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# Fully Automated Life Support Training Effects on Inpatient, Cardiac Arrest Survival Rates

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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,
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Abstract

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MSN, Spring Arbor University, 2016

BSN, Grand Canyon University, 2015

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

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Abstract

In the United States, more than 200,000 adult patients die annually from inpatient cardiac arrest with survival rates stagnated at 22%–25% nationally. Recently, the adoption of fully automated life support training modalities by health care organizations has become widespread with limited literature available showing the effects on inpatient, cardiac arrest survival. The purpose of this quantitative study was to investigate the effects of fully automated life support training on inpatient, cardiac arrest survival. Applying Bloom's mastery learning theory, the impact of the Resuscitation Quality Improvement (RQI) quarterly training and hospital unit compliance on inpatient cardiac arrest return of spontaneous circulation (ROSC) was assessed using retrospective secondary data analysis of the American Heart Association's Get with The Guidelines inpatient cardiac arrest data and historical unit RQI compliance data. Using binary logistic regression, a convenience sample of adult, inpatient cardiac arrest data from between 2015–2019 and RQI training unit compliance data (n=585) were analyzed. Results indicated post RQI training implementation, overall, patients were 1.457 times more likely to achieve ROSC with cardiac and noncardiac preexisting conditions being statistically significant predictors of ROSC; those with only cardiac preexisting conditions were 4.026 times more likely, only noncardiac preexisting conditions were 2.859 times more likely, and those with both cardiac and noncardiac preexisting conditions were 3.060 times more likely than those with no preexisting conditions. This study contributes to positive social change by addressing the existing literature gap and informing stakeholders regarding the effectiveness of fully automated life support training on inpatient cardiac arrest survival.

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# Dedication

This doctoral study is dedicated to my wonderful husband, Nate, who has always been my biggest fan, encourager, and soft place to land on hard days. You have inspired me to dream big and are a constant reminder that all great things are waiting on the other side of fear. I appreciate your love and support more than you could ever know!

To my amazing children, Alex Estelle and Jaxon Owen, your magical spirits and loving souls have given me the courage to take on big goals and big dreams. You have been so graceful in my pursuit of a better World, and I hope witnessing hard work and dedication at a young age inspires you to make and be the change you want to see in the World. You are my heartbeat!

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I am truly grateful to all of you for contributing to the growth I have experienced on this amazing journey!

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# Chapter 1: Introduction to the Study

In the United States, more than 200,000 adult patients die annually from cardiac arrest occurring during their hospital admission (Andersen et al., 2019; Centers for Disease Control [CDC], 2021). Historically, the patient survival rates of inpatient cardiac arrest have been recorded between 22%–25% nationally (Dudzik et al., 2019; Panchal et al., 2020). Even with tremendous scientific strides in medical care over the last several decades, the inpatient, cardiac arrest survival rates in the United States have been stagnated at the current survival rates of 22%–25%. Lack of progress in improving inpatient, cardiac arrest survival rates have led to investigation of current life support training modalities and their effectiveness in training clinicians to respond to inpatient cardiac arrests with high-quality cardiopulmonary resuscitation (CPR) skills (Dudzik et al., 2019; Hansen et al., 2019; Panchal et al.,2020).

Until the recent American Heart Association's (AHA; 2020) *Cardiopulmonary Resuscitation Guidelines* release launching the campaign, "The Time for Digital is Now," the majority of life support training was conducted with instructor-led training (ILT) with a post classroom CPR skills validation conducted by a trained and certified AHA instructor. With a multitude of recent literature supporting the ineffectiveness of biennial ILT on clinical CPR skill retention (i.e., Hansen et al., 2019; Pedersen et al., 2018), the AHA has recommended all life support training transition to a fully automated modality of life support training. Although the AHA's scientific contributions show a positive correlation between fully automated life support training and increased clinician CPR skill retention (Dudzik et al., 2019; Panchal et al., 2020), little research exists that shows the effects of fully automated life support training on inpatient cardiac arrest return of spontaneous circulation (ROSC), which is a critical component of patient survival (Chan & Tang, 2020). To close this existing literature gap, I analyzed the likelihood of inpatient cardiac arrest ROSC pre- and postimplementation of Resuscitation Quality Improvement (RQI) quarterly training. Due to the known contribution and influence multiple variables have on inpatient cardiac arrest ROSC, the following variables were used as predictors for assessing the likelihood of inpatient cardiac arrest ROSC pre- and postimplementation of RQI quarterly training: cardiac and noncardiac preexisting conditions and patient age.

In this chapter, I discuss the background, problem statement, and purpose for this study regarding the effectiveness of fully automated life support training on inpatient cardiac arrest ROSC and the relationship between unit compliance with RQI quarterly training and the likelihood of achieving inpatient cardiac arrest ROSC. In addition, the chapter includes a description of the research questions driving this study, the theoretical framework, the nature of the study, relevant definitions, and assumptions. The scope and delimitations, limitations, and significance of this research study are also provided.

## Background

Clinical performance of CPR skills in the event of an inpatient cardiac arrest can be attributed to the effectiveness of life support training (Cheng et al., 2020; Dudzik et al., 2019; Hansen et al., 2019; Panchal et al., 2020). During the scientific investigation of the clinical effectiveness of traditional ILT courses, Hansen et al. (2019), Harris and Kudenchuk (2018), and Pedersen et al. (2018) found ILT courses to be insufficient in preparing clinicians to perform high-quality CPR. A significant contribution to these inefficiencies was found to be the instructor's lack of objectivity during hands-on CPR skill assessment validations (Hansen et al., 2019; Pedersen et al., 2018). In concert with these findings, Matterson et al. (2018) and Pedersen et al. identified a majority of the ILT inadequacies to be associated with rapid skill decay following life support training using traditional, biennial ILT modalities. Per Pedersen et al., skill decay had been shown to occur within 3 months of training. To combat skill decay and equip clinicians with training that supports high-quality CPR performance in the event of an inpatient cardiac arrest, Pedersen et al. recommended a transition from biennial, facilitator-led, basic life support (BLS) training to automated, self-directed learning tools. Overall, findings suggested automated learning had a greater impact on long-term skills retention than facilitator-led training using the same tools (Hansen et al., 2019; Harris & Kudenchuk, 2018; Matterson et al., 2018; Pedersen et al., 2018).

In response to the demand for fully automated life support training modalities, a life support training program, RQI, was designed and implemented within health care systems across the nation (RQI Partners, 2019). The RQI training program was built to deliver high-quality CPR training to clinical staff based on a mastery learning theoretical framework. Cheng et al. (2018, 2020) identified the mastery learning methodology framework of deliberate practice through low-dose, high-frequency assessments and real-time automated feedback to be contributing factors of improved CPR skill retention over time. Similarly, Dudzik et al. (2019) and Panchal et al. (2020) found the use of RQI as a sole modality of life support training to improve clinician life support skill retention via quarterly cognitive training and corresponding CPR skill assessments along with clinician perception of life support competency attainment and confidence in responding to inpatient cardiac arrests. Though several scientific contributions have shown a positive correlation between the RQI fully automated training program and its positive impact on CPR skill retention, little evidence exists that shows the effects of the RQI training program on inpatient cardiac arrest ROSC. As recommended by current literature, resuscitation education research needed to be conducted to establish links between performance outcomes in training, using fully automated life support training modalities such as RQI, and the impact on patient outcomes (Cheng et al., 2020; Dudzik et al., 2019; Panchal et al., 2020). Since an established gap in literature existed related to the use of fully automated life support training modalities such as RQI and their impact on patient outcomes, this study was necessary to narrow this gap.

## Problem Statement

Each year, more than 200,000 adult cardiac arrests occur in U.S. hospitals and less than 26% of adult patients survive while in the care of BLS-certified clinicians (Andersen et al., 2019; Benjamin et al., 2019; Harris & Kudenchuck, 2018; Neagle & Wachsberg, 2010). Although mandated clinical BLS certification every 2 years was intended to decrease patient mortality, inpatient cardiac arrest survival rates have remained steady at 24%–26% (Dudzik et al., 2019; Panchal et al., 2020). Providing valuable insight, research had emerged over the last 5 years highlighting the ineffectiveness of traditional instructor-led BLS courses on learner skill retention, resulting in poor patient outcomes (Dudzik et al., 2019; Hansen et al., 2019; Harris & Kudenchuck, 2018; Panchal et al., 2020). Moreover, literature supporting the need for innovative and effective BLS training led to the development and rapid adoption of automated self-learning intended to replace traditional facilitator-led courses (Dudzik et al., 2019; Hansen et al., 2019; Panchal et al., 2020).

In concert with supporting literature that prompted the need for more objective and effective life support training, the AHA's (2020) life support guidelines release branded as "The Time for Digital is Now" recommended fully automated modalities of life support training in all health care organizations (RQI Partners, 2019). The Joint Commission (2021) also updated guidelines that advised health care facilities to provide life support education and training on a periodic basis post initial training. From this standpoint, RQI was designed to objectively assess health care provider competency with quarterly cognitive assessments and life support skill assessments (i.e., chest compressions on the adult manikin, chest compressions on the infant manikin, ventilations on the adult manikin, and ventilations on the infant manikin). Per Dudzik et al. (2019) and Panchal et al. (2020), quarterly cognitive and skill assessments were intended to improve clinical competency with life support skills and patient outcomes as well as decrease health care costs associated with life support training. Although RQI was developed to improve clinical competency, little research exists regarding the impact of RQI training on inpatient cardiac arrest ROSC; as such, I conducted this study to explore these outcomes.

In my search of the literature, I found that Dudzik et al. (2019) and Panchal et al. (2020) have produced the only existing RQI program implementation research to date. Dudzik et al. conducted a mixed-methods program implementation study at the first hospital in the Midwest to adopt RQI in 2016 and evaluated CPR performance during quarterly simulation sessions and investigated participant impressions. In the quantitative portion of the study, Dudzik et al. assessed psychomotor compression and ventilation performance, while in the qualitative portion of the study, they evaluated perceptual CPR confidence and satisfaction with RQI. The researchers concluded more research was needed to confirm the effectiveness of RQI at other hospitals and RQI's impact on in-hospital, cardiac arrest patient survival outcomes.

Panchal et al. (2020) conducted a before-after intervention study following the launch of RQI. The CPR skills of registered nurses and patient care assistants were measured quarterly for each learner with a focus on compression and ventilation over the course of 1 year. Additionally, a total of 20 in-hospital, cardiac arrest events occurred (pre- RQI there were 11, and post- RQI there were nine) on the two nursing units being studied during the study period, offering opportunity to assess CPR quality given to patients under real circumstances. Pre- and post- RQI implementation scores were analyzed and compared to BLS skill data captured during the event of an inpatient cardiac arrest response, showing compression fraction improvement pre-RQI to post-RQI from 83% to 93% ($p < 0.001$) and an increase in compressions per minute (pre-RQI = 109 and post- RQI = 120, $p = 0.008$). Panchal et al. recommended further research to validate RQI training effectiveness on CPR skill retention and suggested research be conducted to assess the impact of RQI training on patient survival and neurological outcomes related to in-hospital cardiac arrest.

Dudzik et al. (2019) and Panchal et al.'s (2020) findings justified the need for further RQI implementation research related to RQI's impact on inpatient cardiac arrest outcomes. Overall, I identified a gap in the literature pertaining to the impact of RQI training on inpatient outcomes and, specifically, determining whether a direct link exists between RQI training and inpatient cardiac arrest ROSC outcomes. To close this gap, I conducted this study focusing on the effects of RQI training on inpatient cardiac arrest ROSC.

## Purpose

The purpose of the study was to perform a quantitative analysis to assess the effects of RQI training (i.e., an independent variable) and unit quarterly RQI training compliance (i.e., an independent variable) on inpatient cardiac arrest ROSC (i.e., the dependent variable) while controlling for the potential ROSC influencing variables of cardiac and noncardiac preexisting conditions and patient age. During the literature review, I identified a trending theme of study outcomes focused solely on learner knowledge retention and student learning outcomes in resuscitation education. Limited findings indicating the influence of training on patient outcomes prompted the need for future research to focus on assessing the direct relationship between provider training modality and actual patient outcomes (Cheng et al., 2020). Moreover, existing literature focused solely on the surrogate outcomes of learner knowledge and skill performance in the simulated setting and lacked representation of patient impact. Similarly, little is known concerning the role of unit compliance with quarterly RQI training and inpatient ROSC outcomes. Due to the rapidly shifting paradigm in training modalities, the need for research linking simulation training directly to patient impact was paramount. From this perspective, the current study served as foundational research for the scientific community by addressing the direct link between simulated training and training compliance on inpatient cardiac arrest ROSC.

## Research Questions

RQ1: What is the impact of RQI quarterly training on inpatient cardiac arrest ROSC in comparison to pre-RQI implementation inpatient cardiac arrest ROSC when controlling for cardiac and noncardiac preexisting conditions and age?

$H_0$1: The likelihood of achieving ROSC after inpatient cardiac arrest when controlling for cardiac and noncardiac preexisting conditions and age is not associated with RQI implementation and training of facility staff.

$H_1$1: The likelihood of achieving ROSC after inpatient cardiac arrest when controlling for cardiac and noncardiac preexisting conditions and age is greater following RQI implementation and training of facility staff.

RQ2: What is the impact of hospital unit compliance with RQI quarterly training on inpatient cardiac arrest ROSC when controlling for cardiac and noncardiac preexisting conditions and age?

$H_0$2: The likelihood of achieving ROSC after inpatient cardiac arrest is not associated with cardiac arrests occurring on hospital units achieving higher compliance with quarterly RQI training when controlling for cardiac and noncardiac preexisting conditions and age.

$H_1$2: The likelihood of achieving ROSC after inpatient cardiac arrest is greater with cardiac arrests occurring on hospital units achieving higher compliance with quarterly RQI training when controlling for cardiac and noncardiac preexisting conditions and age.

## Theoretical Framework

The theoretical basis for this study was Bloom's (1968) theory of mastery learning. While the use of this theory has differed from setting to setting, those true to Bloom's ideas included two essential elements: (a) *the feedback, corrective, and enrichment process* and (b) *instructional alignment* (Guskey, 2005). The basic principles of mastery learning are that educational excellence was expected and could be achieved by all learners with little to no variation in measured outcomes (McGaghie, 2015). From this perspective, RQI training was designed with a competency-based approach that emphasized skill mastery through low-dose, high-frequency training (Cheng et al., 2020; RQI Partners, 2019). The concept of mastery learning includes the idea that all learners could and should achieve excellence with consistent measurable outcomes instead of simply meeting minimum standards (Dudzik et al., 2019; McGaghie, 2015). This approach to automated instruction included a pretest; curriculum delivery and deliberate practice; posttest; review of the curriculum/skills, and repeated testing, if needed; and frequent refresher training. Dudzik et al. (2019) and Panchal et al. (2020), whose work was foundational for the current study, used mastery learning as the theoretical underpinning for their studies regarding skill achievement and longitudinal skill retention using fully automated life support training. Furthermore, Dudzik et al.'s and Panchal et al.'s application of Bloom's theory offered insight into the way life support skills are attained and maintained with fully automated life support training and how mastery of these skills translated into clinical performance, affecting inpatient cardiac arrest ROSC.

## Nature of the Study

In this quantitative study, I used multivariate logistic regression to analyze secondary data, collected from the AHA Get with The Guidelines (GWTG) database, to predict the likelihood of achieving ROSC in relation to multiple predictors (see Salkind, 2010). As a primary focus, I assessed the impact of RQI quarterly training on inpatient cardiac arrest ROSC. Secondarily, I investigated the impact of unit compliance with RQI quarterly training on inpatient cardiac arrest ROSC. In alignment with a multivariate logistic regression data requirement, predictor variables were established and recorded during normal organizational operations and documented for each individual resuscitation event. This quantitative analysis of inpatient cardiac arrest ROSC pre- and post- RQI implementation elucidated the impact fully automated life support training has on inpatient ROSC outcomes along with the significance of unit RQI compliance in predicting ROSC achievement.

I accessed inpatient cardiac arrest data from the study site organization's AHA GWTG data set, which included details regarding prevent circumstances, preexisting conditions, code blue event details, initial patient condition, the use of an automated external defibrillator, the presence of ventricular fibrillation/pulseless ventricular tachycardia during resuscitation attempt, ventilation, use of epinephrine, use of other drug interventions, and previous resuscitation-related events and issues (AHA, 2021b). RQI unit compliance data were accessed via the study site organization's RQI historical Juicebox analytics archives, which I requested from the organization's learning management system for the research site. Based on the robustness of the GWTG data set and access to RQI learner compliance archives, data from other sources were not needed.

## Operational Definitions

For the purposes of context clarification, the terms used extensively throughout this research study are listed and defined below.

*Code blue*: In-hospital medical emergency indicating cardiac arrest or respiratory arrest requiring patient resuscitation (Eroglu et al., 2014).

*RQI compliance*: Completion of assigned RQI life support curriculum within the designated calendar quarter (Laerdal, 2021).

*Compression rate*: Rate of manual compression of patient chest wall (Meaney et al., 2013).

*Compression depth*: Internal distance reached by mechanical compression of chest wall (Meaney et al., 2013).

*Fully automated*: Carried out by machines or computers without needing human control (Cambridge University Press, 2021).

*Full chest recoil*: Complete chest wall release wherein the learner does not lean on the chest wall between compressions (Meaney et al., 2013).

*Hyperendemic*: Persistent, high levels of disease occurrence (CDC, 2012).

*Inpatient cardiac arrest*: A loss of circulation prompting resuscitation with chest compressions, defibrillation, or both occurring in a hospitalized patient (Andersen et al., 2019).

*Knowledge retention*: The course of absorbing information and eventually preserving the information over time (Pedersen et al., 2018).

