IMPROVING ETCO2 DEVICE UTILIZATION DURING EMERGENCY DEPARTMENT ADULT RESUSCITATIONS

by

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ABSTRACT

KATHERINE JUDGE. Improving ETCO2 Device Utilization During Emergency Department Adult Resuscitations. (Under the direction of DR. CORY SHEELER)

To impact survival rates by 30%, emergency department (ED) workers should follow the Advanced Cardiovascular Life Support (ACLS) guideline of relying on end-tidal carbon dioxide (ETCO2) monitoring to ensure cardiopulmonary resuscitation (CPR) is high-quality. In a large tertiary care hospital based ED, ETCO2 monitoring was not consistently utilized, despite workers having ACLS training and access to ETCO2 monitoring devices. The purpose of this project was to determine if high-fidelity ACLS simulation and ETCO2 monitoring training affected ED staff's resuscitation self-efficacy and ETCO2 device application during clinical resuscitations. Twenty-eight interprofessional ED healthcare workers participated in high-fidelity adult cardiac arrest simulation scenarios. Paired-samples t-test results showed a significant pre-post simulation survey total average resuscitation self-efficacy improvement from 3.99 to 4.52 ($t = 6.83$, $p < .001$). Ten ED adult cardiac arrest events prior to simulation and twenty events post simulation were retrospectively analyzed for device utilization. Two-tailed paired-samples t-test results showed a non-significant improvement in device utilization ($t = -1.96$, $p = .081$), however utilization more than doubled from 20% to 45%. Overall, results indicated high-fidelity simulation can have a significant improvement in resuscitative confidence of ED workers, which in future studies may translate to higher survival rates for adults in cardiac arrest.

DEDICATION

I dedicate my DNP scholarly project to my husband, James, and my son, Shepherd. I could not have done this major accomplishment without James' support, understanding, and love. Knowing I can inspire Shepherd to dream big and achieve incredible goals was my main motivation. Additionally, a special consideration to my parents, siblings, family, and cat, Taylor, for their constant encouragement and love throughout this journey. Finally, I dedicate this project to other nurses who have dreams of furthering their knowledge to promote our profession's seat at the head of the healthcare policy and management table.

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LIST OF ABBREVIATIONS

ACLS	Advanced Cardiovascular Life Support
AHA	American Heart Association
AVP	Assistance Vice President
RC	Resuscitation Committee
CPR	Cardiopulmonary Resuscitation
DNP	Doctor of Nursing Practice
ED	Emergency Department
EMT	Emergency Medical Technicians
ETCO2	End-tidal Carbon Dioxide
EBP	Evidence-Based Practice
HCT	Healthcare Technicians
HFS	High-Fidelity Simulation
IRB	Institutional Review Board
LPN	Licensed Practical Nurse
NC	North Carolina
QI	Quality Improvement
RN	Registered Nurse
RT	Respiratory Therapist
RSES	Resuscitation Self-Efficacy Scale
ROSC	Return of Spontaneous Circulation
SIM	Simulation

CHAPTER 1: INTRODUCTION

On average, more than 2,200 Americans die each year of cardiovascular disease; that is approximately one death every 39 seconds (McCoy et al., 2019). When a person's heart is not beating, an individual trained for cardiopulmonary resuscitation (CPR) can compress the person's chest to promote blood flow. CPR can provide adequate blood flow until the heart begins beating on its own, a term known as *return of spontaneous circulation* (ROSC). American emergency department (ED) healthcare workers are trained to perform CPR and follow the American Heart Association's (AHA) Advanced Cardiovascular Life Support (ACLS) guidelines in attempt to restart an arrested heart.

While ACLS guidelines should be followed consistently, a lack of adherence to the practice can lead to poor CPR quality. Theoretical and experimental studies have explored the concept of using high-fidelity simulation (HFS) to increase adherence of ACLS guidelines amongst ACLS trained staff during mock or real time cardiac arrest. Doctoral prepared nurses in the clinical setting have a duty to promote a culture of evidence-based practice (EBP) change, implementation, and adherence. Through this paper, this author will address an identified need for practice adherence via implementation of a Doctor of Nursing Practice (DNP) scholarly project involving educational intervention.

1.1 Background

External compressions during CPR assist blood to move through the body and provide oxygen to vital organs, otherwise known as perfusion. Even when life support guidelines are perfectly followed, CPR provides about 15-25% of normal blood flow to vital organs (Dogan et al., 2019). Current AHA guidelines define high-quality CPR as a compression rate of 100-120 beats per minute, a compression depth of at least 2 inches in adults, compressions occurring at least 80% of the time since the heart stopped, and an avoidance of over-ventilation when providing oxygenated breaths (Panchal et al., 2020). To provide the highest-quality CPR for adequate organ perfusion prior to ROSC, growing evidence suggests that “simple changes in technique, with emphasis on proper compression rate, depth, chest wall recoil, minimizing interruptions and avoiding over-ventilation” can markedly improve survival rates (McCoy et al. 2019, p. 16).

