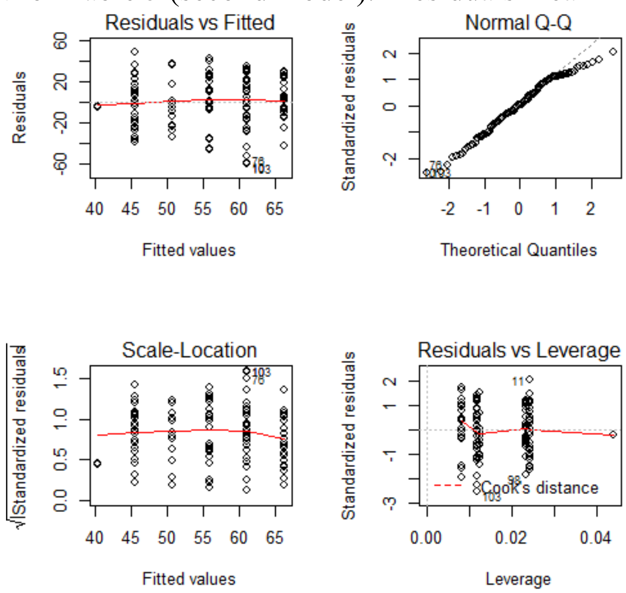
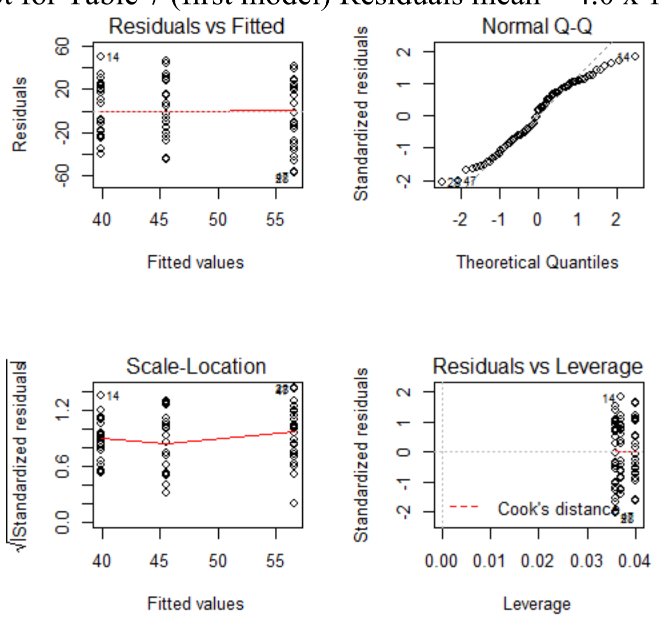
Appendix E: Diagnostic Residual Plots for Linear Regression Models

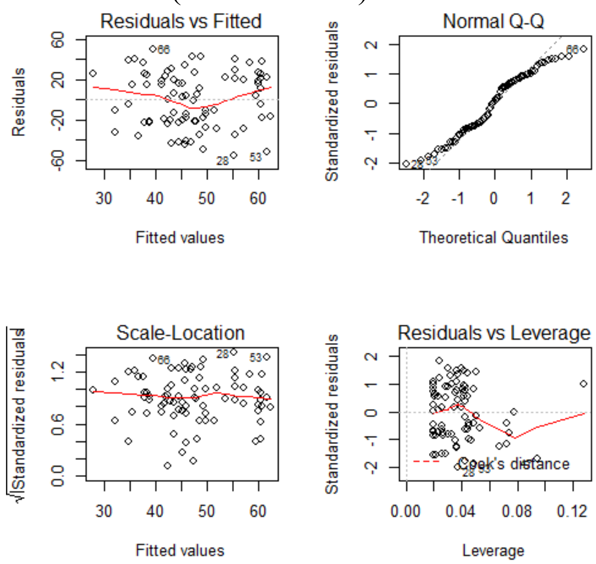
Diagnostic plot for Table 5 (second model). Residuals mean = 4.57×10^{-16}