*ROSC*: Return of spontaneous circulation that is sustained for at least 20 minutes post cardiopulmonary resuscitation (Chan & Tang, 2020).

*Skill decay*: The loss or decay of trained or acquired skills (or knowledge) after periods of nonuse (Maehle et al., 2017).

*Traditional life support training*: Curriculum presented to students via a certified life support instructor followed by instructor-facilitated CPR skills testing and cognitive exam (Hansen et al., 2019; Pedersen et al., 2018).

## Assumptions

I made three assumptions in this research study. To adequately assess the effects of the RQI training program on patient outcomes, the first assumption was that all clinical learners who respond to a code blue had completed RQI entry/prep assignments and remained current with quarterly cognitive and skill assignments. This assumption was necessary to the study because the RQI training program methodology is based on the theory of mastery learning that requires low-dose, high-frequency skill attainment (see Cheng et al., 2020). Based on these principals, RQI was designed for quarterly, small-dose, cognitive and skill sessions (Cheng et al., 2020; RQI Partners, 2018). The second assumption was that each learner participating in the RQI training program had equal skill and ability to perform CPR skills (i.e., chest compression at least 2 inches, chest compression rate 100–120/minute, full chest recoil, and rescue breaths 10–12/minute) when responding to a code blue. Some of the theoretical underpinnings of mastery learning are that educational excellence is expected and can be achieved by all learners with little to no variation in measured outcomes (McGaghie, 2015). The concept of mastery learning includes the idea that all learners could and should achieve excellence with consistent measurable outcomes instead of simply meeting minimum standards (Dudzik et al., 2019; McGaghie, 2015). In alignment with the mastery learning theory, my second assumption that all learners training with RQI had equal CPR skill mastery and ability when responding to a code blue was necessary. Lastly, I assumed that all secondary data used for this study were accurate and had been truthfully reported.

## Scope and Delimitations

The purpose of the study was to perform a quantitative analysis to assess the effects of RQI training on inpatient cardiac arrest ROSC and evaluate the impact of unit RQI compliance and ROSC. Due to current RQI life support education research being primarily focused on learner skill retention and learner self-efficacy (Dudzik et al., 2019; Panchal et al., 2020), the need to take research a step further and explore the relationship between RQI life support education and its effects on inpatient cardiac arrest outcomes was evident. As a result, I chose not to focus on learner skill retention and self-efficacy and instead employed an odds/predictive approach to assess RQI life support training and its effects on patient outcomes, specifically ROSC.

The population chosen for study inclusion were clinical frontline employees who provided bedside care to patients at a health care organization located in the mideastern United States. More specifically, clinical disciplines requiring BLS certification for employment who had been assigned RQI entry/prep and perpetual quarterly assignments to obtain and maintain BLS certification were included. In addition to the established inclusion criteria listed, participants must have also met RQI minimum requirements, wherein each learner completed a cognitive quarterly assessment online along with a subsequent quarterly skills assessment at the RQI training station through the entirety of their enrollment in the RQI training program to maintain training compliance (see RQI Partners, 2018).

Due to the nature of each health care organization having different operational circumstances, generalizability between health care systems could vary. Despite the standardized training the RQI program offers, other factors, such as staffing ratios and clinical discipline mix of staffing, could affect patient outcomes. Additional variables that could also affect generalizability are differing organizational resources and code blue procedures, such as the standard use of a code team and code team availability. Additionally, patient condition and confounding comorbidities could have influenced patient severity and patient response to resuscitation efforts; this variation in patient condition between geographical location and inpatient populations served could also impact generalizability.

## Limitations

All data were collected electronically and disbursed through the study site organization's designated GWTG data extraction team. Onsite presence was not needed to transfer data, and due to current visitor restrictions and furloughs related to the COVID-19 pandemic, I conducted all meetings with organizational data collectors via Zoom and Teams virtual meetings. Additionally, online modes of data transactions were set up with encrypted, password-protected access.

My role as a RQI Partners employee could have introduced potential bias into the study. To mitigate bias, I collected and analyzed secondary data. Due to the longitudinal nature of the secondary data collection required to carry out this study, there was no historical influence of employment status on the collection, storage, or disbursement of data. Ongoing data collection by the organization was done as part of daily organizational operations, so no special accommodations were made to collect the secondary data needed to carry out the current study.

As previously mentioned, patients' existing conditions and the severity of inpatient health statuses were individually driven and as such, could have created variability in an individual's response to resuscitation attempts. The addition of confounding variables was challenging to account for in relation to patient ROSC, which is why the contributing variables of cardiac and noncardiac preexisting conditions and age, outlined in the GWTG Cardiopulmonary Arrest Event (CPA) tool, were accounted for in the multivariate logistic regression analysis. Due to the nature of the multiple variables that could have affected inpatient cardiac arrest ROSC, unit RQI compliance as a predictor of ROSC outcomes was also measured secondarily. I analyzed the effects of unit compliance on ROSC in a separate logistic regression to avoid interference within the main model and included only post- RQI implementation data.

## Significance

The results of this study have clarified the effectiveness of fully automated life support training and its impact on inpatient cardiac arrest ROSC post- RQI implementation as well as shown the influence of unit compliance on inpatient cardiac arrest ROSC post- RQI implementation. The results could be used informatively by health care organizations who are embarking on the transition journey to digital life support training in lieu of instructor-led courses by offering a quantitative analysis of the direct link between training modality and patient outcomes. Additionally, having indicated the impact of training compliance on patient outcomes, the findings could be used to inform organizational compliance policy and assist in shifting the traditional focus of compliance and disciplinary action to a more patient-centered focus of compliance and patient outcomes. Furthermore, this study contributed to positive social change by addressing the existing literature gap regarding the effectiveness of fully automated life support training on inpatient cardiac arrest survival and could be used to enhance knowledge surrounding the use of digital instruction in place of traditional instructor-facilitated courses.

## Summary and Transition

Inpatient cardiac arrest survival rates have remained stagnant at below 25% in U.S. hospitals prompting the need to reevaluate life support training methodology and content delivery (American Heart Association, 2021a; Cheng et al., 2018; 2020). Although a transition to fully automated life support training has been supported by current literature and recommended by the most recent release of the AHA's (2020) cardiopulmonary resuscitation guidelines, the effects of fully automated training on inpatient cardiac arrest ROSC remained unknown. In Chapter 1, I provided supporting information regarding the need for life support education reform that promotes knowledge and skill retention and established that additional research on the effects of fully automated life support training on inpatient cardiac arrest ROSC and an analysis of the impact RQI unit compliance had on inpatient cardiac arrest ROSC was needed.

Looking ahead, in Chapter 2, I will provide a review of the literature available on inpatient cardiac arrest, inpatient cardiac arrest contributing factors, the ineffectiveness of traditional instructor-led life support courses, and the transition from ILT to a fully automated modality of training. Additionally, I will review the extant research that used Bloom's mastery learning as a theoretical underpinning and discuss, in detail, the use of the RQI program as a sole modality of life support training. In Chapter 2, I will also fully explain the key search terms used and provide a description of the literature review.

# Chapter 2: Literature Review

Though many scientific advancements in health care have improved patient outcomes, the patient survival rate of inpatient cardiac arrests has shown little improvement over the last few decades (Cheng et al., 2020; Dudzik et al., 2019; Meaney et al., 2013; Panchal et al., 2019). Traditional ILT life support courses have been shown to be inefficient in correctly identifying learner CPR skill performance competency and ineffective in preventing CPR skill decay (Andersen et al., 2019; Benjamin et al., 2019; Harris & Kudenchuck, 2018; Neagle & Wachsberg, 2010). As a result of ILT shortcomings, the AHA has recommended health care organizations transition to a low-dose, high-frequency fully automated training modality for life support courses (Cheng et al., 2020). Due to the inadequacy of biennial training, the Joint Commission (2021) advised all health care organizations to implement more frequent life support training intervals. In response to AHA and Joint Commission recommendations, health care organizations are rapidly adopting the RQI training program in lieu of conducting ILT courses (Dudzik et al., 2019; Panchal et al., 2019). Despite the rapid adoption of RQI, little research has been conducted on the use of RQI as a sole means of life support training and its effects on patient outcomes. Even less is known about the impact of unit compliance with quarterly RQI training on inpatient cardiac arrest ROSC.

The purpose of this quasi-experimental quantitative study was to assess the effects of RQI training on inpatient cardiac arrest ROSC and evaluate the impact of quarterly RQI training unit compliance on inpatient cardiac arrest ROSC. During the literature review, I identified a trending theme of study outcomes focused solely on learner knowledge retention and student learning outcomes in resuscitation education research, prompting the need for future research focused on assessing the direct relationship between provider training modality and actual patient outcomes (see Cheng et al., 2020). This study addresses the existing literature gap regarding the effectiveness of fully automated life support training on inpatient cardiac arrest ROSC.

In this chapter, I discuss the extant literature on inpatient cardiac arrest, the ineffectiveness of traditional instructor-led life support courses, the transition from ILT to a fully automated modality of training, and the use of the RQI program as a sole modality of life support training. A review of research on the use of Bloom's mastery learning as a theoretical underpinning of this study is also provided. I begin the chapter by presenting a rich description of key search terms and literature search strategy used.

## Literature Search Strategy

To conduct this literature review, I selected articles related to life support training modalities, clinical life support skill retention, and longitudinal skill retention. The keyword search terms used were *basic life support*, *cardiac arrest*, *cardiopulmonary resuscitation, education, facilitator-led learning, learning, learning methods, self-learning, life support training, training modalities, mastery learning, skill retention, inpatient cardiac arrests, patient survival post inpatient cardiac arrest,* and *automated training*. I carried out the keyword searches in the following databases and search engines: Google Scholar, CINAHL Complete, SAGE Journals, Circulation, and the Walden University Library Thoreau multidatabase search tool. My literature search was focused on peer-reviewed articles published within the past 5 years and included science briefings, training guidelines, and best practice recommendations made by the AHA. Additionally, the AHA GWTG heart failure publications were used to provide historical literary context to the use of GWTG data sets.

## Theoretical Foundation

Educational achievement equality has been an important topic since the early 1960s (Guskey, 1997, 2005). Variation in learner achievement, specifically by disparity, was identified as a major U.S. concern during Lyndon Johnson's presidency, birthing the "War on Poverty." As a result of the educational achievement inequality gaps identified, Benjamin S. Bloom (1968, 1977) was tasked with finding a solution to bridging these disparities. Prior to arriving at the mastery learning theory, Bloom's (1968, 1977, 1978) investigation showed teachers to have a strong influence on student achievement variation with minimal application of instructional variation practices to meet the educational needs of each learner. Due to the lack of appropriate instructional variation available in the classroom, many learners who did not resonate with the provided learning style did not excel with educational achievement. Overall, little instructional variation resulted in great variation of student learning.

Bloom (1968) theorized that increased instructional variation could decrease learner educational achievement variation. To test this theory, Bloom investigated the prior works of pioneer theorists who specialized in individual instruction and group-based instruction to find practical ways to integrate effective instructional variation within a classroom composed of diverse learners (Guskey, 2005). Through several trails, Bloom found the use of assessment tools, such as feedback and corrective procedures to diagnose learner difficulties and offer remediated corrective action, to be the best approach in meeting each learner's needs. Based on these findings, Bloom's (1968, 1977) learning for mastery theory, later coined mastery learning theory, was developed.

Bloom's (1977, 1978) mastery learning theory has several major theoretical propositions and assumptions. In the theory, Bloom assumed that all learners have varying learning needs and learning styles that require a variable instructional design to decrease educational achievement differences. From this perspective, Bloom hypothesized that increased instructional variation would decrease learner achievement variation, thus closing the educational achievement gaps amongst students. Bloom's ideas included two essential elements: (a) the feedback, corrective, and enrichment process and (b) instructional alignment (Guskey, 1997, 2005). While both elements are independently crucial to effective instructional design, Bloom proposed that to be optimally effective, they must be used in combination with one another (Guskey, 2005). Bloom presumed that educational excellence is expected and can be achieved by all learners with little to no variation in measured outcomes (McGaghie, 2015). Additionally, Bloom (1978) emphasized the need for mastery learning to be used for higher level learning, such as the development of critical thinking and problem solving, that is essential to the role of the learner so the knowledge and skills can be retained long after the details of the classroom information has been forgotten.

## Current Literature Theory Application

Cheng et al. (2020) identified the mastery learning methodology framework of deliberate practice through low-dose, high-frequency assessments and real-time automated feedback to be contributing factors of improved CPR skill retention over time. Similarly, Dudzik et al. (2019) and Panchal et al. (2020) found Bloom's mastery learning theory, when incorporated in life support training design, improved clinician life support skill retention via quarterly cognitive training and corresponding CPR skill assessments along with clinician perception of increased life support competency attainment and heightened confidence in responding to inpatient cardiac arrests. Cheng et al., Dudzik et al., and Panchal et al. used Bloom's mastery learning as the theoretical underpinning for their studies with a focus on learner skill achievement and longitudinal skill retention using fully automated life support training. Although Dudzik et al. and Panchal et al. did not concentrate on the effects of fully automated life support training and patient survival, their application of Bloom's theory offered insight into the way life support skills are attained and maintained with fully automated life support training as well as how mastery of these skills is predicted to translate into clinical performance, affecting inpatient cardiac arrest patient outcomes.

**Application to Research**

I chose Bloom's mastery learning theory as the foundation of the current study due its contribution to the scientific development of the AHA's RQI training program (see Cheng et al., 2020; Meaney et al., 2013; RQI Partners, 2019). The RQI training methodology was developed using the principals of mastery learning to facilitate an equitable learning experience with life support knowledge and skill attainment by utilizing real-time objective feedback on learner performance, correct learning, and learning enrichment activities (Dudzik et al., 2019; Meaney et al., 2013; RQI Partners, 2019). The instructional alignment was crafted with a mastery learning framework to promote learner achievement of BLS skill mastery and operationalization during real-life emergencies (Cheng et al., 2020). Since I specifically investigated the effects of RQI training and unit compliance with quarterly RQI training on inpatient cardiac arrest ROSC in the study, the use of the mastery learning theory was appropriate.

## Literature Review of Key Variables

In this section, I define, discuss, and put into perspective the key variables of the study based on current research available. The variables of inpatient cardiac arrest, contributors to morbidity and mortality, traditional life support training and instructor led courses, life support training and skill decay, life support training and knowledge retention, and transition to digital and fully automated learning are explored. I conclude the chapter by discussing how the current study has filled gaps in the literature.

### Adult Inpatient Cardiac Arrest

Heart disease and adult cardiac arrest has remained a public health crisis in the United States with an average of more than 600,000 cardiac arrests annually (Andersen et al., 2019; Benjamin et al., 2019). Heart disease, which is the leading contributor to cardiac arrest, has been labeled as a top leading cause of mortality in the nation, categorizing this health disparity as hyperendemic (CDC, 2018). Of the 600,000 annual cardiac arrests nationally, approximately 290,000 occur in the inpatient hospital setting (Andersen et al., 2019). Inpatient cardiac arrests showed a marked increase in incident, almost doubling from 6–7 arrest per 1000 admissions from 2003-2007 to 9–10 per 1,000 admissions from 2008–2017 (CDC, 2018). Although the last 2 decades have shown a marked increase in inpatient cardiac arrest rates, survival rates have maintained in U.S. hospitals at less than 26% nationally, of which, on average, only 17% survive until discharge from the inpatient setting (Andersen et al., 2019; Benjamin et al., 2019; Harris & Kudenchuck, 2018; Neagle & Wachsberg, 2010). Despite stagnated inpatient cardiac arrest survival rates, inpatient cardiac arrest has been neglected when compared to out of hospital cardiac arrests (Neagle & Wachsberg, 2010) until recent literature shed light on the inefficiencies of traditional life support training and the need to revise content delivery in a way that supports the knowledge retention and CPR skill performance of inpatient frontline clinicians (Cheng et al., 2018, 2020).

### ***Contributing Factors: Cardiovascular Comorbidities***

Cardiovascular comorbidities have been considered a major contributor to heart failure, resulting in increased morbidity and mortality rates amongst U.S. citizens (Metra et al., 2011). Established cardiovascular comorbidities known to complicate heart failure and impact heart failure patient prognosis include hypertension, coronary artery disease, peripheral artery disease, cerebrovascular disease, arrhythmias, and valvular heart disease (Metra et al., 2011). In the inpatient setting, heart failure in combination with confounding cardiovascular comorbidities can result in cardiac arrest. Cardiac arrest is considered a medical emergency, and in the hospital setting, is known as a code blue (Eroglu et al., 2014). In response to inpatient code blues, BLS measures are provided by a medical team in an effort to achieve ROSC. According to Pothiawala (2017), regardless of the exact cause of cardiac arrest, when ROSC is achieved, multiple organ systems may be affected secondary to postcardiac arrest syndrome, including electrolyte abnormalities, airway compromise, hypoxia, neurological impairment, and hemodynamic instability. Considering the fragile state of the body postcardiac arrest ROSC, prior cardiac arrest and multiple cardiac arrest cases during the same hospital admission could impact subsequent cardiac arrest patient outcomes (Pothiawala, 2017). In addition to cardiovascular comorbidities, noncardiovascular comorbidities have also been noted as contributing factors to heart disease and heart failure (Sharma et al., 2018).

### ***Contributing Factors: Noncardiovascular Comorbidities***

Although cardiovascular comorbidities have been widely recognized for their contribution to increasing heart failure risk, the role of noncardiovascular comorbidities in heart failure morbidity and mortality have been underestimated. In a recent study, Sharma et al. (2018) called attention to the growing prevalence of noncardiovascular comorbidities amongst hospitalized patients with heart failure. Of noted importance, “chronic obstructive pulmonary disorder/asthma, anemia, diabetes mellitus, obesity [body mass index ≥30 kg/m2], renal impairment, and depression among hospitalized patients” (Sharma et al., 2020, p. 1) had exponentially grown between 2005 and 2014. Per van Deursen et al. (2014), 40% of patients with heart failure had more than five noncardiovascular comorbidities; among chronic heart failure patients, 74% had at least one noncardiovascular comorbidity; and an increasing number of noncardiovascular comorbidities was associated with a greater risk of mortality. Considering these findings, it was necessary to acknowledge the confounding impact noncardiovascular comorbidities may have on heart failure severity and mortality risk as well as the impact they may have on response to resuscitation in the event of cardiac arrest.