End-tidal carbon dioxide (ETCO2) levels can provide a real-time measurement of CPR generated perfusion (Sandroni et al., 2018; Sota, 2021). As soon as the heart stops beating, blood perfusion through the lungs ceases and CO2 has difficulty reaching the lungs for exhalation. A living person’s normal exhaled ETCO2 is in the range of 35 to 45 mmHg. The goal ETCO2 level that ensures CPR-provided perfusion and ventilation is high-quality is 10mmHg or higher. To obtain an ETCO2 level during CPR, a non-invasive capnography tool is attached to a ventilation device, such as a bag valve mask or an endotracheal tube and connected to a defibrillator, which displays a waveform and numeric level (Sandroni et al., 2018). If an ETCO2 level drops below 10mmHg during CPR, perfusion to vital organs is not adequate and techniques should be modified to meet high-quality standards. Thus, in 2020, the AHA updated ACLS guidelines to include a recommendation of continuous monitoring of waveform capnography during resuscitation to promote CPR technique modification.

1.2 Problem Statement

In the project site’s ED at a large tertiary care hospital in Concord, North Carolina (NC), continuous ETCO2 monitoring via waveform capnography is not consistently utilized during resuscitations to measure CPR quality, despite having readily available equipment, the nursing staff being ACLS certified, and medical staff and respiratory therapy being competent to ETCO2 utilization. The project site's ED cardiac arrests reviewed between October 2022 to December 2022 showed zero of five adult resuscitations utilized ETCO2 monitoring. Previous quality improvement (QI) studies have used the concept of supplemental HFS scenarios to increase adherence of ACLS guidelines amongst trained staff during real time cardiac arrest. The overall outcome of these studies demonstrated that HFS training with objective evaluation techniques had a significant influence on self-efficacy and led the project lead to incorporate HFS as the evidence-based educational intervention.

1.3 Purpose of Project

Utilizing waveform capnography as a real-time feedback tool was seen as a possible significant addition to ED staff's resuscitation assessment to optimize CPR quality and facilitate CPR technique change. Practice change implementation was determined to be easy and feasible. To measure waveform capnography, an ETCO2 filter and monitoring device are required. All defibrillators used during resuscitation in the project site's ED have ETCO2 filter connection ports and provide ETCO2 monitoring capabilities. All adult crash carts and resuscitation rooms have ETCO2 filters stocked. The ETCO2 device can easily be attached by any trained ED staff member to the bag valve mask or ventilator. Waveform capnography is a non-invasive tool that can measure ETCO2 and determine "effectiveness of the blood flow generated during compressions" (Sandroni et al., 2018, p. 73). A low ETCO2 value can lead the respiratory therapist (RT), medical provider, or ACLS nurse to recommend improvements in compression quality through increasing compression depth or rate to achieve a higher ETCO2 level. This is significant as higher levels of ETCO2 during CPR can increase the likelihood of achieving ROSC (Panchal et al., 2020).

1.4 Clinical Question

A PICO(T) question was developed after identifying the under-utilization of the ETCO2 device and reviewing literature regarding best practice to influence ACLS guideline adherence. For ED medical staff, RTs, and ACLS-certified ED nursing staff (P), how does supplemental high-fidelity simulation training on use and value of ETCO2 monitoring during resuscitation (I), compared to current practice (C), affect usage of end-tidal carbon dioxide monitoring during resuscitations (O) over a period of three months (T)?

1.5 Project Objectives

Implementation of the DNP scholarly project included a high-fidelity adult cardiac arrest simulation (SIM) scenario with post-SIM retrospective review of clinical ED adult resuscitations. The DNP project involved ED medical providers, RTs, and ACLS-certified staff attending and participating in the HFS mock resuscitation with a didactic portion followed by a debrief. The expected short-term outcome for this project was that ED staff would demonstrate an increase in resuscitation self-efficacy and improved adherence to ETCO2 utilization in simulated cardiac arrests. The expected long-term outcome was for ETCO2 usage to increase in clinical ED cardiac arrest resuscitation events post SIM for a period of three months. Future projects to consider are clinical data demonstrating higher quality CPR in ED resuscitations and increased survivability to admission rates.

CHAPTER 2: LITERATURE REVIEW

Using the PICOT question as a guide, a comprehensive literature search was conducted using the Atkins Library resources at The University of North Carolina at Charlotte between September 2022 and March 2023. Three databases were used: CINAHL, PubMed, and Medline. Search terms used to find potential research articles included *simulation*, *education*, *nursing education*, *self-efficacy, retention*, *cardiopulmonary resuscitation, advanced cardiac life support*, *end-tidal carbon dioxide*, and *ACLS*. A date range of seven years was set.

Boolean operators AND and OR were used to combine search terms in various combinations. For combined search results, additional limiters of 'adult' age, 'human' subjects, and 'English' language were added. The combination that identified the greatest number of relevant sources were *cardiopulmonary resuscitation* and *end-tidal carbon dioxide*, which provided 38 relevant sources. Articles that were excluded from review did not address a human adult population, were not in the date range, and not in the English language.

The project lead chose 22 articles for review, and included case-control, retrospective observational, randomized controlled trial, and systemic review studies. To ensure the evaluated data was relevant, this author considered each article for its reliability and transferability to the ED setting and population. Review of the 22 identified articles demonstrated that HFS training with objective evaluation techniques had a significant influence on self-efficacy (one's perceived confidence to perform a skill), ACLS skills retention, CPR quality when performed in a simulated setting and adherence to ACLS skills when performed in a clinical setting. Unfortunately, there remains a lack of "high-quality randomized controlled trials examining interventions that improve resuscitation skills retention" (Au et al., 2019, p. 284).