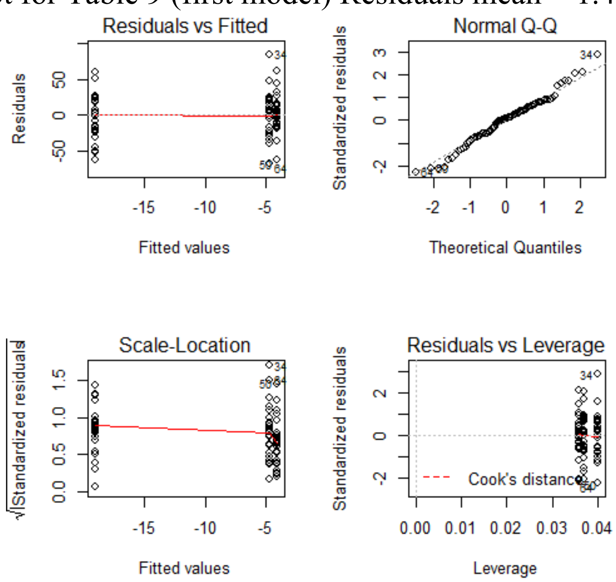
Diagnostic Plot for Table 7 (first model) Residuals mean = 4.0×10^{-16}



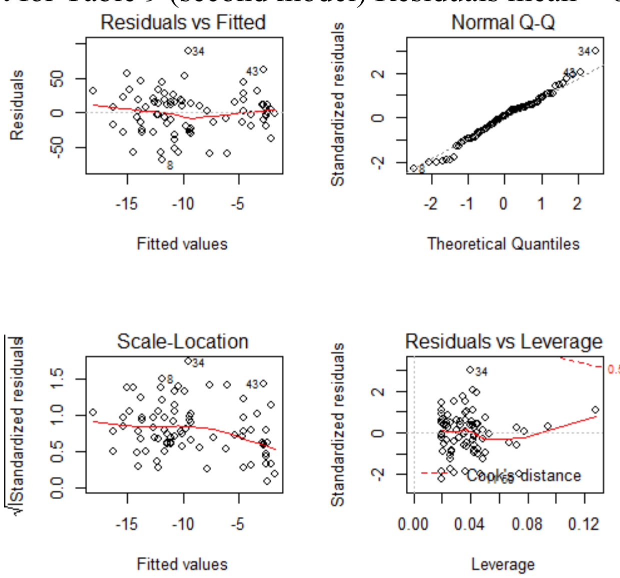
Diagnostic Plot for Table 7 (second model) Residuals mean = 3.49×10^{-16}



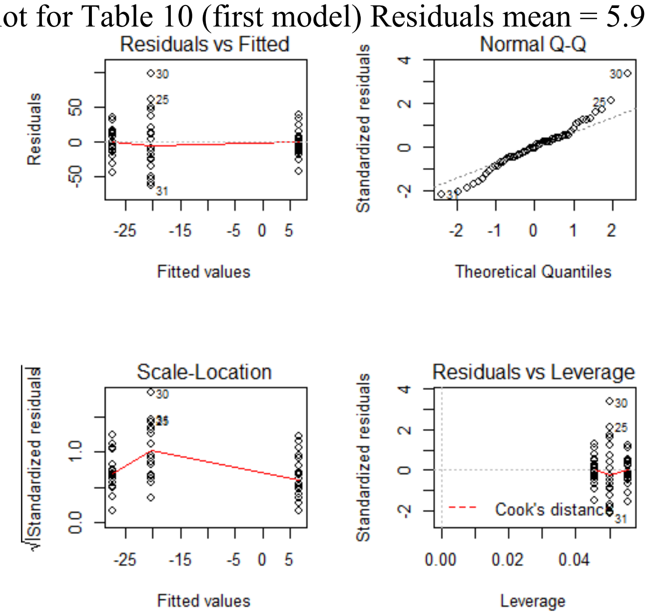
Diagnostic Plot for Table 9 (first model) Residuals mean = 1.48×10^{-16}



Diagnostic Plot for Table 9 (second model) Residuals mean = 6.87×10^{-16}



Diagnostic Plot for Table 10 (first model) Residuals mean = 5.91×10^{-17}



Diagnostic Plot for Table 10 (Second model) Residuals mean = 1.24×10^{-16}