**Traditional Life Support Training**

The recommendation to mandate biennial, clinical BLS certification for frontline clinical staff was intended to decrease patient mortality and increase inpatient cardiac arrest survival rates (Harris & Kudenchuk, 2018). As outlined by Kleinman et al. (2015) and recommended by the most recent AHA guidelines (Cheng et al., 2020; Meaney et al., 2013), the five key metrics identified as necessary for high quality CPR training are:

- Chest compression rate (i.e., 100–120 compressions per minute).
- Chest compression depth (i.e., at least 2 inches deep for adult patients).
- Chest compression fraction and minimizing pauses (i.e., minimize pauses in compressions for less than 10 seconds).
- Allowing full chest recoil (i.e., no pressure on the chest between compressions).
- Controlled ventilation with avoidance of hyperventilation (i.e., ratio of 2 breaths per 30 compressions with no advanced airway present; 1 breath every 5 to 6 seconds with advanced airway present).

In accordance with AHA training recommendations, these five key metrics were integrated in BLS curriculum and skills demonstration for traditional BLS certification courses (CITE). Until recently, traditional courses had been strictly facilitated by a certified AHA BLS instructor in a face-to-face format with content delivered via standardized video education and intermittent skills practice (Hansen et al., 2019; Harris & Kudenchuk, 2018; Pedersen et al., 2018). In linear fashion, curriculum was delivered, learners demonstrated CPR skills proficiency on adult and infant manikins, learner skill competency was validated by a designated AHA instructor, and each learner was required to pass a standardized test developed by the AHA. To become BLS certified, each learner would have to pass both the instructor-facilitated skills validation and cognitive assessment in accordance with AHA (2020) standards. Although the concept of CPR had shown evolutionary strides since its initial recommendation in the 1960s (AHA, 2021a), traditional modalities of training have had little impact on inpatient cardiac arrest survival rates, prompting the need for further investigation of content delivery by means of instructor-led courses (Dudzik et al., 2019; Panchal et al., 2020).

With traditional instructor-led courses having little impact on overall inpatient cardiac arrest survival rates (Andersen et al., 2019; Benjamin et al., 2019; Harris & Kudenchuck, 2018; Neagle & Wachsberg, 2010), several studies have been conducted with the aim of investigating certified BLS instructors' assessment of CPR skills. Knowing that high-quality CPR had a direct impact on patient survival after cardiac arrest, Hansen et al. (2019) investigated the efficiency of BLS instructor assessment of learner CPR skills. Using a post hoc analysis of data from a randomized control trial, Hansen et al. assessed the accuracy of pass/fail decisions made by instructors during learner competency validation. During learner CPR skills assessment, the certified instructors and learners were blinded to manikin feedback. Although unable to view or hear manikin feedback during CPR skills validations, CPR quality from the manikin feedback during skills tests were recorded and analyzed for each learner. After data from the manikin feedback was compared with instructor assessments, a significant discrepancy between instructor assessments and manikin feedback data was evident. Of the 81 learners receiving a passing score on CPR skills (i.e., the depth and rate of chest compressions and rescue breathing), per manikin data, only two learners performed adequate resuscitation in all CPR categories.

Like Hansen et al.'s (2019) findings, Lynch et al.'s (2008) study also demonstrated that certified instructors often fail to identify inadequate chest compression depth. Although Lynch et al.'s participating instructors were effective in identifying adequate rescue breathing skills, Hansen and colleagues found that certified instructors struggle to properly identify both subpar chest compression depth and ineffective rescue breathing. Overall, current research raises concerns with inaccuracy of the certified instructors' ability to accurately assess learners' CPR skill performance and the potential for instructor reward, based on a passing score for below standard skill performance in the simulated environment, to lead to suboptimal CPR performance when responding to real-life emergencies (Cheng et al., 2015; Hansen et al., 2019; Lynch et al., 2008). To optimize inpatient cardiac arrest patient outcomes, focused efforts on life support training modalities and the delivery of content were made (Meany et al., 2013).

***Skill Decay***

Learner knowledge retention and skill decay were vital concepts to consider when creating effective life support training courses, especially when the goal of learning is longitudinal retention of information and skills (Cheng et al., 2018; 2020; Dudzik et al., 2019; Maehle et al., 2017). Shedding light on these concepts and their relationship to life support training, the AHA's scientific exploration of learner life support knowledge retention revealed inadequacies among clinical staff spanning across frontline health care disciplines (Cheng et al., 2020; Dudzik et al., 2019). This lack of knowledge retention over time was attributed to high-dose, low-frequency training methodologies that have historically served as the foundational building blocks of traditional life support certification training (Cheng et al., 2020; Dudzik et al., 2019; Panchal et al., 2020; Pedersen et al., 2020).

From this perspective, research showed approximate skill decay at 3-12 months post traditional life support training courses (Cheng et al., 2020; Dudzik et al., 2019; Panchal et al., 2019). With skill decay happening shortly after traditional life support certification and much sooner than the biennial recertification, an urgent need to explore more effective modalities of life support was unmistakable. In conjunction with evidence supporting the move from ILT courses to digital platforms, intended to achieve more objective learner assessments (Cheng et al., 2015; Hansen et al., 2019; Lynch et al., 2008; Meany et al., 2017), with the critical need for a low-dose, high frequency training model to prevent skill decay, the AHA recommended the transition to fully digital life support training (Cheng, 2020).

***Transition to Digital***

The International Liaison Committee on Resuscitation Formula for Survival emphasizes three essential components influencing survival outcomes from cardiac arrest: (a) guidelines based on current resuscitation science, (b) effective education of resuscitation providers, and (c) local implementation of guidelines during patient care (Cheng et al., 2020). With a great emphasis placed on the role of effective education to improve learner skill acquisition and retention for critical tasks, the AHA has recommended a mass transition to digital life support education. The AHA Guideline's released on October 21, 2020, urged health care organizations to begin moving away from ILT courses towards fully automated life support training, and Joint Commission recommendations reinforced the need for learners to receive low-dose, high-frequency training consistent with a deliberate practice and mastery learning model (Joint Commission, 2021). In addition to AHA recommendations to move toward automated training, the need to adhere to COVID-19 safety guidelines for training centers (CDC, 2021) has propelled the rapid adoption of automated life support throughout the U.S.

**Resuscitation Quality Improvement**

In response to the demand for fully automated life support training modalities, a life support training program, RQI (RQI Partners, 2019), was designed and implemented within health care systems across the nation. The RQI training program was built to deliver high-quality CPR training to clinical staff based on a mastery learning theoretical framework. In contrast to traditional BLS training courses, RQI was designed with a competency-based approach which emphasizes skill mastery through low-dose, high-frequency training. To achieve the benefits of low-dose, high-frequency training, the RQI program historically included a series of online eSimulation and psychomotor skill modules practiced quarterly on mobile training stations equipped to provide real-time audiovisual feedback based on objective learner assessments. Consistent with the mastery learning model, the RQI training program included a pretest, curriculum delivery and deliberate practice, posttest, review of the curriculum/skills and repeat testing if needed, and frequent refresher training (Dudzik et al., 2019; RQI Partners, 2020).

The RQI online cognitive modules contain video education and interactive cardiac arrest eSimulations (Dudzik et al., 2019; RQI Partners, 2020). The RQI training stations consist of a Laerdal Resusci AnneR adult/infant manikin and a CPR quality measurement device embedded in each manikin chest which are integrated with a laptop monitoring system; adult and infant bag-valve masks are also included with the station although organizations are encouraged to use their own equipment for clinical familiarity with standard equipment used during real-life emergencies (RQI Partners, 2020). During self-directed learner assessments, psychomotor skills (60 compressions and ventilations over 1 minute) are measured by the CPR quality measurement sensor, ensuring learners are performing in alignment with current AHA standards. If the learner performs outside of AHA parameters on chest compressions and ventilations, the RQI program corrects the learner with real-time audiovisual feedback via the laptop connected to the RQI training station (RQI Partners, 2020). Upon completion of quarterly skills assessments, each learner receives a detailed breakdown of their performance in comparison to AHA standards and the option for additional guidance in areas flagged for needed improvement. Individual performance history is maintained in the RQI platform for learner review later. Additionally, each learner's archived psychomotor skills assessments can be accessed after quarterly completion for skills practice between mandated quarterly assessments.

At the time of this study's inception, limited literature existed on the effects of fully automated life support training in the clinical setting. Based on the literature search results, Dudzik et al. (2019) and Panchal et al. (2019) conducted the only RQI implementation studies known to date. Dudzik et al. conducted a pre- and post- RQI implementation mixed-methods study that evaluated CPR performance during RQI quarterly simulation sessions and participant perceptual CPR confidence and program satisfaction. Results demonstrated perpetual learning of RQI skills on a quarterly basis positively influenced learner psychomotor CPR skill performance of both chest compressions and ventilations. Likewise, qualitative data captured 30 months post-implementation via a program satisfaction survey indicated learner perception of increased CPR skill confidence and general satisfaction with the RQI program. Like Dudzik et al.'s post- RQI implementation outcome focus, Panchal et al. (2019) also evaluated learner CPR performance pre- and post- RQI implementation with a focus on feasibility of fully automated training in the clinical setting and application of CPR knowledge and skills to real inpatient cardiac arrests.

Panchal et al. (2019) assessed pre- and post- RQI implementation data collected during routine organizational operations. Learner compliance data were collected over the course of four quarters, 1 full year of program implementation. Inpatient defibrillator data was collected 6 months pre- and post- RQI implementation. As part of routine quality improvement operations, significant event data were collected via defibrillators which included chest compression performance and continual ECG monitoring during inpatient cardiac arrest resuscitation attempts. Chest compression performance data was used to measure CPR performance of RQI learners pre- and post- RQI. Results indicated low-dose, high-frequency training with RQI to be feasible in the clinical setting with a high rate of compliance and overall enhanced CPR skill retention with improved in-hospital CPR quality. Dudzik et al. (2019) and Panchal et al. (2019) both recommended further research be conducted with a focus on the RQI training program and its direct effects on patient outcomes.

## Summary and Conclusion

In Chapter 2 I will provide a solid foundation of the literature available on inpatient cardiac arrest, contributing factors of morbidity and mortality, ineffectiveness of traditional instructor-led life support courses, and the transition from ILT to a fully automated modality of training. A review of research utilizing Bloom's mastery learning as a theoretical underpinning of study was also discussed. The literature review conducted revealed, despite limited research available on the direct effects RQI training and patient outcomes, current literature does show the use of the RQI training program to be clinically feasible, increase clinician confidence in performing CPR, improve learner knowledge and skill retention, and enhance inpatient CPR quality (Dudzik et al., 2019; Panchal et al., 2019). Due to the rapidly shifting paradigm from ILT courses to fully automated modalities of training, the need for research linking simulation training directly to patient impact is paramount. From this perspective, this study has been conducted to serve as foundational research for the scientific community that addresses the direct link between RQI quarterly training and impact on inpatient cardiac arrest survival and has elucidated the influence unit compliance with quarterly RQI training on inpatient cardiac arrest ROSC.

In Chapter 3, I will provide further details regarding the study variables, the methodology used for the research, secondary data collection details, and data analysis procedures that will be used. Ethical considerations and institutional review board (IRB) information will be discussed. Additionally, a clear and thorough description of the RQI training program design, implementation details, and learner assessment metrics will be provided.

# Chapter 3: Research Method

The purpose of the study was to perform a quantitative analysis to assess the effects of RQI quarterly training and unit RQI quarterly training compliance (i.e., the independent variables) on inpatient cardiac arrest ROSC (the dependent variable coded as yes or no) while controlling for the covariates of patient history of preexisting cardiac conditions, noncardiac conditions, and patient age. During the literature review, I identified a trending theme of study outcomes based solely on learner knowledge retention and student learning outcomes in resuscitation education research prompting the need for future research to focus on assessing the relationship between provider training modality and actual patient outcomes (see Cheng et al., 2020). Due to the rapidly shifting paradigm in training modalities, the need for research linking simulation training directly to patient impact was paramount. From this perspective, the current study served as foundational research for the scientific community that addresses the impact of quarterly RQI training on inpatient cardiac arrest ROSC and the predictive influence unit RQI quarterly training compliance has on inpatient cardiac arrest ROSC.

In this chapter, I detail the target population of study, research design and rationale, methodology, process of secondary data retrieval, and operationalization of constructs. Additionally, the data analysis plan, threats to validity, and ethical procedures are discussed.

## Quantitative Research Design and Rationale

In alignment with a quantitative paradigm, I employed a retrospective design that is consistent with analyzing historical data (see Salkind, 2010; Unite for Sight, 2021).

Consistent with a retrospective quantitative research design, the bivariate outcome (i.e., ROSC = yes or no) and covariates had already been naturally formed during normal organizational operations and GWTG data collection processes. The research questions and corresponding hypotheses for the study were:

RQ1: What is the impact of RQI quarterly training on inpatient cardiac arrest ROSC in comparison to pre-RQI implementation inpatient cardiac arrest ROSC when controlling for cardiac and noncardiac preexisting conditions and age?

$H_0$1: The likelihood of achieving ROSC after inpatient cardiac arrest when controlling for cardiac and noncardiac preexisting conditions and age is not associated with RQI implementation and training of facility staff.

$H_1$1: The likelihood of achieving ROSC after inpatient cardiac arrest when controlling for cardiac and noncardiac preexisting conditions and age is greater following RQI implementation and training of facility staff.

RQ2: What is the impact of hospital unit compliance with RQI quarterly training on inpatient cardiac arrest ROSC when controlling for cardiac and noncardiac preexisting conditions and age?

$H_0$2: The likelihood of achieving ROSC after inpatient cardiac arrest is not associated with arrests when controlling for cardiac and noncardiac preexisting conditions and age occurring on hospital units achieving higher compliance with quarterly RQI training.

$H_1$2: The likelihood of achieving ROSC after inpatient cardiac arrest when controlling for cardiac and noncardiac preexisting conditions and age is greater with arrests occurring on hospital units achieving higher compliance with quarterly RQI training.

Study Variables I used binary logistic regression to assess the effects of RQI quarterly training on inpatient cardiac arrest ROSC. Additionally, an independent logistic regression was used to assess the likelihood of achieving ROSC based on unit RQI quarterly training compliance. From this standpoint, the dependent variable in both research questions was inpatient cardiac arrest ROSC. The primary independent variables were RQI quarterly training and RQI quarterly training unit compliance. Covariates of interest were preexisting cardiac conditions, noncardiac conditions, and patient age. All covariates of interest were captured in GWTG data collection nationally and were considered necessary measurements and indicators for quality improvement initiatives. I selected these variables because they were felt to affect the success of an individual resuscitation attempt and could have varied within each individual patient.

**Study Design**

I used a quantitative retrospective design to assess the likelihood of ROSC in relation to the predictive variables of RQI quarterly training and unit RQI quarterly training compliance. From this perspective, binary logistic regression was chosen based on the dichotomous nature of the independent variable (i.e., ROSC or no ROSC) and the aim of the study to find the most reasonable model to describe the relationship between an ROSC achievement and the predictor variables of RQI training and unit RQI training compliance. In alignment with binary logistic regression, the predictor variables may be of any data level (i.e., categorical, ordinal, or continuous), which was fitting for the study's covariate data level variability. Like other studies assessing outcome odds (i.e., Sell et al., 2010; Topeli & Cakir, 2021), the use of logistic regression was consistent with research designs employed to assess the relationship between independent variables and a dependent variable while accounting for multiple covariates.

## Methodology

In this section, I describe the population of interest for the study, the type of sampling and sampling procedures used, and recruitment information for the participants. The type of data collection and data analysis procedures are discussed along with details regarding the secondary data collection process. Threats to the study's validity and ethical considerations are also examined.

### Population

The focus population for this study was medical professionals employed at a health care organization in the mideastern United States who participated in RQI for quarterly life support training. Clinicians who may respond to an inpatient code blue and participate in resuscitation measures for inpatient cardiac arrests were included in the study. Based on the differing protocols between adults and pediatric resuscitation measures and requirements, the second group of participants, the patients, were purposefully limited to adult patients who were actively admitted to the hospital, experienced a cardiac arrest, and received standard resuscitation by clinicians.

### Sampling and Procedures

As a participant of the AHA GWTG program, the study site organization had historically extracted all inpatient cardiac arrest data from their electronic medical record

(EMR). I obtained and reviewed inpatient cardiac arrest data via GWTG reports that had been collected during normal business operations. Inpatient cardiac arrest data reviewed were from 2 years pre-RQI implementation (i.e., 2015–2017) and 2 years post-RQI implementation (2017–2019).

**Secondary Data Collection**

All data I collected and analyzed for the study had been collected during normal business operations. Inpatient cardiac arrest data were collected as a requirement for participation in the AHA’s GWTG program, which was a standard practice for all GWTG participants in the nation. All patient data submitted to the GWTG database was de-identified prior to submission and remained de-identified during the analysis process in the current study.