2.1 HFS Training Influencing Resuscitation Self-Efficacy

The reviewed studies showed that HFS with objective evaluation techniques have a significant positive influence on self-efficacy (Al-Kalaldeh & Al-Olime, 2022; Bowers et al., 2020; Huang et al., 2018; Jang et al., 2021; Kim et al., 2020). Al-Kalaldeh & Al-Olime (2022) measured resuscitation self-efficacy of nurses who had at least one year of experience in critical care (i.e., ED, intensive care unit, recovery unit, or operating room) using the Resuscitation Self-Efficacy Scale (RSES) in a pre/post QI study utilizing HFS. All four dimensions (recognition; debriefing and recording; responding and rescuing; and reporting) improved and written ACLS test scores improved post HFS. The researchers reported significant improvements in nurse self-efficacy, knowledge, and performance of ACLS practice after receiving HFS education on resuscitation. Similarly, Kim et al. (2020) compared SIM-based Advanced Life Support vs. lecture-based education and their effects on nurses' resuscitation self-efficacy. The HFS group showed statistically significant higher scores in knowledge ($P < .001$), performance ($P < .001$), and self-efficacy ($P = .049$) than lecture-based, leading to researchers determining that SIM-based advanced life support education is optimal to improving resuscitation self-efficacy over lecture-based education.

2.2 Research Focused on HFS Training Influencing Skill Retention and Self-Efficacy

The reviewed studies also demonstrated that HFS with objective evaluation techniques has a significant positive influence on ACLS skill retention (Au et al., 2019; Berger et al., 2019; Bingham et al., 2015; Bowers et al., 2020; Campbell & Clark, 2020; Jang et al., 2021; McCoy et al., 2019). In considering both short- and long-term skill retention, the studies allowed various time periods between HFS intervention and post-intervention skills assessment. Campbell & Clark (2020) explored retention of emergency nurses' knowledge and ACLS skills who participated in an ACLS SIM-based learning experience. The researchers focused on a retention time span of two weeks and eight weeks post intervention. They concluded that SIM-based learning experience can be an adjunct instructing method to promote ALCS skill retention up to eight weeks post intervention Other researchers focused individually on longer time lengths, up to six months, and roles, including nurses, pharmacists, and medical doctors, which showed in multiple studies that retention was either no longer significant or decreased after six months post intervention for all roles (Au et al., 2019; Berger et al., 2019; Bingham et al., 2015; Jang et al., 2021).

2.3 Impacting CPR Quality in a Simulated Setting Involving Various Healthcare Roles

The ED setting relies on multiple interdisciplinary healthcare professionals working as a team to achieve optimal patient care. Thus, research was reviewed regarding HFS education's impact on various health care roles, including nursing. The selected literature included studies with participants who were ED nurses, physicians, paramedics, and pharmacists, and had various levels of experience, from medical and nursing students to established, expert professionals. All roles studied throughout the reviewed literature included nursing students, medical students, medical doctors, pharmacy students, critical care curses (emergency and intensive care), emergency medical technicians (EMT) and paramedics, RTs, and pharmacists. There was sufficient evidence to support HFS training has a positive impact on CPR quality in a simulated setting for all roles (Au et al., 2019; Berger et al., 2019; Bingham et al., 2015; Campbell & Clark, 2020; Chang et al., 2021; Kim, 2018; McCoy et al., 2019; Rishipathak et al., 2020; Thorne et al., 2020; Toft et al. 2022). Berger et al. (2019) conducted a randomized single blinded trial involving 112 medical doctors participating in lecture- and SIM-based education regarding CPR following International Liaison Committee on Resuscitation guidelines. Research showed that problem-based learning combined with HFS training leads to a measurable short-term increase in initiating sufficient CPR immediately after training as compared to traditional lecture-based education. Rishipathak et al. (2020) observed paramedic CPR quality using a high fidelity simulator prior to and post a didactic intervention. Researchers found participants significantly performed critical CPR actions and managed the HFS scenarios as per AHA 2015 guidelines better than prior to intervention.

2.4 Effect of HFS Training on ACLS Skills Adherence During Clinical Cardiac Arrest Situations

The long term outcome expected for this project was to demonstrate an increase in ACLS skills adherence via ETCO2 device connection during emergency cardiac arrest situations. Thus, research was evaluated for demonstrated success of ACLS skills adherence in clinical cardiac arrest situations post HFS training. Multiple articles focused on this purpose and were applicable for the development of this scholarly project (Berger et al., 2019; Bingham et al., 2015; Didwania et al., 2011; Han et al., 2014; McCoy et al., 2019; Paddock, 2021; Toft et al., 2022; Wayne et al., 2008). Thorough evaluation of these articles showed that HFS training has a positive influence on ACLS skills adherence during clinical cardiac arrest situations. For example, Berger et al.'s 2019 randomized single blinded trial demonstrated that 51.9% of the SIM group met the criteria of sufficiently performed CPR in clinical practice as compared to only 12.5% in the lecture group on day of intervention ($p = 0.007$). This research also successfully demonstrated that ACLS training via SIM influences clinical practice up to 120 days post intervention. Encouragingly, Toft et al. (2022) demonstrated that SIM resulted in a sustained improvement in team ACLS algorithm adherence during clinical practice for up to one year. Their participant group included an interprofessional team of internal medicine residents, nurses, RTs, and pharmacy residents.