The GWTG resuscitation tool, Resuscitation Patient Management Tool: CPA Event (Appendix A: Exhibit A), is a standard tool used by GWTG participating hospitals. The CPA tool captures, but is not limited to, patient history of cardiac arrest, prehospital cardiac arrest, multiple cardiac arrests during same patient admission, and preexisting cardiac and noncardiac conditions. Additional information specific to hospital quality metrics are also captured, such as access to rapid response, acute airway management, cardiac resuscitation events, post resuscitation care, and extracorporeal membrane oxygenation. The tool has been used to track CPA events for neonatal through adult patients. As the study site is a participant in the GWTG program, inpatient cardiac arrest data were extracted from the EMR by GWTG data extraction certified personnel and applied to the standard GWTG CPA form electronically and submitted to the organization's GWTG database for data tracking and trending. Standard data collected for the purposes of data collection for organizational quality metrics, which are specific to adult inpatient cardiac arrest, are as follows:

CPA 2.1: Preevent

CPA 2.2: Preexisting Conditions

CPA 3.1: Event

CPA 4.1: Initial Condition

CPA 4.2: Automated External Defibrillator and Ventricular Fibrillation/Pulseless Ventricular Tachycardia

CPA 4.3: Ventilation

CPA 5.1: Epinephrine

CPA 5.2: Other Drug Interventions

CPA 6.1: Event Outcome

CPA 6.2: Post-Roc Care

CPA 7.1: CPR Quality

CPA 7.2: Resuscitation-Related Events and Issues

Per standard process at the study site organization, the certified data extractor, a clinical education coordinator, reviewed inpatient cardiac arrest data in the EMR, extracted the data components related to, and input data to corresponding CPA sections. Once the CPA form was completed, it was submitted to the organization's GWTG database and archived for organizational data tracking and trending. Each inpatient cardiac arrest was assessed independently, and a new CPA form completed per significant event. For the purposes of this study, I requested GWTG reports dating from 2015–2019 from the organization. Secondary data included only inpatient adult cardiac arrests; approval to use a digital copy and printable copy of the CPA tool for this research was granted by the AHA (see Appendix B).

**Sample Size**

I conducted a power analysis to determine the appropriate minimum sample size for the study using the online tool G* Power 3 (see Faul et al., 2007). Based on acceptable standards for similar logistic regression analysis, a sample size was calculated using a priori alpha of 0.05, power of 0.80, and an odds ratio of 1.7 with binomial distribution (see Devereaux, 2019). In alignment with recommendations for unknown data set probability outcomes in favor of the hypothesis and/or null hypothesis, I set a conservative predicted outcome at 0.3: Pr (Y = 1 | X = 1) $H_0$ (see Uekawa, 2019). Based on estimated calculations for unknown outcome probability, the G*Power analysis recommended a sample size of at least 421 inpatient cardiac arrests. Since an appropriate sample size leads to greater sensitivity to demonstrate that the outcome can be predicted by the independent variables (Creswell, 2018), all inpatient adult cardiac arrests between 2015–2019 were included. Additionally, after collinearity was assessed in the logistical model, I excluded multiple variables from the statistical test to prevent violating assumptions, decreasing the need for a larger sample size. Considering this, the sample size of 585 cases exceeded final sample size recommendations.

**Operationalization of Constructs**

The independent variables in this study were RQI quarterly life support training and unit RQI quarterly training compliance; covariates of interest were preexisting cardiac conditions, noncardiac conditions, and age. Since clinicians included in the study were, by hospital policy, according to (the clinical education coordinator, participants in RQI life support training, I assumed that each clinician who would likely respond to a code blue and perform CPR were participants of RQI quarterly training. Additionally, RQI quarterly training was implemented systemwide, as opposed to a phased roll-out, with all employed clinicians assigned RQI curriculum and given an established timeline to complete RQI entry/prep assignments and subsequent quarterly assignments. The dependent variable of ROSC (either yes or no) within established pre- and post- RQI implementation timeframes was coded as a dichotomous variable and based on ROSC data collected via GWTG CPA event logs pre- and post- RQI implementation.

Since both pre- and postimplementation data were collected, I separated each recorded code blue and resuscitation attempt into categories by date: 2 years pre-RQI implementation (i.e., 2015-2017) and 2 years post- RQI implementation (i.e., 2017–2019). As mentioned previously, the likelihood of inpatient cardiac arrest ROSC was compared both pre- and post- RQI implementation to assess the predictive relationship between RQI implementation and inpatient cardiac arrest ROSC. Furthermore, I created a separate data set that isolated only post- RQI implementation inpatient cardiac arrests to correlate with quarterly unit compliance data.

**Data Analysis Plan**

I used IBM Statistical Package for the Social Sciences (SPSS) 27 for data analysis. Resuscitation data recorded via the GWTG program on the Resuscitation Patient Management Tool: CPA Event was organized and recorded categorically by date. As previously discussed, date separations were: 2 years pre-RQI implementation (i.e., 1/1/2015–6/30/2017) and 2 years post- RQI implementation (i.e., 7/1/2017–12/31/2019). Incomplete CPA forms were discarded and were not used in data analysis.

To answer the research questions, I established the impact of RQI quarterly training on inpatient cardiac arrest ROSC by assessing pre- and post- RQI implementation ROSC (no = 0 or yes = 1) and coding pre- RQI implementation (0) and post- RQI implementation (1) while controlling for influencing variables of cardiac preexisting conditions (i.e., continuous), noncardiac preexisting conditions (i.e., continuous), combined cardiac and noncardiac preexisting conditions (i.e., continuous) and age (i.e., continuous). Since unit RQI quarterly training compliance pertained to only post- RQI timelines, I answered RQ2 by performing a separate logistic regression that accounted solely for post- RQI implementation timelines with an outcome of ROSC (no = 0 or yes = 1) in relation to the predictive variables of unit RQI quarterly training compliance, preexisting conditions, and age.

Each GWTG inpatient cardiac arrest between 2015-2019 was broken down into individual events in IBM SPSS 27. Each code blue event was coded as pre- RQI implementation (0) and post- RQI implementation (1) with the dependent variable ROSC coded dichotomously (no = 0 or yes = 1). The following covariates were coded as such:

patient history of cardiac arrest (no = 0 or yes = 1), pre- hospital cardiac arrest (no = 0 or yes = 1), multiple cardiac arrests during same patient admission (interval- 1, 2, 3, ect..), cardiac (congestive heart failure (no = 0 or yes = 1), hypotension/hypoperfusion (no = 0 or yes = 1), myocardial infarction this admission (no = 0 or yes = 1), myocardial infarction prior to current admission (no = 0 or yes = 1) and noncardiac (diabetes mellitus (no = 0 or yes = 1) , hepatic insufficiency (no = 0 or yes = 1), metabolic and electrolyte abnormality (no = 0 or yes = 1), pneumonia (no = 0 or yes = 1), renal insufficiency (no = 0 or yes = 1), respiratory insufficiency (no = 0 or yes = 1), total number of cardiac and noncardiac preexisting conditions (continuous, - 1, 2, 3, ect..). Since the primary logistic regression model included pre- and post- RQI implementation inpatient cardiac arrests, a secondary independent logistic regression was conducted to assess unit RQI quarterly training compliance impact on inpatient cardiac arrest ROSC from 2017-2019.

To assess the effects of unit RQI quarterly training compliance scores, each quarterly compliance score was tabled as a continuous variable which included both percentage of cumulative calendar quarter compliance and an overall compliance score based on 10 quarters was assigned to each location event. This compliance data served as a predictor of how well staff at the event location was prepared to perform CPR and influence the likelihood of achieving ROSC. A secondary logistic regression was conducted using only post- RQI implementation cardiac arrests; all covariates were coded consistent with the main model represented above. Performing a secondary logistic regression was optimal for assessing which units had higher quarterly RQI training compliance within the organization and assisted in identifying staff training level and its impact on the likelihood of achieving ROSC on a unit level. The likelihood of ROSC, in both research questions, was represented in an odds/ratio display with a corresponding percentage of likelihood ROSC would be achieved in relation to RQI life support training and event location quarterly compliance scores.

Because logistic regression does not require a linear relationship between the dependent and independent variables, residuals did not need to be normally distributed, homeostacity was not required, and the dependent variable in logistic regression was not measured on an interval or ratio scale (Statistic Solutions, 2020). Although logistic regression did not follow key linear regression key assumptions, the main assumptions applied (Statistics Solutions, 2020). These assumptions were as follows:

1. Binary logistic regression required the dependent variable to be binary and ordinal logistic regression required the dependent variable to be ordinal.
2. Observations had to be independent of each other; the observations should not come from repeated measurements or matched data.
3. There should be little or no multicollinearity among the independent variables; the independent variables should not be too highly correlated with each other.
4. Independent variables are linearly related to the log odds.

From this standpoint, logistic regression required a large sample size, which was exceeded by the sample size collected for this study. Since the study had a dichotomous outcome, ROSC (yes or no), the first assumption held true. Moreover, all BLS learners were enrolled in the RQI program upon implementation of the training program per organizational policy; considering this, it was reasonable to assume that all learner participants met the second assumption of independent observations. All patients receiving resuscitation care were independent of one another which met the third assumption. The relationship and influence between independent variables were assessed and highly correlated variables removed from the analysis model. No statistically significant correlational effects between independent variables were present in the bivariate logistic regression model. Knowing this, assumption four was also met.

## Threats to Validity

The ability to accept or reject the null hypothesis was based on valid findings. There were potential issues that could have influenced the validity of a research study, and in the following sections I have discussed internal, external, construct, and statistical conclusion validity. Additionally, ethical procedures were discussed in detail.

### Threats to External Validity

The study may not be generalizable to all health care organizations and patient populations. Health care organizations consist of varying degrees of specialty care, staffing ratios, training methodologies, and clinical make up which make generalizing findings between facilities a challenge. Similarly, the patient condition, response to treatment, lifestyle, and environmental contributors to health are also variables that needed to be considered. Similarly, race, ethnicity, equitable health care, socio-economic status, and geographical residence could contribute to the existing diversity amongst patient populations. The current study focused solely on one health care organization in the mideastern U.S. that serves patients of varying health conditions, cultural backgrounds, and socioeconomic status. Based on the major differences between health care organizations and serviced patient population, all patient types and inpatient adult resuscitation efforts made at the organization of interest were included in this study.

**Threats to Internal Validity**

One of the main threats to internal validity which had to be considered was the choice of instrumentation (Creswell, 2018). For the given study, the standard GWTG CPA tool was referenced for data collection. The use of the CPA form for resuscitation metric tracking was used consistently amongst all U.S. hospitals participating in the GWTG resuscitation program. The CPA collection tool was developed and updated to reflect updated AHA (2021b) guidelines and trending patient contributors to inpatient cardiac arrest. This validated tool is updated and maintained by the AHA regularly (Holmberg et al., 2020). Data collected came from the organization's historic use of the CPA tool, which increased the internal validity of the study.

**Threats to Construct and Statistical Validity**

As referenced in the operationalization of constructs, the independent variables were clearly defined as the use of RQI quarterly training and unit RQI quarterly training compliance and the dependent variable of inpatient cardiac arrest ROSC, which were each measurable. Since the constructs in question were defined and able to be adequately measured, construct validity was met (Creswell, 2018). Per Creswell (2018), statistical validity can be challenged if the statistical test used to analyze data violates assumptions, contains an inadequate number of participants, or is founded on an inaccurate statistical power. Considering this, logistic regression assumptions were reviewed prior to the data analysis process; of importance, collinearity was thoroughly assessed in the predictive model. In the case of collinearity, highly correlational variables were separated and excluded from the model per standard process. Further, a power analysis was conducted to ensure the participant pool was adequate to conduct this study, maintaining statistical validity.

## Ethical Procedures

Careful considerations were made to ensure learner anonymity during data collection and data analysis. Learners and learner department codes were deidentified and patient data remained deidentified in analysis and results reporting. Patient rights were protected, and risk minimized due to the pre- deidentified secondary data used in the study. All data were stored on a secure, password- protected device and was only accessed by me for data review and analysis. Permission for data collection was granted from the Walden University's IRB (07-16-21-0980243) as well as the organization of study's IRB; approval was received before any data collection procedures were initiated. Per the organization's IRB request, Walden University was identified as the IRB of record and in alignment with the AHA research standards, single site research using GWTG data sets negated the need for AHA IRB approval.

## Summary

Inpatient cardiac arrest outcomes have remained stagnant despite advances in medical technology. After traditional life support training method reevaluations, a rapid shift away from traditional training modalities to fully automated life support training options ensued. Although current literature supports this shift to fully automated training, founded in mastery learning principals, the effects of fully automated training on inpatient cardiac arrest ROSC remained unknown, with even less known regarding unit compliance with RQI quarterly training as a predictor of ROSC. This quantitative prospective study, which assessed the effects of RQI quarterly training and ROSC and unit RQI quarterly compliance as a predictor of ROSC, has provided evidence of the effectiveness of the RQI program and influenced effects of quarterly training compliance in enhanced patient outcomes.

In Chapter 3, I described the target population of study, research design and rationale, methodology, process of secondary data retrieval, and operationalization of constructs. Additionally, the data analysis plan, potential threats to validity, and ethical procedures were discussed. Looking ahead, in Chapter 4, I will expand on the data collection process used for the given study, the results of the data analysis, visual representation of findings, and discussion of the study results. In concert with my results discussion, any challenges encountered during data collection and analysis, and the support or rejection of the hypotheses is examined.

# Chapter 4: Results

The purpose of this quantitative study was to explore the relationship between the impact of RQI quarterly training on inpatient cardiac arrest ROSC and the impact of hospital unit compliance with RQI quarterly training on inpatient cardiac arrest ROSC when controlling for preexisting cardiac and noncardiac conditions and patient age. Furthermore, I examined the influence of cardiac preexisting conditions (i.e., congestive heart failure, hypotension/hypoperfusion, myocardial infarction this admission, myocardial infarction prior to current admission) and noncardiac preexisting conditions (i.e., diabetes mellitus, hepatic insufficiency, metabolic and electrolyte abnormality, pneumonia, renal insufficiency, respiratory insufficiency) and patient age to assess their influence on ROSC.

In this chapter, I describe the process of secondary data collection and management as well as the descriptive analysis used to explain the demographic characteristics of the sample population. The statistical assumptions are explained, and the results of the statistical analysis are presented in relation to the research questions. The bivariate logistic regression analyses performed are discussed and presented in tabular and graphic forms.

## Data Collection and Data Management

### RQ1

The data collected and analyzed for this study were extracted from the GWTG database by the onsite certified data extractor. After receiving data from the onsite data extractor, I input all inpatient adult cardiac arrests between 2015 and 2019 into the SPSS, Version 24 software package for analysis. I organized and categorized the data set by the date and time of cardiac arrest: 2 years pre- RQI implementation (i.e., 1/1/2015–6/30/2017) and 2 years post- RQI implementation (i.e., 7/1/2017–12/31/2019). A binary logistic regression was used to test the null hypotheses for RQ1.

### RQ2

RQI quarterly unit compliance data were provided by the study site organization from a historical learning management system archive. I organized compliance data in a table by calendar quarter with each unit's quarterly compliance being displayed in a total unit compliance score aligning with post- RQI training implementation dates (i.e., July 1st, 2017 through December 31st, 2019), which accounted for a total of 10 calendar quarters of unit compliance. Using only a post- RQI training implementation timeframe, an independent binary logistic regression was used to test the null hypotheses for RQ2.

The research questions and associated hypotheses that guided this study were as follows:

> RQ1: What is the impact of RQI quarterly training on inpatient cardiac arrest ROSC in comparison to pre- RQI implementation inpatient cardiac arrest ROSC when controlling for cardiac and noncardiac preexisting conditions and age?
>
> > H01: The likelihood of achieving ROSC after inpatient cardiac arrest when controlling for cardiac and noncardiac preexisting conditions and age is not associated with RQI implementation and training of facility staff.

H11: The likelihood of achieving ROSC after inpatient cardiac arrest when controlling for cardiac and noncardiac preexisting conditions and age is greater following RQI implementation and training of facility staff.

RQ2: What is the impact of hospital unit compliance with RQI quarterly training on inpatient cardiac arrest ROSC when controlling for cardiac and noncardiac preexisting conditions and age?

H02: The likelihood of achieving ROSC after inpatient cardiac arrest is not associated with arrests occurring on hospital units achieving higher compliance with quarterly RQI training when controlling for cardiac and noncardiac preexisting conditions and age.

H12: The likelihood of achieving ROSC after inpatient cardiac arrest is greater with arrests occurring on hospital units achieving higher compliance with quarterly RQI training when controlling for cardiac and noncardiac preexisting conditions and age.

## Characteristics of the Study Sample

### RQ1

The demographic characteristics of this study included a sample of 586 total cases; one case was removed due to missing data, resulting in 585 valid cases of adult inpatient cardiac arrests between 2015–2019. Total valid cases in the preintervention group were 190, and the postintervention group had 395 total valid cases. I assessed the covariates of pre- and post- RQI implementation cardiac (i.e., congestive heart failure, hypotension/hypoperfusion, myocardial infarction this admission, and myocardial infarction prior to current admission) and noncardiac preexisting conditions (i.e., diabetes mellitus, hepatic insufficiency, metabolic and electrolyte abnormality, pneumonia, renal insufficiency, and respiratory insufficiency), the combined total number of cardiac and noncardiac preexisting conditions, and age to ensure model fit. During data cleaning and auditing, maternal and neonatal inpatient cardiac arrests found in the data set were excluded to ensure consistency within the intended group of study. Additionally, I excluded open chest CPR and mechanical CPR from the data set due to the RQI life support training being specific to traditional BLS skills. In tandem, incomplete CPA forms were also discarded.

**RQ2**

Compliance data included adult learners who required BLS certification as a function of their job duties outlined by hospital policy. All hospital units identified in the GWTG dataset and associated learners requiring BLS certification and enrolled in the RQI training program were included in the data set. Per the low-dose, high-frequency training modality of curriculum delivery, I organized the compliance data for each unit in a table by calendar quarter, with each unit’s quarterly compliance displayed in a total unit compliance score aligning with post- RQI training implementation dates of July 1st, 2017 through December 31st, 2019. Given the post- RQI implementation timeframe, a total of 10 calendar quarters of unit compliance was tabled. Considering only post- RQI training implementation dates had associated program compliance, the data set contained 268 inpatient cardiac arrest cases, of which 23 cases were excluded due to missing location of event. As a result of exclusions, the total valid cases were 245.

## Descriptive Statistics

### RQ1

I analyzed the characteristics of the sample population based on the independent variables of interest. Valid adult inpatient cardiac arrests (*n* = 585) from 2015–2019 were included in data analysis. Independent variables of interest included RQI implementation (i.e., pre- RQI implementation with *n* = 190 and post- RQI implementation with *n* = 395), preexisting conditions, and age. The data set included patients with no preexisting conditions at arrest, only cardiac preexisting conditions, only noncardiac preexisting conditions, and a combination of both cardiac and noncardiac preexisting conditions. Patient age was analyzed as a continuous variable with a minimum age of 18 years old, a max age of 96, and a mean age of 66.75. Further information regarding descriptive statistics of the study sample can be found in Table 1.

**Table 1**

*Research Question 1 Descriptive Statistics*

| Variable | Frequency | Percent |
|---|---|---|
| Adult cardiac arrests | | |
| Pre-RQI implementation | 317 | 54.1 |
| Post-RQI implementation | 268 | 45.8 |
| Preexisting conditions | | |
| None | 41 | 7 |
| Only cardiac | 38 | 6.5 |
| Only noncardiac | 106 | 18.1 |
| Both cardiac/noncardiac | 401 | 68.4 |

### RQ2

Data analyzed for RQ2 included only post- RQI implementation inpatient cardiac arrest events (*n* = 245). Postimplementation events that did not list event location were excluded from the analysis due to event location being a primary value needed to answer RQ2. Similar to the RQI1 data set, only utilizing postimplementation cases, I analyzed patient age as a continuous variable with a minimum age of 23 years old, a maximum age of 95, and a mean age of 67.17. Of the valid 245 inpatient cardiac arrests, 4% had no preexisting conditions, 2.8% had only cardiac preexisting conditions, 17.5% had only noncardiac preexisting conditions, and 75.5% had a combination of cardiac and noncardiac preexisting conditions. Furthermore, inpatient cardiac event location was analyzed with the 10 event locations used being present in the GWTG data set and identified as locations where inpatient cardiac arrests occurred. Per the descriptive statistics, Locations 906 and 967 were the primary event locations with Location 906 having 35.3% of total inpatient cardiac arrest events and Location 967 with 30.9% of total inpatient cardiac arrest events. In tandem with event location, I evaluated compliance scores based on 10 calendar quarters were evaluated. Event location compliance scores ranged from a minimum score of 466 to a maximum score of 982, with a mean compliance score of 915.38. Table 2 displays the descriptive statistics for RQ2.

**Table 2**

*Research Question 2 Descriptive Statistics*

| Variable | Frequency | Percent |
|---|---|---|
| Adult cardiac arrests | | |
| Post-RQI implementation | 245 | 100 |
| Preexisting conditions | | |
| None | 10 | 4 |
| Only cardiac | 7 | 2.8 |
| Only noncardiac | 43 | 17.5 |
| Both cardiac/noncardiac | 185 | 75.5 |
| Event location | | |
| 466 | 2 | .6 |
| 570 | 2 | .6 |
| 774 | 9 | 2.8 |
| 817 | 1 | .3 |
| 861 | 7 | 2.2 |
| 906 | 112 | 35.3 |
| 929 | 24 | 7.6 |
| 964 | 2 | .6 |
| 967 | 98 | 30.9 |
| 982 | 32 | 10.1 |

## Statistical Assumptions

The first assumption for a binary logistic regression is that the dependent variable is binary or dichotomous, consisting of two values (Kalil et al., 2010). The binary assumption was met for this study because the dependent variable (i.e., ROSC) had two values (i.e., yes and no). The second assumption of logistic regression assumes the independence of each observation. Both GWTG ROSC data and learner quarterly compliance data met this assumption with observations containing no matched or repeated data. The third assumption requires the independent variables to have minimal or no multicollinearity, which means that the independent variables (i.e., cardiac, noncardiac preexisting conditions, and age) should not have a high correlation; I found no multicollinearity between the predictor variables used in this analysis, meeting Assumption 3. Noted by Kalil et al. (2010), in the case of multicollinearity existing among variables in the data set, it would not decrease the reliability of the model. According to Kalil et al., the fourth assumption relates to the linearity of the explanatory variables and the logit of the response variable. The fourth assumption was met due to linearity between the independent variables and the logit of the response variable. The fifth assumption indicates the sample size of the data set must be large enough to draw valid conclusions from the fitted logistic regression model (Kalil et al., 2010). Due to the abundance of data collected through the GWTG database, this study met Assumption 5 with 585 adult inpatient cardiac arrests. Secondarily, the compliance data during the post-RQI training implementation period yielded 268 adult inpatient cardiac arrests for analysis.

## Statistical Analyses Results

To assess the relationship between predictor variables within the data set and ROSC, I used a binary logistic regression. Binary logistic regression is used to examine the relationship between predictor variables and a binary outcome (Tabachnick & Fidell, 2018). Due to the inclusion of all adult inpatient cardiac arrest from 2015–2019 needed to answer RQ1 and the inclusion of only post- RQI training dates needed to assess the relationship between compliance and ROSC, a separate logistic regression was conducted for RQ2.

## Model Fit

### *RQ1*

During model fit analysis, I conducted an omnibus test of model coefficients to assess the model chosen for analysis. The omnibus test of model coefficients employs chi-square tests to assess for significant differences between log-likelihood of the base model and the new model chosen; in this case, the omnibus tests was statistically significant for model fit ($p$= 0.005). Although the Cox & Snell R square indicated 2.8% variability of the dependent variable explained by the model ($p$ = .028), the Hosmer and Lemeshow test ($p$ = .758) indicated good model fit with the RQ1 data set.

### *RQ2*

I conducted an omnibus test of model coefficients to assess the model chosen for analysis of the post- RQI implementation data set for RQ2. The chi-square test assessed for significant differences between log-likelihood of the base model and the new model chosen; in this case, the chi-Square showed nonsignificant ($p$ = 0.197), and the Cox and Snell R square indicated 3% variability of the dependent variable explained by the model ($p$ = .030). However, with a significance of model fit for the Hosmer and Lemeshow test being $p > 0.05$, the test indicated good model fit with the RQ2 data set ($p$ = .201).

## RQ1 Results

I calculated binary logistic regression to examine how the training intervention affects patients' ROSC status while controlling for cardiac and noncardiac preexisting conditions and age. The results (see Table 3) showed that the RQI training intervention was a statistically significant predictor of ROSC status while controlling for cardiac and noncardiac comorbidities and age (*OR* = 1.457, *p* = .040, *OR* CI 95% [1.017, 2.087]), the odds of achieving ROSC in the posttraining group were 1.457 times the odds of achieving ROSC in the pretraining group. Additionally, the odds of a patient achieving ROSC with only cardiac preexisting conditions present were 4.026 times the odds when no preexisting condition were present (*OR* = 4.046, *p* = .005, *OR* CI 95% [1.535, 10.665]). Similarly, the odds of achieving ROSC with only noncardiac preexisting conditions were 2.859 times the odds of doing so with no preexisting condition (*OR* = 2.859, *p* = .007, *OR* CI 95% [1.334, 6.128]) and the odds of achieving ROSC with both cardiac and noncardiac preexisting conditions were 3.060 times the odds of doing so with no preexisting condition (*OR* = 3.060, *p* = .002, *OR* CI 95% [1.529, 6.122]). Age was not a significant predicter of ROSC. Given the statistically significant results for post-training periods and prediction of ROSC, I rejected the RQ1 null hypothesis.

**Table 3**

*Binary Logistic Regression Table of Predicting ROSC Status While Controlling for Cardiac and Noncardiac Preexisting Conditions and Age*

| | | | | | | | 95% CI for *OR* | |
|---|---|---|---|---|---|---|---|---|
| | *B* | *SE* | Wald | *df* | *p* | *OR* | Lower | Upper |
| Age | -.005 | .006 | .687 | 1 | .407 | .995 | .983 | 1.007 |
| Combinations – no preexisting | | | 11.209 | 3 | .011 | | | |
| Only cardiac | 1.398 | .494 | 7.992 | 1 | .005 | 4.046 | 1.535 | 10.665 |
| Only noncardiac | 1.051 | .389 | 7.297 | 1 | .007 | 2.859 | 1.334 | 6.128 |
| Combined cardiac and noncardiac | 1.118 | .354 | 9.989 | 1 | .002 | 3.060 | 1.529 | 6.122 |
| RQI pre- and postimplementation | .376 | .183 | 4.215 | 1 | .040 | 1.457 | 1.017 | 2.087 |
| Constant | -.126 | .470 | .072 | 1 | .789 | | | |

## RQ2 Results

I calculated a separate binary logistic regression to assess the relationship between unit quarterly compliance and ROSC status while controlling for cardiac and noncardiac comorbidities, age, and compliance score based on 10 quarters. The results (see Table 4) showed unit quarterly compliance to have no statistically significant impact on ROSC (*OR* = 1.000, $p$ = .966, *OR* CI 95% [.996, 1.004]). Considering the lack of statistical significance of unit quarterly compliance predicting ROSC, I failed to reject the null hypothesis.

**Table 4**

*Binary Logistic Regression Table of Predicting ROSC Status While Controlling for Cardiac and Noncardiac Preexisting Conditions, Age, and Unit Compliance Score*

| | | | | | | | 95% CI for *OR* | |
|---|---|---|---|---|---|---|---|---|
| | *B* | *SE* | Wald | *df* | *p* | *OR* | Lower | Upper |
| Age | .003 | .010 | .068 | 1 | .794 | 1.003 | .983 | 1.022 |
| Combinations – no preexisting | | | 6.881 | 3 | .076 | | | |
| Only cardiac | .700 | 1.001 | .489 | 1 | .484 | 2.014 | .283 | 14.329 |
| Only noncardiac | 1.873 | .757 | 6.123 | 1 | .013 | 6.506 | 1.476 | 28.674 |
| Combined cardiac/noncardiac | 1.400 | .675 | 4.310 | 1 | .038 | 4.056 | 1.081 | 15.216 |
| Compliance score 10 quarters | .000 | .002 | .002 | 1 | .966 | 1.000 | .996 | 1.004 |
| Constant | -.477 | 2.107 | .051 | 1 | .821 | .620 | | |

## Summary

I evaluated secondary data for 585 inpatient cardiac arrests to assess the impact of the RQI training program implementation and 268 inpatient cardiac arrests to assess the impact of quarterly unit compliance with training on ROSC. Secondarily, the influence of cardiac and noncardiac preexisting conditions and age as predictors of ROSC was also assessed. I rejected Null Hypothesis 1 regarding RQI implementation and ROSC) was supported and failed to reject Null Hypothesis 2 regarding quarterly compliance and ROSC. In the final chapter, I will compare the study findings to existing literature, explain my conclusions and the implications of the study, and suggest a series of recommendations.

# Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this quantitative study was to explore the relationship between the impact of RQI quarterly training on inpatient cardiac arrest ROSC and the impact of hospital unit compliance with RQI quarterly training on inpatient cardiac arrest ROSC. In this chapter, I summarize the main findings of the study based on the research questions. This chapter includes a discussion of the relevance of these findings, their contribution to literature, limitations of the study, and my recommendations for future research based upon the results.

## Interpretation of Findings

### RQ1

For RQ1, I conducted a binary logistic regression to analyze the effects of RQI training implementation on predicting ROSC when controlling for cardiac and noncardiac preexisting conditions and age. The analysis revealed a statistically significant relationship between RQI training implementation and predicting ROSC ($p$ = .04). The odds of achieving ROSC post- RQI training implementation were 1.457 times the odds of doing so in the pre- RQI training group (or were 45.7% more likely). Considering the increased likelihood of achieving ROSC post- RQI training implementation, the findings are also clinically significant. This study results are consistent with Donoghue et al.'s (2021) findings. In a longitudinal study, Donoghue et al. assessed RQI's low-dose, high-frequency modality of life support training within the emergency department at a children's hospital. They found a significant association between the number of quarterly RQI training sessions and the percent of compressions, meeting AHA guidelines for rate when performing CPR on children (β coefficient = -0.08; standard error = 0.04; $p$ = 0.03). Although Donoghue et al.'s sole focus was on adherence to the RQI quarterly skills assessments and real event skill performance, their findings suggested that high-frequency CPR training among pediatric emergency department health care providers led to consistently increased performance of high-quality CPR in ongoing training sessions. Consistent with Donoghue's findings, Cheng et al. (2018), Dudzik et al. (2019), and Maehle et al. (2017) found low-dose, high-frequency models of training to increase knowledge retention and prevent skill decay. From this perspective, the supporting literature and the current study findings support Bloom's mastery learning theoretical underpinnings of deliberate practice with corrective feedback and instructional alignment improving learner longitudinal knowledge retention and application of knowledge to practice (see Guskey, 1997, 2005; McGaghie, 2015).

According to Metra et al. (2011) and Sharma et al. (2018), preexisting cardiac and noncardiac conditions are key contributors leading to cardiac arrest and mortality. Of noted importance, van Deursen et al. (2014) found an increasing number of noncardiovascular comorbidities with at least one cardiac comorbidity was associated with greater risk of mortality. Due to the literature confirming the role preexisting conditions play in cardiovascular risk, the independent variables of cardiac, noncardiac, and a combination of both cardiac and noncardiac preexisting conditions were analyzed in the current study to determine their influence on the prediction of ROSC. I found that patients with only cardiac preexisting conditions ($p$ = .005) and only noncardiac preexisting conditions ($p$ = .007) were statistically significant in predicting ROSC. The odds of achieving ROSC with only cardiac preexisting conditions were 4.046 times the odds of doing so compared to patients with no preexisting condition [*OR* = 4.046, 95%]. Similarly, the odds of achieving ROSC with only noncardiac preexisting conditions present were 2.859 times the odds of doing so when compared to no preexisting conditions [*OR* = 2.859, 95%]. Furthermore, patients with both cardiac and noncardiac preexisting conditions present were 3.060 times more likely to achieve ROSC compared to odds of doing so when no preexisting conditions were present [*OR* = 3.060, 95%]. All variations in preexisting condition categories suggest patients who have only cardiac, only noncardiac, and/or a combination of both to have a statistically significant higher likelihood of achieving ROSC than patients who have no preexisting conditions. One possible explanation for this could be the likelihood of persons with known preexisting conditions having medical management of conditions before and during the hospital admission as opposed to those with unknown and untreated conditions at time of hospital admission.

Lastly, I also analyzed the influence of age as a predictor of ROSC. In a longitudinal study, Makino et al. (2021) estimated 10-year cardiovascular disease (CVD) risk using the revised World Health Organization CVD risk estimation charts. They found CVD risk in old age to be a predictor of disability and mortality. Furthermore, Sergi et al. (2015) found frailty status to be a predictor of CVD events and outcomes. Although the extant literature points to age being a predictor of disability, frailty status, and mortality, I did not determine that age to be a statistically significant predictor of ROSC ($p = .407$) in this study. A possible cause is the wide variation in age in the GWTG data set used, ranging from 18 to 96 years old (*M* = 66.75). Like those cases with no preexisting conditions, there is a possibility that patients in the younger age group could have been admitted to the hospital for unexpected and uncontrolled emergent medical conditions (e.g., trauma, drug overdose, or suicide attempt) that could significantly impact their likelihood of survival. Since the GWTG data set did not include the cause of cardiac arrest, the analysis regarding the influence of age as a predictor of ROSC was limited.

**RQ2**

I used a separate logistic regression to analyze event location RQI compliance as a predictor of ROSC. The analysis was based on only post- RQI implementation cases that included a total of 245 valid cases. Due to unit compliance scores being consistently higher than 900 over 10 quarters and not many cases of low compliance, these results were expected. With more variation among compliance scores, there may have been more evidence available to assess the effect of compliance on likelihood of achieving ROSC. Although unit compliance scores based on 10 quarters did not hold statistical significance (*OR* = 1.000, $p$ = .966, *OR* CI 95% [.996, 1.004]), like in the RQ1 analysis, I controlled for cardiac, noncardiac, a combination of cardiac and noncardiac comorbidities, and age due to their influence on ROSC. Only noncardiac preexisting conditions ($p$ = .013) and a combination of cardiac and noncardiac comorbidities ($p$ = .038) resulted as statistically significant predictors of ROSC. Cardiac preexisting conditions showed intermediary statistical significance ($p$ = .076) and age showed no statistical significance ($p$ = .794) in predicting ROSC in the RQ2 logistic regression analysis.

## Limitations of the Study

The current study was subject to several limitations. One limitation was that I collected secondary data from a single health care system in which data were specific to the patient population the organization services. Based on the social demographics of the patient population, not all races, ethnicities, and health disparities could be accounted for. In concert with race, ethnicity, and gender data limitations, the GWTG data set did not include data on the cause of cardiac arrest, which would have contributed to a better understanding of how age and preexisting conditions at time of cardiac arrest influenced ROSC prediction. As a result of limited patient demographic information in the data set, gender and race were not represented in this analysis. Husaini et al. (2011) found the likelihood of African American men under the age of 50 years old developing heart failure was 20 times higher than that of comparable European American men. Additionally, Black women were noted to have higher incidence of heart failure and CVD compared to White women. The researchers also reported that the elderly, immigrant, and low-income populations are disproportionately affected by heart disease and heart failure. Similarly, Bays (2020) noted African American men to have the highest rate of CVD of any U.S. ethnic or racial groups. Bays also identified CVD to be the leading cause of death among Hispanic populations and the leading cause of mortality among young White women. Bay reported a wide variance in age-related CVD risk and mortality in older adults due to the dependence of underlying diseases and degree of frailty. Considering the known variation in cardiovascular risk and mortality among age, races, and genders, controlling for these variables as a demographic trifecta in the primary analysis model could have created a more dynamic approach to predictors of ROSC.