2.5 Theoretical Framework

As the long term goal of this project was to promote and increase adherence to an EBP amongst ED staff, it was prudent to structure the project around a theoretical framework that offers an approach to EBP implementation. The Iowa Model: Evidence-Based Practice to Promote Quality Care focuses on knowledge-focused triggers to implement a change in practice (Hanrahan et al., 2019). Knowledge-focused triggers are opportunities within clinical practice for EBP change to occur according to national and organizational guidelines (Green, 2020). The identified knowledge focused trigger of failing to adhere to the ACLS guideline of utilizing ETCO2 for CPR quality monitoring prompted the hospital's Resuscitation Committee (RC) and the project lead to consider ETCO2 monitoring a priority EBP change project.

To begin evidence-based project development to promote quality resuscitative care in the ED using the IOWA model framework for project development, the lead researcher identified a knowledge-focused issue and developed a PICOT question. The topic of ETCO2 utilization in cardiac arrests became a priority for the RC. After processing the research, the project lead determined desired outcomes, assembled, critiqued, and synthesized relevant and related to determine practice interventions, collected baseline data, and designed, implemented, and evaluated evidence-based interventions.

Since various clinical researchers have found the IOWA model to be "useful for guiding clinicians from a clinical problem to a sustainable EBP change" (Hanrahan et al., 2019, p. 122), and as ACLS is a national guideline lacking adherence in the project site's ED, the IOWA model was determined to be the best framework of choice to guide this particular project.

Overall, literature showed positive results regarding HFS effects on an interdisciplinary team's resuscitation self-efficacy and ACLS adherence in clinical practice. Skills retention, CPR quality, and skills adherence was measured from as little as two weeks to up to one year post intervention, though retention collectively was either no longer significant or decreased six months post intervention. As the project setting has demonstrated poor adherence to nationally recommended guidelines involving cardiac arrest, an EBP change through a QI project had to be made a priority. For the project lead to become more familiar with proper EBP practice change and implementation, an established theoretical framework had to be identified and followed to guide the QI project.

CHAPTER 3: METHODS

The project lead designed a pre-post intervention QI DNP scholarly project involving HFS adult cardiac arrest scenarios evaluating ED staff resuscitation self-efficacy and post-SIM retrospective review of ETCO2 device utilization in ED adult cardiac arrest resuscitations.

3.1 Project Design

Following the guide of the IOWA model, the project lead formed a team of identified stakeholders, assembled, and reviewed systematic literature review, and finalized and implemented the project design. Implementation of this QI DNP scholarly project included HFS adult cardiac arrest scenarios evaluating short term resuscitation self-efficacy with long term post-SIM retrospective review of clinical ED adult resuscitations. Resuscitation self-efficacy and ETCO2 device utilization during clinical resuscitations was conducted in a "pre/post intervention structure." The intervention included two ten-minute HFS exercises separated by a ten-minute didactic session comprised of a ten-slide PowerPoint presentation with hands-on skills demonstration for device attachment and data transmission. Surveys regarding resuscitation self-efficacy were provided on paper immediately prior to and after the HFS. The entire HFS session, including the didactic portion and time for survey completion, lasted one hour. Clinical ETCO2 device usage during ED cardiac arrests was collected pre and post HFS. The project was conducted over a period of five months, from August 2023 to January 2024, including two months of pre-intervention device usage data collection, an intervention week of HFS training, and three months of post-intervention device usage data collection.

3.2 Sample

The population of interest for this scholarly project was the site's ACLS-certified ED nursing staff and ED medical staff and RTs who are trained and familiar with ETCO2 utilization in cardiac arrest. The ACLS-certified ED nursing staff includes approximately 70 nurses, both registered (RN) and licensed practical nurses (LPN) as well as ACLS-certified ED paramedics. The ED has approximately 50 emergency medical practitioners who vary from medical doctors, doctors of osteopathy, nurse practitioners, and physician assistants. RTs also participate in cardiac arrests in the ED; however, while not every RT is ACLS certified, all are competent to use ETCO2 in cardiac arrest.

Inclusion criteria for the sample population included RTs, ED emergency medical practitioners, RNs, LPNs, and paramedics employed at the project site who work primarily in the ED. RNs, LPNs, and paramedics not certified in ACLS training were ineligible for participation in the project. While there are other ED teammates such as healthcare technicians (HCT) who may participate in clinical cardiac arrest scenarios, ETCO2 device utilization is not discussed in basic life support courses, thus they were also excluded from the sample as HCT's only cardiac arrest training is basic. Retrospective data analysis for ETCO2 utilization only occurred in adult (18 years or older) patients who have documented cardiac arrest and performed CPR.

Key stakeholders for this QI scholarly project included the RC leader, the Assistant Vice President (AVP) and nurse manager of the ED, the ED medical director, the AVP of RT, the SIM coordinator, and ACLS trained ED staff. Initial formal communication via a virtual option was performed with the various leaders to discuss the purpose of the project and implementation plan. Communication strategies to market the project to the staff were discussed and agreed upon with senior leadership.

Starting a month prior to the SIM experiences, the project lead sent electronic communication regarding the project objectives, participation involvement and expectations, and SIM dates and times, to eligible participants. Participants used the online event planning software application SignUp Genius to easily sign up for a SIM session date and time of their choice. An informational flyer with a QR code to the sign up genius was distributed via email, a weekly PowerPoint sent to the ED staff with process/practice changes and educational opportunities entitled Weekly Updates, at the ED huddle board, and the ED's Facebook page to reach as many of the staff as possible including those who were part time or per diem.