Additional limitations include the number of pre- and postimplementation cases and model fit constraints. In the RQ1 data set, there were 317 preimplementation cases and 268 postimplementation cases. Due to the variation in pre- and post- group cases, the results could have been influenced. Furthermore, with a Cox and Snell R square of .028 in the RQ1 data set, only 2.8% of the variability of the dependent variable was explained by the model. Similarly, with the Cox and Snell R square of .030 in the RQ2 data set, only 3% of the variability of the dependent variable was explained by the model, meaning having additional predictors for the dependent variable would have created a better model fit for both research questions.

Lastly, I pulled secondary unit compliance data from an archived learning management system database that had different unit identifiers than RQI analytics. The discrepancies in unit and event locations were manually associated with site verification for accuracy. The manual manipulation and third party validation of information could have caused a data discrepancy, limiting data trustworthiness. Lack of variation in unit compliance scores throughout the organization also limited the ability to assess the influence of event location compliance on ROSC. A more robust data set with different compliance levels may prove more beneficial to the prediction of ROSC in future studies.

## Recommendations

The results of the study indicate RQI training as a significant predictor of ROSC. However, based on the limitations mentioned above, use of a larger sample population at more than one site and geographical location would increase the generalization of findings and would better be able to assess the impact that low-dose, high-frequency life support training has on inpatient cardiac arrest survival. Additionally, the inclusion of demographic variables, such as gender, race, insurance status of the patient, and socioeconomic status, would create a more well-rounded and population-centric approach for future research.

Future studies may also consider assessing quarterly unit compliance over a larger timeframe than 10 calendar quarters to establish variation among unit compliance and its influence on ROSC. Subsequent studies may also consider using compliance and individual assignment skills scores to code team members or persons who frequently participate in code blues. This approach would allow the researcher(s) to assess team compliance, live event performance, and ROSC impact. Finally, if possible, future studies could also include characteristics of the facility staff, such as years in practice, clinical discipline, and individually rated self-efficacy associated with performance of life support skills in an emergent situation. Isolating individual characteristics of the code blue response team could help identify gaps in practice and potentially lead to clinical quality improvement implications and change in practice.

## Implications

The positive social change implications of the current study include providing an improved understanding of fully automated life support training in a low-dose, high-frequency training model and its influence on inpatient cardiac arrest survival. The results of the study indicate a statistically significant relationship between RQI training and the prediction of ROSC. With ROSC achievement 1.457 times more likely (i.e., 45.7%) in the post- RQI implementation group, there is substantial patient impact and clinical significance.

Furthermore, the results of the study could be used informatively by health care organizations who are considering the transition to high-frequency digital life support training in lieu of instructor-led courses. The study findings could be used to inform organizational life support certification policy and assist in shifting the traditional focus from traditional 2-year certification courses to a competency validation model. This study has also provided foundational insight into how GWTG data and training data could be used to close the existing literature gap regarding fully automated life support training and its community impact. Lastly, the study could be used to enhance knowledge related to the use of digital instruction in the clinical setting.

## Conclusion

The results of this study indicated fully digital, low-dose, high-frequency modalities of life support training improve ROSC rates. Furthermore, the study contributes to the limited literature on the use of fully digital training and its clinical implications. The implementation of the RQI training program was both statistically and clinically significant in predicting ROSC, with patients 45.7% more likely to achieve ROSC in the post- implementation group. While unit compliance at the event location was not shown as a statistically significant predictor of ROSC, further research with more training compliance variation may show the impact of training compliance and ROSC.

Further research expanding on fully digital modalities of life support training could also offer additional clinical practice implications and insight on community impact.

References

American Heart Association. (2020, October 21). *2020 BLS provider course (Instructor-led training FAQ)* [pdf]. https://cpr.heart.org/-/media/cpr-files/courses-and-kits/health care-professional/bls-ilt/2020-bls-ilt-faq_102120.pdf?la=en

American Heart Association. (2021a, February 4). *Get with the Guidelines - Resuscitation Patient Management Tool data submission, performance reporting and more*. https://www.heart.org/en/professional/quality-improvement/get-with-the-guidelines/get-with-the-guidelines-resuscitation/get-with-the-guidelines-resuscitation-registry-tool

American Heart Association. (2021b). *History of CPR: Highlights from the 16th century to the 21st century*. https://cpr.heart.org/en/resources/history-of-cpr

Andersen, L. W., Holmberg, M. J., Berg, K. M., Donnino, M. W., & Granfeldt, A. (2019). In-hospital cardiac arrest: A review. *Journal of the American Medical Association, 321*(12), 1200–1210.

Bays, H. E. (2020). Ten things to know about ten cardiovascular disease risk factors (“ASPC Top Ten – 2020”). *American Journal of Preventive Cardiology, 1*. https://doi.org/10.1016/j.ajpc.2020.100003

Benjamin, E. J., Muntner, P., Alonso, A., Bittencourt, M. S., Callaway, C. W., Carson, A. P., Chamberlain, A. M., Chang, A. R., Cheng, S., Das, S. R., Delling, F. N., Djousse, L., Elkind, M. S., Ferguson, J. F., Fornage, M., Chafflin Jordan, L., Khan, S. S., Kissela, B. M., Knutson, K. L.,…Virani, S. S. (2019, March 5). Heart disease and stroke statistics- 2019 update: A report from the American Heart Association. *Circulation, 5*(139), e56-e528. https://doi.org/10.1161/CIR.0000000000000659

Bloom, B. S. (1968). Learning for mastery. *Evaluation Comment*, *1*(2), 1-12.

Bloom, B. S. (1977). Favorable learning conditions for all. *Teacher, 95*(3), 22-28.

Bloom, B. S. (1978). New views of the learner: Implications for instruction and curriculum. *Educational Leadership, 35*(7), 563-576.

Cambridge University Press. (2021). *Cambridge dictionary.* https://dictionary.cambridge.org/us/dictionary/english/automated

Centers for Disease Control and Prevention. (2012). *Principles of epidemiology in public health practice* (3rd ed.). U.S. Department of Health and Human Services. https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section11.html

Centers for Disease Control and Prevention-National Center for Health Statistics. (2018). *Data briefs: Mortality in the United States, 2018.* https://www.cdc.gov/nchs/products/databriefs/db355.htm

Centers for Disease Control and Prevention. (2021, January 15). *Global COVID-19.* https://www.cdc.gov/coronavirus/2019-ncov/global-covid-19/index.html#:~:text=The%20COVID%2D19%20pandemic,like%20COVID%2D19.

Chan, P., & Tang, Y. (2020). Risk-standardizing rates of return of spontaneous circulation for in-hospital cardiac arrest to facilitate hospital comparisons. *Journal of the American Heart Association, 9*(7). https://doi.org/10.1161/JAHA.119.014837

Cheng, A., Donoghue, A., & Bhanji, F. (2015). Time to incorporate real-time CPR feedback and CPR debriefings into advanced life support courses. *Resuscitation, 90*, e3-e4. https://doi.org/10.1016/j.resuscitation.2015.02.012

Cheng, A., Magid, D. J., Auerback, M., Bhanji, F., Bigham, B. L., Blewer, A. L., Dainty, K. N., Diederich, E., Lin, Y., Leary, M., Mahgoub, M., Mancini, M. E., Navarro, K., & Donoghue, A. (2020). Part 6: Resuscitation education science 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *AHA Circulation, 142*, 551-579. https://doi.org/10.1161/CIR.0000000000000903

Cheng, A., Nadkarni, V. M., Mancini, M. B., Hunt, E. A., Sinz, E. H., Merchant, R. M., Donoghue, A., Duff, J. P., Eppich, W., Auerbach, M., Bigham, B. L., Blewer, A. L., Chan, P. S., & Bhanji, F. (2018). Resuscitation education science: Educational strategies to improve outcomes from cardiac arrest: A scientific statement from the American Heart Association. *Circulation*, *138*, e82-e122. https://doi.org/10.1161/CIR.0000000000000583

Creswell, J., W. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

Devereaux, S. C. (2019). *Factors contributing to high readmissions for congestive heart failure among African Americans* (Accession No. 2275499682). Dissertations & Theses @ Walden University.

Donoghue, A., Heard, D., Griffin, R., Abbadessa, M. K., Gaines, S., Je, S., Hanna, R., Erbayri, J., Myers, S., Niles, D., & Nadkarni, V. (2021). Longitudinal effect of high frequency training on CPR performance during simulated and actual pediatric cardiac arrest. *Resuscitation Plus, Volume 6*. https://doi.org/10.1016/j.resplu.2021.100117

Dudzik, L. R., Heard, D. G., Griffin, R., Vercellino, M., Hunt, A., Cates, A. & Rebholz, M. (2019). Implementation of a low-dose, high-frequency cardiac resuscitation quality improvement program in a community hospital. *The Joint Commission Journal on Quality and Patient Safety*, *45*, 789-797. https://doi.org/10.1016/j.jcjq.2019.08.010

Eroglu, S. E., Onur, O., Urgan, O., Denizbasi, A., & Akoglu, H. (2014). Blue code: Is it a real emergency? *World Journal of Emergency Medicine*, *5*(1), 20–23. https://doi.org/10.5847/wjem.j.issn.1920-8642.2014.01.003

Faul, F., Erdfelder, E., Lang, A.G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*, 175–191. https://doi.org/10.3758/BF03193146

Guskey, T. R. (1997). *Implementing mastery learning* (2nd ed.). Wadsworth. https://www.researchgate.net/publication/236273526_Lessons_of_Mastery_Learning

Guskey, T. R. (2005). *Formative classroom assessment and Benjamin S. Bloom: Theory research and implications* [Technical paper presentation]. Annual Meeting of the American Educational Research Association, Montreal, Canada. https://www.researchgate.net/publication/228980284_Formative_classroom_assessment_and_Benjamin_S_Bloom_Theory_research_and_implications

Hansen, C., Bang, C., Staerk, M., Krogn, K. & Lofgren, B. (2019). Certified basic life support instructors identify improper cardiopulmonary resuscitation skills poorly: Instructor assessments versus resuscitation manikin data. *Simulation Health care*, *14*(5), 281-286. https://doi.org/10.1097/SIH.0000000000000386

Harris, A. W., & Kudenchuk, P. J. (2018). Cardiopulmonary resuscitation: The science behind the hands. *Heart*, *104*(13), 1056-1061. https://doi.org/10.1136/heartjnl-2017-312696

Holmberg, M. J., Granfeldt, A., Girotra, S., Donnino, M. W., Andersen, L. W., & American Heart Association's Get With The Guidelines-Resuscitation Investigators. (2020). Trends in survival and introduction of the 2010 and 2015 guidelines for adult in-hospital cardiac arrest. *Resuscitation*, *157*, 112–120. https://doi.org/10.1016/j.resuscitation.2020.10.022

Husaini, B. A., Mensah, G. A., Sawyer, D., Cain, V. A., Samad, Z., Hull, P. C., Levine, R. S., & Sampson, U. K. (2011). Race, sex, and age differences in heart failure-related hospitalizations in a southern state: Implications for prevention. *Circulation: Heart Failure*, *4*(2), 161–169. https://doi.org/10.1161/CIRCHEARTFAILURE.110.958306

Joint Commission. (2021). R3 Report: Requirements, rationale, reference. *The Joint Commission Journal on Quality and Patient Safety*, (29), 1-7. https://www.jointcommission.org/standards/r3-report/r3-report-issue-29-resuscitation-standards-for-hospitals/

Kalil, A. C., Mattei, J., Florescu, D. F., Sun, J., & Kalil, R. S. (2010). Recommendations for the assessment and reporting of multivariable logistic regression in transplantation literature. *American Journal of Transplantation: Official Journal of the American Society of Transplantation and the American Society of Transplant Surgeons*, *10*(7), 1686–1694. https://doi.org/10.1111/j.1600-6143.2010.03141.x

Kleinman, M. E., Brennan, E. E., Goldberger, Z. D., Swor, R. A., Terry, M., Bobrow, B. J., Gazmuri, R. J., Travers, A. H., & Rea, T. (2015). Part 5: Adult basic life support and cardiopulmonary resuscitation quality. *Circulation, 132*(18), 414-435. https://doi.org/10.1161/CIR.0000000000000259

Laerdal. (2021). *RQI – Resuscitation Quality Improvement Program*. https://laerdal.com/gb/doc/3512/RQI-Resuscitation-Quality-Improvement-Program

Lynch, B., Einspruch, E. L., Nichol, G., & Aufderheide, T. P. (2008). Assessment of BLS skills: Optimizing use of instructor and manikin measures. *Resuscitation, 76*(2), 233–243. https://www.sciencedirect.com/science/article/abs/pii/S0300957207003875

Maehle, V., Cooper, K., & Kirkpatrick, P. (2017). Absolute clinical skill decay in the medical, nursing and allied health professions: A scoping review protocol. *Joanna Briggs Institute Database of Systematic Reviews and Implementation Reports, 15*, 1522-1527. https://doi.org/10.11124/JBISRIR-2016-003094

Makino, K., Lee, S., Bae, S., Chiba, I., Harada, K., Katayama, O., Shinkai, Y., & Shimada, H. (2021). Absolute cardiovascular disease risk assessed in old age predicts disability and mortality: A retrospective cohort study of community-dwelling older adults. *Journal of the American Heart Association, 10*(24), e022004. https://doi.org/10.1161/JAHA.121.022004

Matterson, H. H., Szyld, D., Green, B. R., Howell, H. B., Pusic, M. V., Mally, P. V., & Bailey, S. M. (2018). Neonatal resuscitation experience curves: Simulation based mastery learning booster sessions and skill decay patterns among pediatric residents. *Journal of Perinatal Medicine*, *46*(8), 934-941. https://doi.org/10.1515/jpm-2017-0330

McGaghie, W. C. (2015). Mastery learning: It is time for medical education to join the 21st century. *Academic Medicine*, *90*(11), 1438-1441. https://journals.lww.com/academicmedicine/Fulltext/2015/11000/Mastery_Learning__It_Is_Time_for_Medical_Education.9.aspx

Meaney, P., Bobrow, B., Mancini, M., Christenson, J., de Caen, A., Bhanji, F., Abella, B., Kleinman, M., Edelson, D., Berg, R., Aufderheide, Tom., Menon, V., & Leary, Marion. (2013). CPR quality: Improving cardiac resuscitation outcomes both inside and outside the hospital: A consensus statement from the American *Heart Association. Circulation*, *128*, 417-435. https://doi.org/10.1161/CIR.0b013e31829d8654

Metra, M., Zacà, V., Parati, G., Agostoni, P., Bonadies, M., Ciccone, M., Cas, A. D., Iacoviello, M., Lagioia, R., Lombardi, C., Maio, R., Magrì, D., Musca, G., Padeletti, M., Perticone, F., Pezzali, N., Piepoli, M., Sciacqua, A., Zanolla, L., … Heart Failure Study Group of the Italian Society of Cardiology. (2011). Cardiovascular and noncardiovascular comorbidities in patients with chronic heart failure. *Journal of Cardiovascular Medicine*, *12*(2), 76–84. https://doi.org/10.2459/JCM.0b013e32834058d1

Neagle, J. T. & Wachsberg, K. (2010). What are the chances a hospitalized patient will survive in-hospital arrest? *The Hospitalist, 2010*(9). https://www.the-hospitalist.org/hospitalist/article/124220/what-are-chances-hospitalized-patient-will-survive-hospital-arrest

Panchal, A. R., Norton, G., Gibbons, E., Buehler, J., & Kurz, M. C. (2020). Low dose-high frequency, case based psychomotor CPR training improves compression fraction for patients with in-hospital cardiac arrest. *Resuscitation, 146*, 26-31. https://doi.org/10.1016/j.resuscitation.2019.10.034

Pedersen, T. H., Kasper, N., Roman, H., Egloff, M., Marx, D., Abegglen, S., & Greif, R. (2018). Self-learning basic life support: A randomized controlled trial on learning conditions. *Resuscitation, 126*, 147-153. https://doi.org/10.1016/j.resuscitation.2018.02.031

Pothiawala, S. (2017). Post-resuscitation care. *Singapore Medical Journal*, *58*(7), 404–407. https://doi.org/10.11622/smedj.2017060

RQI Partners. (2019). Home page. https://rqipartners.com/

Salkind, N. J. (2010). *Encyclopedia of research design* (Vols. 1-0). SAGE Publications, Inc. https://doi.org/10.4135/9781412961288.n42

Sell, R. E., Sarno, R., Lawrence, B., Castillo, E. M., Fisher, R., Brainard, C., Dunford, J. V., & Davis, D. P. (2010). Minimizing pre- and post-defibrillation pauses increases the likelihood of return of spontaneous circulation (ROSC). *Resuscitation*, *81*(7), 822–825. https://doi.org/10.1016/j.resuscitation.2010.03.013

Sharma, A., Zhao, X., Hammill, B. G., Hernandez, A. F., Fonarow, G.C., Felker, G. M., Yancy, C. W., Heidenreich, P. A., Ezekowitz, J. A., & DeVore, A. D. (2018). Trends in noncardiovascular comorbidities among patients hospitalized for heart failure: Insights from the Get With The Guidelines–Heart Failure Registry. *Circulation: Heart Failure, 11*(6), e004646. https://doi.org/10.1161/CIRCHEARTFAILURE.117.004646

Statistics Solutions. (2020). *Assumptions of logistic regression*. https://www.statisticssolutions.com/assumptions-of-logistic-regression/

Tabachnick, B. G., & Fidell, L. S. (2018). Using multivariate statistics (7th ed.). *Pearson.*

Topeli, A., & Cakir, B. (2021). Evaluation of the blue code system established in the health campus of a university hospital. *Turkish Journal of Emergency Medicine, 21*(1), 14–19. https://doi.org/10.4103/2452-2473.301912

Uekawa, K. (2019, May 11). *G*Power for logistic regression* [video]. https://www.youtube.com/watch?v=WJJCcvH61tQ

Unite for Sight. (2020). *Module 2: Study design and sampling*. http://www.uniteforsight.org/research-methodology/module2

van Deursen, V. M., Urso, R., Laroche, C., Damman, K., Dahlström, U., Tavazzi, L., Maggioni, A.P., Voors, A. A. (2014). Co-morbidities in patients with heart failure: An analysis of the European Heart Failure Pilot Survey. *European Journal of Heart Failure, 16*, 103–111. https://doi.org/10.1002/ejhf.30

Appendix A: AHA/GWTG's "Resuscitation Patient Management Tool: CPA Event"

**located @ https://www.heart.org/-/media/files/professional/quality-improvement/get-with-the-guidelines/get-with-the-guidelines-resuscitation/cpa-crf_jan2021.pdf?la=en**

Resuscitation Patient Management Tool

**Cardiopulmonary Arrest (CPA) EVENT** **March 2020**



| **OPTIONAL:** | Local Event ID: | |
|---|---|---|
| Did patient receive chest compressions and/or defibrillation during this event? | O Yes | O No/ Not Documented (Does NOT meet inclusion criteria) |
| Date/Time the need for chest compressions (or defibrillation when initial rhythm was VF or Pulseless VT) was FIRST recognized: | __/__/____ __:__ (MM/DD/YYYY HH:MM) | ☐ Time Not Documented |

**CPA 2.1 PRE-EVENT** ***Pre-Event Tab***

**OPTIONAL**

| | | |
|---|---|---|
| Was patient discharged from an Intensive Care Unit (ICU) within 24 hours prior to this CPA event? | O Yes | O No |
| If yes, date admitted to non-ICU unit (after ICU discharge): | __/__/____ __:__ | MM/DD/YYYY HH:MM |
| Was patient discharged from a Post Anesthesia Care Unit (PACU) within 24 hours prior to this CPA event? | O Yes | O No |
| Was patient in the ED within 24 hours prior to this CPA event? | O Yes | O No |
| Did patient receive conscious/procedural sedation or general anesthesia within 24 hours prior to this CPA event? | O Yes | O No |
| Enter vital signs taken in the 4 hours prior to the CPA event (up to 4 sets) | ☐ Pre-Event VS Unknown/Not Documented | |

| Date / Time | Heart Rate | Systolic / Diastolic BP | Respiratory Rate | SpO2 | Temp | Units |
|---|---|---|---|---|---|---|
| __/__/____ __:__ | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | O C O F |
| __/__/____ __:__ | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | O C O F |
| __/__/____ __:__ | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | O C O F |
| __/__/____ __:__ | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | ☐ Not Documented | O C O F |

**CPA 2.2 PRE-EXISTING CONDITIONS** ***Pre-Event Tab***

| | | |
|---|---|---|
| Did patient have an out-of-hospital arrest leading to this admission? | O Yes | O No/Not Documented |

**Pre-existing Conditions at Time of Event** (check all that apply):

- ☐ None (review options below carefully)
- ☐ Acute CNS non-stroke event
- ☐ Acute Stroke
- ☐ Baseline depression in CNS function
- ☐ Cardiac malformation/abnormality – acyanotic (pediatric and newborn/neonate only)
- ☐ Cardiac malformation/abnormality – cyanotic (pediatric and newborn/neonate only)
- ☐ Congenital malformation/abnormality (Non-Cardiac) (pediatric and newborn/neonate only)
- ☐ Congestive heart failure (this admission)
- ☐ Congestive heart failure (prior to this admission)
- ☐ Diabetes mellitus
- ☐ Hepatic insufficiency
- ☐ History of vaping or e-cigarette use in the past 12 months?
- ☐ Hypotension/Hypoperfusion
- ☐ Major trauma
- ☐ Metastatic or hematologic malignancy
- ☐ Metabolic/electrolyte abnormality
- ☐ Myocardial ischemia/infarction (this admission)
- ☐ Myocardial ischemia/infarction (prior to admit)
- ☐ Pneumonia
- ☐ Recently delivered or currently pregnant (if selected, maternal in-hospital cardiac arrest section is required)
- ☐ Renal Insufficiency
- ☐ Sepsis
- ☐ **Active or suspected bacterial or viral infection at admission or during hospitalization:**
  - ☐ Seasonal cold or flu
  - ☐ Bacterial infection
  - ☐ Emerging Infectious Disease
    - ☐ SARS-COV-1
    - ☐ SARS-COV-2 (COVID-19)
    - ☐ MERS
    - ☐ Other Infectious Respiratory Pathogen
  - ☐ None/ND

***Additional Personal Protective Equipment (PPE) Donned by the responders?***

- O **Yes**
- O **No/ND**

**CPA 2.2 INTERVENTIONS ALREADY IN PLACE** ***Pre-Event Tab***

Resuscitation Patient Management Tool

**Cardiopulmonary Arrest (CPA) EVENT** **March 2020**



**Interventions ALREADY IN PLACE when need for chest compressions and/or defibrillation was first recognized (check all that apply):**

| **Part A:** | ☐ None |
|---|---|
| ❑Non-invasive assisted ventilation<br>☐ Bag-Valve-Mask<br>☐ Mask and/or Nasal CPAP<br>☐ Mouth-to-Barrier Device<br>☐ Mouth-to-Mouth<br>☐ Laryngeal Mask Airway (LMA)<br>☐ Other Non-Invasive Ventilation: (specify)<br>________ | ❑ Invasive assisted ventilation, via an:<br>☐ Endotracheal Tube (ET)<br>☐ Tracheostomy Tube<br>❑ Intra-arterial catheter<br>❑ Conscious/procedural sedation<br>❑ End Tidal $CO_2$ ($ETCO_2$) Monitoring<br>❑ Supplemental oxygen (cannula, mask, hood, or tent) |

| | | | | |
|---|---|---|---|---|
| **Monitoring** | ☐ Apnea | ☐ Apnea/Bradycardia | ☐ ECG | ☐ Pulse Oximetry |
| Vascular Access | ○ Yes | | ○No/ Not Documented | |
| Any Vasoactive Agent in Place? | ○ Yes | | ○No/Not Documented | |

**OPTIONAL**

| **Part B:** | ☐ None |
|---|---|
| ☐ IV/IO continuous infusion of antiarrhythmic(s)<br>☐ Dialysis/extracorporeal filtration therapy (ongoing) | ☐ Implantable cardiac defibrillator (ICD)<br>☐ Extracorporeal membrane oxygenation (ECMO) |

**CPA 3.1 EVENT** ***Event Tab***

| | | |
|---|---|---|
| Date/Time of Birth: | ____/____/________ ____:____ (MM/DD/YYYY HH:MM) | |
| Age at Event (in yrs., months, weeks, days, hrs., or minutes): | ________ ○Years ○Months ○Weeks ○Days ○Hours ○Minutes ❑Estimated ❑Age Unknown/Not Documented | |
| Subject Type | ○ Ambulatory/Outpatient<br>○ Emergency Department<br>○ Hospital Inpatient – (rehab, skilled nursing, mental health wards) | ○ Rehab Facility Inpatient<br>○ Skilled Nursing Facility Inpatient<br>○ Mental Health Facility Inpatient<br>○ Visitor or Employee |
| Illness Category | ○ Medical-Cardiac<br>○ Surgical-Cardiac<br>○ Obstetric<br>○ Other (Visitor/Employee) | ○ Medical-Noncardiac<br>○ Surgical-Noncardiac<br>○ Trauma |
| Event Location (Area) | ○ Ambulatory/Outpatient Area<br>○ Adult Coronary Care Unit (CCU)<br>○ Adult ICU<br>○ Cardiac Catheterization Lab<br>○ Delivery Suite<br>○ Diagnostic/Intervention Area (excludes Cath Lab)<br>○ Emergency Department (ED)<br>○ General Inpatient Area<br>○ Neonatal ICU (NICU)<br>○ Newborn Nursery | ○ Operating Room (OR)<br>○ Pediatric ICU (PICU)<br>○ Pediatric Cardiac Intensive Care<br>○ Post-Anesthesia Recovery Room (PACU)<br>○ Rehab, Skilled Nursing, or Mental Health Unit/Facility<br>○ Same-Day Surgical Area<br>○ Telemetry Unit or Step-Down Unit<br>○ Other<br>○ Unknown/Not Documented |
| Event Location (Name) | ____________________ | |
| Event Witnessed? | ○ Yes | ○ No/Not Documented |
| Was a hospital-wide resuscitation response activated? | ○ Yes | ○ No/Not Documented |

**CPA 4.1 INITIAL CONDITION** ***Initial Condition/Defibrillation/Ventilation Tab***

| | | | |
|---|---|---|---|
| Condition that best describes this event: | ○ Patient was PULSELESS when need for chest compressions and/or need for defibrillation of initial rhythm VF/Pulseless VT was first identified<br>○ Patient had a pulse (poor perfusion) requiring chest compressions PRIOR to becoming pulseless<br>○ Patient had a pulse (poor perfusion) requiring chest compressions, but did NOT become pulseless at any time during this event | | |
| Did receive chest compressions (includes open cardiac massage)? | ○ Yes | ○ No/Not Documented | ○ No, Per Advance Directive |
| Compression Method(s) used (check all that apply): | ☐ Standard Manual Compression<br>☐ Open chest CPR (direct [internal] cardiac compression)<br>☐ IAC-CPR (interposed abdominal compression cardiopulmonary resuscitation) | | |

Resuscitation Patient Management Tool

**Cardiopulmonary Arrest (CPA) EVENT** **March 2020**



| | | |
|---|---|---|
| | ☐ Automatic Compressor<br>☐ Unknown/Not documented | |
| Date/Time compression started | ____/____/________ ____:____ | ☐ Time Not Documented |
| **If compressions provided while pulse present:** Rhythm when patient with pulse FIRST received chest compressions during event: | ○ Accelerated idioventricular rhythm (AIVR)<br>○ Bradycardia<br>○ Pacemaker<br>○ Sinus (including Sinus Tachycardia) | ○ Supraventricular Tachyarrhythmia (SVTarrhy)<br>○ Ventricular Tachycardia (VT) with a pulse<br>○ Unknown/Not Documented |
| **If pulseless at ANY time during event:** Date/Time pulselessness first identified: | ____/____/________ ____:____<br>(MM/DD/YYYY HH:MM) | ☐ Time Not Documented |
| First documented pulseless rhythm: | ○ Asystole<br>○ Pulseless Electrical Activity (PEA)<br>○ Pulseless Ventricular Tachycardia | ○ Ventricular Fibrillation<br>○ Unknown/Not Documented |

**CPA 4.2 AED and VF/Pulseless VT** — *Initial Condition/Defibrillation/Ventilation Tab*

| | | | |
|---|---|---|---|
| Was automated external defibrillator (AED) applied or manual defibrillator in AED/Shock Advisory mode applied? | ○ Yes | ○ No/Not Documented | ○ Not Applicable (not used by facility) |
| Date/Time AED or manual defibrillator in AED/Shock Advisory mode applied? | ____/____/________ ____:____<br>(MM/DD/YYYY HH:MM) | | ☐ Time Not Documented |
| Did the patient have Ventricular Fibrillation (VF) OR Pulseless Ventricular Tachycardia ANY time during this event? | ○ Yes | | ○ No/Not Documented |
| Date/Time of Ventricular Fibrillation (VF) OR Pulseless Ventricular Tachycardia? | ____/____/________ ____:____<br>(MM/DD/YYYY HH:MM) | | ☐ Time Not Documented |
| Was Defibrillation shock provided for Ventricular Fibrillation (VF) OR Pulseless Ventricular Tachycardia? | ○ Yes | ○ No/Not Documented | ○ No, Per Advance Directive |
| Total # of Shocks | ______ | ☐ Unknown/Not Documented | |
| Date/Time | ____/____/________ ____:____<br>(MM/DD/YYYY HH:MM) | | ☐ Not Documented |
| Energy (Joules) | __________ | | ☐ Not Documented |

**Details of Each Shock (maximum of 4):**

| Date/Time | | Energy (joules) | |
|---|---|---|---|
| ____/____/________ ____:____ | ☐ Not Documented | __________ | ☐ Not Documented |
| ____/____/________ ____:____ | ☐ Not Documented | __________ | ☐ Not Documented |
| ____/____/________ ____:____ | ☐ Not Documented | __________ | ☐ Not Documented |
| ____/____/________ ____:____ | ☐ Not Documented | __________ | ☐ Not Documented |

| | | |
|---|---|---|
| Documented reason (s) (patient, medical, hospital related or other) for not providing defibrillation shock for Ventricular Fibrillation (VF) or Pulseless Ventricular Tachycardia (VT) in first two minutes? | ○ Yes | ○ No |

| | |
|---|---|
| Patient Reason(s): | ☐ Initial Refusal (e.g. family refused) |
| Medical Reason(s) | ☐ ICD in place which shocked patient within first 2 minutes of identification of VF or Pulseless VT<br>☐ LVAD or BIVAD in place<br>☐ Rhythm change to non shockable rhythm within 2 minutes of identification of VF or Pulseless VT<br>☐ Spontaneous Return of Circulation within first 2 minutes of identification of VF or Pulseless VT |
| Hospital Related or Other Reason(s) | ☐ Equipment related delay (e.g., defibrillator not available, pad not attached)<br>☐ In-hospital time delay (e.g. code team delays, personnel not familiar with protocol or equipment, unable to locate hospital defibrillator)<br>☐ Other → (Please Specify) ____________________ |

**CPA 4.3 Ventilation** — *Initial Condition/Defibrillation/Ventilation Tab*

| | | |
|---|---|---|
| Types of Ventilation/Airways used | ☐ None | ☐ Unknown/Not Documented |
| Ventilation/Airways Used (Select all that apply) | ☐ Bag-Valve-Mask<br>☐ Mask and/or Nasal CPAP/BiPAP | ☐ Laryngeal Mask Airway (LMA)<br>☐ Endotracheal Tube (ET) |

Resuscitation Patient Management Tool

**Cardiopulmonary Arrest (CPA) EVENT** **March 2020**



| | | |
|---|---|---|
| | ☐ Mouth-to-Barrier Device<br>☐ Mouth-to-Mouth | ☐ Tracheostomy Tube<br>☐ Other Non-Invasive Ventilation, Specify_______ |
| Was Bag-Valve-Mask ventilation initiated during the event? | O Yes | O No · O Not Documented |
| Date/Time | _____/_____/_______ _____:____ | ☐ Time Not Documented |
| Was any Endotracheal Tube (ET) or Tracheostomy Tube inserted/re-inserted during event? | O Yes | O No |
| Date/Time Endotracheal Tube (ET) or Tracheostomy Tube inserted if not already in place and/or re-inserted during event: | ___/___/_______ ___:___ (MM/DD/YYYY HH:MM) | ☐ Time Not Documented |
| Method(s) of confirmation used to ensure Endotracheal Tube (ET) or Tracheostomy Tube placement in trachea (check all that apply): | ☐ Waveform capnography (waveform ETCO2)<br>☐ Capnometry (numeric ETCO2)<br>☐ Exhaled CO2 colorimetric monitor (ETCO2 by color change)<br>☐ Esophageal detection devices | ☐ Revisualization with direct laryngoscopy<br>☐ None of the above<br>☐ Not Documented |

| **CPA 5.1 Epinephrine** | | | *Other Interventions Tab* |
|---|---|---|---|
| Was IV/IO Epinephrine BOLUS administered? | O Yes | O No | O Not Documented |
| Date/Time | _____/_____/_______ _____:____ (MM/DD/YYYY HH:MM) | | ☐ Time Not Documented |
| Total Number of Doses | ______ | | ☐ Unknown/Not Documented |
| If IV/IO Epinephrine was not administered within the first five minutes of the event, was there a documented patient, medical, hospital related or other reason for not providing Epinephrine bolus? | | O Yes | O No |
| Patient Reason(s) | ☐ Initial Refusal (e.g. family refused) | | |
| Medical Reason(s) | ☐ Patient already receiving vasopressor (e.g. Epinephrine) as a continuous IV infusion prior to and during arrest<br>☐ Spontaneous Return of Circulation within first 5 minutes of the date/time pulselessness was first identified (or the need for chest compressions was first recognized (pediatric only))<br>☐ Medication allergy | | |
| Hospital Related or Other Reason(s) | ☐ In-hospital time delay (e.g., delay in locating medication)<br>☐ No route to deliver medication (e.g. no IV/IO access)<br>☐ Other → (Please Specify) ____________ | | |

| **CPA 5.2 Other Drug Interventions** | | *Other Interventions Tab* |
|---|---|---|
| *Select all either initiated, or if already in place immediately prior to, continued during event.* | | |
| ☐ **None** (select only after careful review of options below)<br>☐ **Antiarrhythmic medication(s):**<br>☐ Adenosine/Adenocard<br>☐ Amiodarone/Cordarone<br>☐ Lidocaine<br>☐ Procainamide<br>☐ Other antiarrhythmics: _____ | ☐ **Vasopressor(s) other than epinephrine bolus:**<br>☐ Dobutamine<br>☐ Dopamine > 3mcg/kg/min<br>☐ Epinephrine, IV/IO continuous infusion<br>☐ Norepinephrine<br>☐ Phenylephrine<br>☐ Other Vasopressors: ________ | ☐ Atropine<br>☐ Calcium Chloride/Calcium Gluconate<br>☐ Dextrose Bolus<br>☐ Magnesium Sulfate<br>☐ Reversal agent (e.g., naloxone/Narcan, flumazenil/Romazicon, neostigmine/Prostigim)<br>☐ Sodium Bicarbonate<br>☐ Other Drug Interventions: ____________ |

| **CPA 5.3 Non-Drug Interventions** | *Other Interventions Tab* |
|---|---|
| *Select each intervention that was employed during the resuscitation event.* | |
| ☐ None (review options below carefully)<br>☐ Cardiopulmonary bypass / extracorporeal CPR (ECPR)<br>☐ Chest tube(s) inserted<br>☐ Needle thoracostomy | ☐ Pacemaker, transcutaneous<br>☐ Pacemaker, transvenous or epicardial<br>☐ Pericardiocentesis<br>☐ Other non-drug interventions ___________ |

| **CPA 6.1 Event Outcome** | | *Event Outcome Tab* |
|---|---|---|
| Was ANY documented return of adequate circulation [ROC] (in the absence of ongoing chest compressions return of adequate pulse/heart rate by palpation, auscultation, Doppler, arterial blood pressure waveform, or documented blood pressure) achieved during the event? | | O Yes<br>O No/Not Documented |
| Date/Time of FIRST adequate return of circulation (ROC): | ____/_____/_________ _____:_____ | ☐ Time Not Documented |
| Reason resuscitation ended | O Survived – ROC | O Died – Efforts terminated, no sustained ROC |