The project lead also promoted the project at department staff meetings. Marketing the SIM a month prior allowed staff to adjust their schedules so they were available to attend. Since department senior leadership preferred this educational opportunity to be recommended rather than required, it was important to schedule SIM sessions at the most opportune times to ensure staff availability. Times were determined from the department's educational needs assessments regarding the best perceived time for education to be provided. Thus, sessions were scheduled at 8:00 a.m., 11:00 a.m., and 2:00 p.m. throughout the scheduled week.

Staff was made aware of the one hour time commitment for the SIM and that the scenario was mock ACLS codes. A week prior to the SIMs, an email was sent to all participants signed up with instructions on SIM lab location, recommended attire, and the time of their session. A reminder one week prior was posted on the unit's Facebook page.

3.3 Setting

Implementation of this QI scholarly project was conducted at the project site. The project site is a tertiary care center with 457 licensed beds, the second-largest facility of the site's organization within the Greater Charlotte region. The site houses a SIM lab with SIM monitors, SIM resuscitation equipment, and HFS manikins. The HFS mock resuscitation experience for ED staff was conducted in the SIM lab. After the scheduled SIM experiences concluded, adult cardiac arrests that occurred in ED were retrospectively reviewed for ETCO2 device utilization.

The project site's ED is a 46-bed, level 3 trauma center with a county dedicated Emergency Medical Services agency. The ED has 4 resuscitation identified rooms, 45 identified cardiac arrests in 2022, and 97 identified adult cardiac arrests prior to the scheduled SIM sessions in 2023.

3.4 Intervention

The goal of the HFS experience was to improve resuscitative self-efficacy and demonstrate the benefits of continuous waveform capnography during cardiac arrest to increase adherence to device utilization amongst ED staff. Participants attended a one-hour SIM experience between September 27, 2023 and October 4, 2023. Staff completed a pre-SIM anonymous demographic survey (Appendix A) as well as the RSES (Appendix B). A formal pre-brief was conducted for each session to review the HFS mechanics and a simulated report regarding the manikin was given to provide participants with an understanding of the manikin's medical condition. The pre-brief established that the SIM was a learning opportunity and not punitive. Staff then performed an uncoached 10-minute cardiac arrest scenario without the ETCO2 device. The project lead evaluated all high-quality CPR components via the Laerdal Session Viewer.

Following the first scenario, the project lead conducted a formal debrief with didactic education. Participants had an opportunity to discuss algorithm adherence, what they felt went well, and what they felt they could do better. The project lead reviewed the staff's high-quality CPR components measured by the simulator via the Laerdal Session Viewer. These components included compression rate, compression depth, ventilation rate and tidal volume, and chest compression fraction. The concept of waveform capnography including its evidence-based importance during cardiac arrest was reviewed along with the ETCO2 device and device application. Defibrillator data transmission steps and 2023 ED cardiac arrest data was also reviewed.

Immediately following the didactic session, a second SIM was conducted. The same report as the first session was given and the staff again performed the uncoached 10-minute cardiac arrest scenario. The project lead again evaluated all high-quality CPR components. It was expected that staff during the second scenario would apply the ETCO2 device. Once the ETCO2 device was applied, the project lead manually dropped the ETCO2 level to a pre-established amount whenever high-quality CPR component(s) were not met. Following conclusion of the second scenario, the project lead once again reviewed the staff's high-quality CPR components measured by the simulator in comparison with the first scenario. A formal debrief again occurred and lastly, participants completed a post SIM RSES scale. Finally, following successful SIM session completion on October 4, 2023, ETCO2 utilization during ED adult cardiac arrests was tracked for three months from October 5, 2023 to January 5, 2023.

3.5 Measurement Tools

HFS participants were anonymously surveyed to determine the following demographic information: role in AHEC ED, years of resuscitation experience, resuscitative certification, and previous HFS experience. The measurement tool used to collect the ED staff's self-perceived capability to execute proper resuscitative care prior to and following conclusion of the HFS session was the RSES. The RSES includes 17 items divided between 4 components: recognition; debriefing and recording; responding and rescuing; and reporting. Participants self-reported each item via a 5-point Likert scale that ranged from 1 (least confident) to 5 (very confident) (Roh et al., 2012). Permission to use the RSES was requested and permission to use the RSES was obtained in March 2023 (Appendix C, Appendix D).

The LifePak 15 defibrillator with CodeStat transmission capability was used to collect device application (whether applied or not) in ED clinical adult resuscitations post HFS. CodeStat is a data collection application that receives real-time resuscitation data for retrospective resuscitation quality review.

Simulated high-quality CPR performance metrics were measured during both mock codes (one with the ETCO2 device and one without) and shared with the participants to demonstrate how ETCO2 levels can prompt the resuscitative team to adjust their CPR techniques and maintain quality in cardiac arrest scenarios. The measurement tool that was used to collect simulated high-quality CPR performance metrics was the Laerdal SimMan patient simulator software and viewed via the Laerdal Session Viewer. However, as the long term goal of this project was to promote and increase adherence to the EBP of ETCO2 device utilization and not BLS performance metrics, session metrics were not included in data analysis for this project.

3.6 Data Collection Procedure

The project lead tracked ETCO2 device utilization in clinical ED adult cardiac arrests prior to the SIM sessions, from August 1, 2023 to September 26, 2023, utilizing the CodeStat data application which displays transmitted Lifepak 15 cardiac arrest data. Of 17 adult cardiac arrests identified during that time, 11 had transmitted data showing only 2 had utilized the ETCO2 device. Starting on September 27, 2023, prior to beginning each SIM session, demographic surveys and two copies of the RSES were provided to each participant. Participants were instructed to complete the demographic survey and first copy of the RSES prior to the SIM. Immediately following each SIM session, the participants were instructed to complete the second RSES and turn in all three papers to the project lead. All demographic surveys and pre-SIM/post-SIM RSES had been collected by the last day of the SIM sessions on October 4, 2023. ETCO2 device utilization in clinical ED adult cardiac arrests was then tracked by the project lead using the CodeStat data application to review Lifepak15 transmitted ED adult cardiac arrest data from October 5, 2023 to January 5, 2024.

3.7 Data Analysis

Once data collection was completed, the project lead analyzed the following: mean comparison of pre HFS and post HFS RSES scores and pre/post HFS mean comparison of ETCO2 device utilization in clinical ED cardiac arrests. Data from the secure data spreadsheet file was transferred into an SPSS file format. IBM SPSS Statistics version 28 was used as the data analyzation software. As the method for this QI scholarly project was pre/post in nature, paired t tests were performed for each comparison being analyzed.

3.8 Ethical Considerations

Institutional review board (IRB) approval was obtained for this project from both the project lead's educational institution, the University of North Carolina at Charlotte (IRB 23-0961) and the project setting's overseeing organization, AH Wake Forest Baptist (IRB00100167). As this scholarly project is QI, consent for this project was obtained verbally. A disclaimer of Project Information and Participation was available for participants to review.

To maintain anonymity, each participant randomly selected a number between 1-100 that they used to mark their pre and post RSES. The participant used that randomly assigned number to mark the demographic survey. Each number was used only once. Survey answers were separate from the demographic survey. The de-identified demographic data was described separately for general population data. Participants' names were collected to validate worked time for their leadership, but no session information or study data was shared with their leadership and participants' names were not collected for study data. Participants' work telephone numbers and full-face photographic images were accessible to the project lead via the electronic mail addresses, but this information was not collected for study data.

The project lead collected all surveys and manually inputted the physical responses into a secure electronic data file that is located behind an AH fire wall. At all times, the original physical responses were kept secured either in a locked file cabinet or under direct observation of the project lead (for example, when entering the responses into the secure electronic file). Physical copies were kept for a month and then destroyed. The electronic data was stored in a secure data file set in the secured personal network drive behind the AH security system that was only accessible to the project lead via username and password. The only participant identifier was previously described (random number for paired t-test; demographics not linked to number).

AH collected retrospective CPR data for regulatory compliance and QI purposes and the project lead analyzed the retrospective data of CPR quality for ETCO2 device utilization. The retrospective data included the date, time, and hospital the code occurred, ETCO2 capnography and capnometry, chest compression fraction average, external compression impendence waveform and rate, ventilation rate, and time of pauses in CPR. The data currently resides in a secure AH resuscitation data application called CodeStat. This data was not, nor will it be, linked to individual patient accounts for the purposes of this project. Since LifePak 15 defibrillator activity was transmitted into CodeStat and post clinical resuscitation is routinely abstracted by internal site clinical nurse leaders to meet regulatory standard, determination of ETCO2 device utilization can be included in this quality review. CodeStat database automatically assigns a unique code for each retrospective quality data set. These are not in any way linked to a medical record number or personally identifiable information. CodeStat also labels the device ID that was used for each event.

In conclusion, this pre-post intervention designed QI DNP scholarly project included high-fidelity adult cardiac arrest SIM scenarios evaluating resuscitation self-efficacy and post-SIM retrospective review of ETCO2 device utilization in ED adult cardiac arrest resuscitations. IRB approval was obtained for this project and the project was conducted over a period of five months at the project site's SIM lab. Participants in this project included an interdisciplinary team of emergency medical professionals trained and familiar with ETCO2 utilization in cardiac arrest. The goal of the HFS experience was to improve participants resuscitative self-efficacy and to increase ETCO2 device utilization amongst ED staff.

CHAPTER 4: PROJECT RESULTS

Results of this QI DNP project include improved resuscitation self-efficacy amongst HFS participants and ETCO2 device utilization in ED clinical cardiac arrests. However, only improved participant resuscitation self-efficacy was found to be statistically significant.

4.1 Sample Demographic Information

28 individuals participated in the HFS portion of this quality improvement project. Of the 28 individuals, 82.1% were registered nurses and 17.9% comprised of paramedics, emergency medical providers, and respiratory therapists. Years of experience amongst the participants varied from less than one year of experience to 20 or more years of resuscitative experience. 42.8% of the participants had one-five years of experience, with one-two years of experience and three-five years of experience both equaling 21.4%, the highest percentages of the sample. All participants had active certifications in both BLS and ACLS. 71.4% of participants have participated in a HFS session prior to this project's simulation and 28.6% had never participated in HFS prior to this educational session. See Table 1 for sample demographic information.