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| | | |
|---|---|---|
| Date and time sustained ROC ***began lasting > 20 min*** OR resuscitation efforts were terminated (End of event) | ____/____/________ ____:____ (MM/DD/YYYY HH:MM) | ☐ Time Not Documented |

| **CPA 6.2 Post-ROC Care** | | | | | | ***Event Outcome Tab*** |
|---|---|---|---|---|---|---|
| **Highest patient temperatures during first 24 hrs. after ROC:** Temperature | O ______ **C** | | O ______ **F** | | ☐ Temperature Not Documented | |
| Site | OAxillary<br>OBladder | OBlood<br>OBrain | OOral<br>ORectal | OSurface (skin, temporal)<br>OOther | OUnknown<br>OTympanic | |
| Date/Time Recorded: | ____/____/________ ____:____ | | | ☐ Time Not Documented | | |

| **CPA 7.1 CPR Quality** | | | | ***CPR Quality Tab*** |
|---|---|---|---|---|
| Was performance of CPR monitored or guided using any of the following? (Check all that apply) | ☐ None<br>☐ Waveform Capnography/End Tidal CO2 (ETCO2)<br>☐ Arterial Wave Form/Diastolic Pressure<br>☐ CPR mechanics device (e.g. accelerometer, force transducer, TFI device) | | | ☐ CPR Quality Coach<br>☐ Metronome<br>☐ Other, Specify: ___________ |
| **If CPR mechanics device (e.g. accelerometer, force transducer, TFI device) used:** | | | | |
| Average Compression Rate | __________ (Per Minute) | | ☐ Not Documented | |
| Average Compression Depth | O __________ mm | O __________ cm | O __________ inches | ☐ Not Documented |
| Compression Fraction | __________ (Enter number between 0 and 1) | | | ☐ Not Documented |
| Percent of chest compressions with complete release | __________ (%) | | | ☐ Not Documented |
| Average Ventilation Rate | __________ (Per Minute) | | | ☐ Not Documented |
| Longest Pre-shock pause | __________ (Seconds) | | | ☐ Not Documented |
| Was a team debriefing on the quality of CPR provided completed after the event? | O Yes | O No | | O Not Documented |

| **CPA 7.2 Resuscitation-Related Events And Issues** | | ***CPR Quality Tab*** |
|---|---|---|
| **OPTIONAL:** ☐ No/Not Documented | | |
| Universal Precautions | ☐ Not followed by all team members (specify in comments section) | |
| Documentation | ☐ Signature of code team leader not on code sheet<br>☐ Missing other signatures<br>☐ Initial ECG rhythm not documented | ☐ Medication route(s) not documented<br>☐ Incomplete documentation<br>☐ Other (specify in comments section) |
| Alerting Hospital-Wide Resuscitation Response | ☐ Delay<br>☐ Pager Issues | ☐ Other (specify in comments section) |
| Airway | ☐ Aspiration related to provision of airway<br>☐ Delay<br>☐ Delayed recognition of airway misplacement/displacement<br>☐ Intubation attempted, not achieved | ☐ Multiple intubation attempts → Number of Attempts ______<br>☐ Unknown/ Not Documented<br>☐ Other (specify in comments section) |
| Vascular Access | ☐ Delay<br>☐ Inadvertent arterial cannulation | ☐ Infiltration/Disconnection<br>☐ Other (specify in comments section) |
| Chest Compression | ☐ Delay ☐ No back board | ☐ Other (specify in comments section) |
| Defibrillations | ☐ Energy level lower/higher than recommended<br>☐ Initial delay, personnel not available to operate defibrillator<br>☐ Initial delay, issues with defibrillator access to patient | ☐ Initial delay, issue with paddle placement<br>☐ Equipment Malfunction<br>☐ Given, not indicated<br>☐ Indicated, not given<br>☐ Other (specify in comments section) |
| Medications | ☐ Delay<br>☐ Route<br>☐ Dose | ☐ Selection<br>☐ Other (specify in comments section) |
| Leadership | ☐ Delay in identifying leader<br>☐ Knowledge of equipment<br>☐ Knowledge of medications/protocols<br>☐ Knowledge of roles | ☐ Team oversight<br>☐ Too many team members<br>☐ Other (specify in comments section) |
| Protocol Derivation | ☐ ACLS/PALS ☐ NRP | ☐ Other (specify in comments section) |

| | | | |
|---|---|---|---|
| Equipment | ☐ Availability | ☐ Function | ☐ Other (specify in comments section) |
| Comments | | | |
| Was this cardiac arrest event the patient's index (first) event? | O Yes | | O No |

**Comments & Optional Fields**: *Do not enter any Personal Health Information/Protected Health Information into this section.*

| | |
|---|---|
| Field 1 | Field 2 |
| Field 3 | Field 4 |
| Field 5 | Field 6 |
| Field 7 | Field 8 |
| Field 9 | Field 10 |
| Field 11 | Field 12 |
| Field 13 ___/___/______ ___:___ | Field 14 ___/___/______ ___:___ |

**MATERNAL IN-HOSPITAL CARDIAC ARREST** ***Research Tab***

| | | | |
|---|---|---|---|
| If Recently delivered or currently pregnant was selected under Pre-existing conditions, please select one of the following: | ___/___/______ ___:___ (MM/DD/YYYY HH:MM) | | ☐ Not Documented |
| O Patient recently delivered fetus | If patient recently delivered a fetus, select delivery date: ___/___/______ ___:___ (MM/DD/YYYY HH:MM) | | ☐ Not Documented |
| O Patient is currently pregnant | If patient is currently pregnant, enter EDC/Due Date: ___/___/______ (MM/DD/YYYY) | ☐ Not Documented | Gestational Age ___ |
| Select Number of Fetuses (Single Select) | O Single<br>O Multiple | O Unknown<br>O Not Documented | |
| The patient had the following delivery or pregnancy complications | ☐ Not Documented<br>☐ None<br>☐ Alcohol Use<br>☐ Chorioamnionitis<br>☐ Cocaine/Crack use<br>☐ Gestational Diabetes<br>☐ Diabetes<br>☐ Eclampsia<br>☐ GHTN (Pregnancy induced/gestational hypertension)<br>☐ Hypertensive Disease<br>☐ Magnesium Exposure<br>☐ Major Trauma | ☐ Maternal Group B Strep (Positive)<br>☐ Maternal Infection<br>☐ Methamphetamine/ICE use<br>☐ Narcotic given to mother within 4 hours of delivery<br>☐ Narcotics addiction and/or on methadone maintenance<br>☐ Obstetrical hemorrhage<br>☐ Pre-eclampsia<br>☐ Prior Cesarean<br>☐ Urinary Tract Infection (UTI)<br>☐ Other (specify) __________ | |
| Total # of pregnancies (gravida) | __________ (Integer Field) | ☐ Unknown/Not Documented | |
| Total # of deliveries (parity) | __________ (Integer Field) | ☐ Unknown/Not Documented | |
| Delivery Mode (Single Select): | O Vaginal/Spontaneous<br>O Vaginal/Operative | O VBAC<br>O C-Section/Scheduled | O C-Section/Emergent<br>O Unknown/Not Documented |
| Left Lateral Uterine Displacement: | ☐Yes<br>☐Unknown/Not Documented<br>Time recognized ___:___ | Select Method(s) (select all that apply) | ☐ Manual Uterine Displacement<br>☐ Left Lateral Tilt<br>☐ Unknown/Not Documented |
| Neonatal Outcome (Single Select) | O Delivered (**If delivered, enter Apgar Scores**):<br>☐Enter 1 min. Apgar score (integer field range: 0-10)<br>☐Enter 5 min Apgar score (integer field range: 0-10) __________<br>☐Unknown/Not Documented | | O Undelivered<br>OIUFD (intrauterine fetal death)<br>OViable<br>OUnknown/Not Documented |
| **Was a CPA event completed for the newborn?** | O Yes | O No | O Unknown/ Not Documented |

**CPA 5.3 OTHER DRUG INTERVENTIONS**

Resuscitation Patient Management Tool

**Cardiopulmonary Arrest (CPA) EVENT** **March 2020**



| | | | |
|---|---|---|---|
| *Select each intervention that was employed during the resuscitation event:* | ❑ **None** (review options below carefully) | | ❑ Cardiopulmonary bypass / ECMO or extracorporeal CPR (ECPR) |
| Was ECPR process activated? | ❑ ECMO/ECPR activated | | |
| Is there an ELSO record for this patient? | O Yes | O No | O Unknown/ND |
| If yes, enter ELSO Patient Record Number (**optional**) | ______________ | | |
| Was cannulation attempted? | O Yes | O No | O Unknown/ND |
| Was cannulation successful? | O Yes<br>O No | O Unknown/Not Documented<br>O Cannulation initiated but not completed | |
| Date/Time ECMO started ____/____/_______ ____:____ | Date/Time ECMO ended ____/____/_______ ____:____ | | |
| Initial Extracorporeal Life Support Mode (check all that apply) | ❑ Venoarterial ECMO<br>❑ Venovenous ECMO<br>❑ Veno-Venoarterial ECMO<br>❑ AVECCO2R | ❑ VVECCO2R<br>❑ Other _____________<br>❑ Unknown/ND | |

**Cannulation Anatomical Site (check all that apply)**

| | | | | | |
|---|---|---|---|---|---|
| ❑ RCCA – Percutaneous? | O Yes | O No | ❑ Aorta ❑ LA | ❑ PA | ❑ RA |
| ❑ LCCA – Percutaneous? | O Yes | O No | ❑ LSA – Percutaneous? | O Yes | O No |
| ❑ RIJV – Percutaneous? | O Yes | O No | ❑ LSV – Percutaneous? | O Yes | O No |
| ❑ RIJVC – Percutaneous? | O Yes | O No | ❑ RSA – Percutaneous? | O Yes | O No |
| ❑ RFA – Percutaneous? | O Yes | O No | ❑ RSV – Percutaneous? | O Yes | O No |
| ❑ LFA – Percutaneous? | O Yes | O No | ❑ Other – Percutaneous? | O Yes | O No |
| ❑ RFV – Percutaneous? | O Yes | O No | ❑ Unknown/ND | | |
| ❑ LFV – Percutaneous | O Yes | O No | | | |

**ECMO Cannulation Location (area)**

| | | |
|---|---|---|
| O Ambulatory/Outpatient Area<br>O Adult Coronary Care Unit (CCU)<br>O Adult ICU<br>O Cardiac Catheterization Lab<br>O Delivery Suite<br>O Diagnostic/Intervention. Area (excludes Cath Lab) | O Emergency Department (ED)<br>O Inpatient Area<br>O Neonatal ICU (NICU)<br>O Newborn Nursery<br>O Operating Room (OR)<br>O Pediatric ICU (PICU)<br>O Pediatric Intensive Care Unit | O Post-Anesthesia Recovery Unit (PACU)<br>O Rehab, Skilled Nursing, or Mental Health Unit/Facility<br>O Same-day Surgical Area<br>O Telemetry unit or Step-down unit<br>O Other (Specify) _____________<br>O Unknown/Not Documented |
| Team Member(s) Performing ECMO Cannulation: | ❑ Anesthesiologist<br>❑ Intensivist<br>❑ Surgeon | ❑ Other (Specify) _____________<br>❑ Unknown/Not Documented |
| ECMO circuit priming (select all that apply): | ❑ Crystalloid<br>OSaline<br>OPlasma-Lyte<br>OOther Crystalloid ________<br>❑ 5% or 25% Albumin | ❑ Plasma<br>❑ RBC<br>❑ Whole Blood<br>❑ Other (Specify) ________<br>❑ Unknown/Not Documented |

| | | |
|---|---|---|
| Date/Time: ____/____/_______ ____:____ | Blood flow ________(mL/minute) at 4 hours after cannulation | ❑ ND |
| Date/Time: ____/____/_______ ____:____ | Blood flow ________(mL/minute) 24 hours after cannulation | ❑ ND |
| Date/Time: ____/____/_______ ____:____ | FsO2 ________at 4 hours after cannulation | ❑ ND |
| Date/Time: ____/____/_______ ____:____ | FsO2 ________24 hours after cannulation | ❑ ND |

Resuscitation Patient Management Tool
**Cardiopulmonary Arrest (CPA) EVENT** **March 2020**


| | | | |
|---|---|---|---|
| Head CT performed? | O Yes | O No | O Unknown/Not Documented |
| If Yes, enter Date/Time CT Performed (for first CT post-cannulation if multiple CTs were performed): | | Date/Time: | ____/____/________ ____:____ |
| Cerebral MRI performed? | O Yes | O No | O Unknown/Not Documented |
| If Yes, Date/Time Cerebral MRI performed (for first MRI post-decannulation if multiple MRIs were performed): | | Date/Time: | ____/____/________ ____:____ |
| **Neurologic injury or events detected during ECMO or after ECMO (Less than 6 weeks after separation from ECMO or by Hospital Discharge, which ever one comes first). (check all that apply):** | | | |
| ❑ None/Not Documented | | | |
| ❑ Anoxic Brain Injury | Date/Time detected: ____/____/________ ____:____ | | ❑ Date/Time Unknown/ND |
| ❑ Brain Death | Date/Time detected: ____/____/________ ____:____ | | ❑ Date/Time Unknown/ND |
| ❑ Cerebral Microbleeds | Date/Time detected: ____/____/________ ____:____ | | ❑ End Date/Time Unknown/ND |
| ❑ Intracranial Hemorrhage | Date/Time detected: ____/____/________ ____:____ | | ❑ Date/Time Unknown/ND |
| ❑ Ischemic Stroke | Date/Time detected: ____/____/________ ____:____ | | ❑ Date/Time Unknown/ND |
| ❑ New Clinical Seizure(s) | Date/Time detected: ____/____/________ ____:____ | | ❑ Date/Time Unknown/ND |
| EEG performed within in first 24 hours post-ROC? | O Yes | O No | O Unknown/Not Documented |
| If EEG was performed, was there an indication of electrographic seizure activity? | O Yes | O No | O Unknown/Not Documented |
| If EEG was performed, was an antiepileptic administered? | O Yes | O No | O Unknown/Not Documented |
| END OF FORM | | | |

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https://www.heart.org/-/media/files/professional/quality-improvement/get-with-the-guidelines/get-with-the-guidelines-resuscitation/cpa-crf_jan2021.pdf?la=en

# Appendix B: AHA Approval Letter

American Heart Association.

Inv #17050
Fees waived for Student

April 9, 2021

## PRINT & ELECTRONIC COPYRIGHT USE AGREEMENT

Adessa Goss
For: Walden University
345 Depot St.
Constantine, MI 49042

Dear Ms. Goss:

Amount Due: **$0.00 U.S. Funds (WAIVED)** (This is a fee for service and not a charitable contribution). Our tax id number is 13-5613797. **Please consider this letter an invoice.**

Approval of this request is contingent upon receipt of a $0.00 U.S. Funds (WAIVED) processing fee and a signed copy of this Agreement (including Exhibit A.) Please send a check (drawn on a U.S. Bank or an inter-national money order) payable to the American Heart Association with a copy of this Agreement **(including Exhibit A)** to P.O. Box 841750, Dallas TX, 75284-1750. A credit card form will be provided upon request.

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6. Student projects may only be presented in a classroom setting for academic credit.

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8. The website/university repository must require a UserID/password to access material.

This permission is not valid until we receive a signed copy of this agreement. If the signed agreement is not received within 30 days, the request will be considered withdrawn and no longer in effect. No reminder notices will be sent.

Upon receipt of payment and the signed agreement, permission will be granted on your original request. **Your cancelled check or credit card statement will be your receipt.**

E-SIGNED by Adessa Goss
on 2021-04-09 14:21:13 CDT

**Signature of Requestor**________________________________________

**Printed name**_______________________________________________

April 09, 2021

**Date** __________________________

# EXHIBIT A

## **Publication Name**— www.heart.org

Specifically:
AHA/GWTG's "Resuscitation Patient Management Tool: CPA Event" located @

https://www.heart.org/-/media/files/professional/quality-improvement/get-with-the-guidelines/get-with-the-guidelines-resuscitation/cpa-crf_jan2021.pdf?la=en

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## For Use In:

a print and secured, online version of the student's dissertation titled "Fully Automated Life Support Training Effects on Inpatient Cardiac Arrest Survival Rates". The online version will only be placed in the university's secured repository.

**NOTE:** If the student decides at a later date to publish the thesis with the AHA material, a new request form **must** be submitted to the AHA for review/approval **before** the AHA material can be published.