Table 1

HFS Participant Demographics

Demographic Categories	Frequency	Percentage
Role		
Registered Nurse	23	82.1
Non-Nurse (Paramedic, DO, RT)	5	17.9
Years of Experience		
<1 year	4	14.3
1-2 years	6	21.4
3-5 years	6	21.4
6-10 years	5	17.9
11-15 years	4	14.3
16-19 years	0	0
≥ 20 years	3	10.7

Table 1 (continued)

HFS Participant Demographics

Active Certifications		
BLS	28	100
ACLS	28	100
Prior HFS Participation		
Yes	20	71.4
No	8	28.6

4.2 Results of Resuscitation Self-Efficacy Scale (RSES)

After the HFS, a paired-samples t-test was run to determine if resuscitation self-efficacy had significant improvement. Paired-samples t-test results showed a significant change from pre-HFS RSES average total score (*M*= 3.99, *SD*= 0.59) to post-HFS RSES average total score (*M*= 4.52, *SD*= 0.44), t= 6.83, $p < .001$. Individual pre-HFS and post-HFS RSES items showed significant improvement on all with the exception of item numbers 1 (*M*= 4.54 to *M*= 4.71, p = .134), 4 (*M*= 4.39 to *M*= 4.64, p = .050), and 10 (*M*=4.46 to *M*=4.57, p = .264). While these three items did not show statistical significance in improvement, there was a noted clinical improvement for each item during the HFS. Individual item improvement that had the highest statistical significance ($p < .001$) included items 5, 6, 7, 12, 13, 14, 15, and 17. Items 12 (demonstrates correct management of defibrillator) and 13 (explains clinical findings and lab values) were of particular importance as the ETCO2 device must be applied to the defibrillator and the ETCO2 value must be explained in clinical arrests to adjust high-quality CPR tactics. Excitingly, while there was a mix of participant resuscitative experience and ED role difference, participant ED role difference did not impact statistical significance of RSES improvement (ps > .590). See Table 2 for RSES pretest and posttest comparison of each question and the total score.

Table 2

RSES Pretest-Posttest Comparison with Total Score

RSES Item	Pretest	Posttest	p value
1. Demonstrates correct measurement, interpretation and documentation of vital signs	4.54 (0.69)	4.71 (0.46)	.134
2. Initiates relevant patient monitoring (electrocardiogram, pulse oximeter)	4.54 (0.64)	4.68 (0.48)	.043
3. Recognizes signs and symptoms of a critical event	4.11 (0.79)	4.54 (0.58)	.001
4. Demonstrates a focused assessment following the ABC (Airway, Breathing, Circulation) principles	4.39 (0.69)	4.64 (0.49)	.050
5. Performs debriefing or problem solving after the event	3.71 (0.90)	4.50 (0.64)	< .001
6. Completes quality improvement documentation	3.32 (0.82)	4.04 (0.79)	< .001
7. Demonstrates staying calm and focusing on required tasks	3.82 (0.98)	4.54 (0.64)	< .001
8. Performs re-assessment or re-evaluation	4.07 (0.72)	4.57 (0.63)	.001
9. Performs cardiopulmonary resuscitation according to resuscitation algorithm	3.68 (1.12)	4.32 (0.61)	.003
10. Demonstrates effective chest compressions (hand placement, depth, speed)	4.46 (0.69)	4.57 (0.57)	.246
11. Demonstrates effective bag valve mask ventilations (volume, minute volume, pressure, etc.)	4.07 (0.81)	4.57 (0.57)	.001
12. Demonstrates correct management of defibrillator	3.29 (1.18)	4.36 (0.68)	< .001
13. Explains clinical findings and critical lab values	3.75 (0.89)	4.50 (0.69)	< .001
14. Provides appropriate messages and information to resuscitation team member	3.61 (0.83)	4.46 (0.64)	< .001
15. Utilizes resources and external experts	3.82 (0.98)	4.57 (0.63)	< .001
16. Demonstrates use of appropriate means of communication according to the hospital's policy	4.07 (0.98)	4.57 (0.69)	.004
17. Understands when to call for help	4.61 (0.50)	4.75 (0.44)	.043
Total score	3.99 (0.59)	4.52 (0.44)	< .001

4.3 Clinical Cardiac Arrest Event Information

Prior to HFS sessions, 15 total adult cardiac arrest events with documented CPR occurred in the ED. Of these 15 events, 10 were transmitted into CodeStat for analysis of device utilization. Two of the 10 analyzed events utilized the ETCO2 device (20%). Following the HFS session, 31 total adult cardiac arrest events with documented CPR occurred in the ED. Of these 31 events, 20 were transmitted into CodeStat for analysis of device utilization. Nine of the 20 analyzed codes utilized the ETCO2 device (45%). See Table 3 for clinical cardiac arrest event information pre- and post-SIM.

Table 3

Clinical Cardiac Arrest Events

Events	Total Events	Transmitted Events	Utilized ETCO2	Utilization Percentage
PreSIM	15	10	2	20
PostSIM	31	20	9	45

4.4 Results of ETCO2 Device Utilization

After completion of data collection, a two-tailed paired-samples t-test was performed regarding ETCO2 device utilization from transmitted CodeStat data pre- and post-HFS. Results did not show significant change in ETCO2 device utilization preSIM (*M*= 0.200, *SD*= 0.42) to postSIM (*M*= 0.500, *SD*= 0.53), t= -1.96 (9), p = .081. The mean difference was -.300 [95% CI: -.646, -.046]. See Table 4 for ETCO2 device utilization results pre- and post-HFS.

Table 4

ETCO2 Device Utilization Pre-Post HFS

ETCO2 Device	PreSIM	PostSIM	p value
Utilized	0.200 (0.42)	0.500 (0.53)	.081

CHAPTER 5: SIGNIFICANCE AND IMPLICATIONS

This QI DNP project demonstrated increased levels of resuscitation self-efficacy as reported by participants after completing an ACLS oriented HFS which mirrors the findings of similar studies. However, skills adherence in clinical cardiac arrest situations was not found to be significant as in other studies involving HFS, self-efficacy, and skills adherence.

5.1 Discussion and Interpretation of Results

Simple changes to high-quality CPR technique can improve patient survival rates and using ETCO2 levels as a real-time measurement for high-quality CPR can lead to real-time technique adjustments (McCoy et al. 2019, p. 16; Sandroni et al., 2018; Sota, 2021). However, adherence to attaching the ETCO2 device for monitoring is a known issue in the project site's ED amongst the interprofessional team. To promote adherence to device utilization, resuscitation self-efficacy improvement and skills practice for knowledge retention can be impacted by HFS (Al-Kalaldeh & Al-Olime, 2022). Additionally, HFS can positively influence ACLS skills adherence, including ETCO2 device utilization, in clinical cardiac arrest situations (Toft et al., 2022). For this project, resuscitation self-efficacy and clinical skills adherence via ETCO2 device utilization post HFS were addressed.

Self-efficacy is the confidence one has to perform actions needed to successfully accomplish a task (Kim, 2018). In this project, participants reported higher levels of resuscitation self-efficacy after participating in an ACLS-oriented HFS than prior to participation, and the scores were significantly improved. These results further demonstrate that HFS positively impacts overall self-efficacy regarding technical skills. While all items of resuscitation self-efficacy improved, there was no significant improvement in 3 of the 17 items "demonstrates correct measurement, interpretation, and documentation of vital signs;" "demonstrates a focused assessment following the ABC (airway, breathing, circulation) principles;" and "demonstrates effective chest compressions (hand placement, depth, speed)". However, some of the most significant individual item improvement was pertinent to ETCO2 device application and utilization, including "demonstrates correct management of defibrillator," "explains clinical findings and critical lab values," and "provides appropriate messages and information to resuscitation team member."

Enhanced SIM curriculums regarding cardiac arrests have been shown to significantly impact ACLS skills adherence (Toft et al., 2023). Unfortunately, unlike these studies demonstrating significant skills adherence in clinical cardiac arrest situations, this project did not demonstrate a significant adherence to utilizing the ETCO2 device in adult clinical arrests which may be due to the HFS participant and clinical cardiac arrest sample size. While there was not a demonstrated statistical significance in this project's results, ETCO2 device utilization increased to almost 50%, which is clinically significant for emergency practice.

5.2 Limitations

Limitations for this scholarly project included the small sample size of both HFS participants and clinical cardiac arrests, lack of interprofessional participation, and technological limitations regarding code transmission. The intent of this project was to have a large number of ED interprofessional team members participate in the simulation, with sessions available to accommodate up to 140 participants. However, only 28 participants completed the simulation and surveys. This small sample size could be due to the lack of a mandatory requirement to participate from nursing leadership, as is the usual process for practice change within the department. Additionally, as the simulation needed to be completed outside of working hours but still onsite, nursing staff that live a considerable amount of time away were unable to attend. RT leadership was supportive of the project and encouraged staff to attend, however RT staff expressed that a lack of continuing education hours offered for this simulation was a deterrent to participation. Finally, the small sample size may have been a result of some communication and networking challenges with the emergency provider team.

While the amount of emergency clinical cardiac arrests is out of the project lead's control, retrospective code data transmission further limited the amount of inclusive clinical arrests to be considered for analyzation. 15 cardiac arrest events were identified pre-HFS, however only 10 were included for ETCO2 device utilization analysis due to having transmitted data. 31 cardiac arrests were identified post-HFS, however only 20 were included for the same inclusion reason. Regarding limitations with data transmission, the defibrillators that collect the cardiac arrest quality data must have a teammate manually transmitting the data. The expectation is that once the code has completed, the teammate should push a button on the defibrillator to connect the defibrillator with the CodeStat server. However, due to limited HFS participation, if the code team members were not present at the HFS, they may not have the knowledge to transmit the data. Archived data can be transmitted; however, the defibrillator used will only store up to 90 minutes of code data. Thus, if 90 minutes of archived data is not transmitted, any new data collection will permanently delete and replace non-transmitted archived data.

5.3 Recommendations

This project further supports similar studies that compare HFS effect on resuscitation self-efficacy compared to the traditional lecture style. Historically, ACLS training does not utilize HFS for mock cardiac arrest scenarios, so it is recommended that HFS be incorporated into the course content to continue to promote the self-efficacy of its learners. At the project site, this implementation will be considered with the AHA coordinator to assist in improving resuscitative confidence across the facility. Additionally, this project has initiated an interest in developing future simulation experiences for orienting emergency nurses and respiratory therapists as a means to jumpstart interdisciplinary teamwork and respect.

5.4 Future Projects or Research

With the conclusion of this project not demonstrating significant clinical adherence to ETCO2 device utilization, projects with larger sample sizes must be conducted to further explore the impact of HFS and skills adherence in clinical practice. In regard to resuscitation self-efficacy, previous studies have compared the participant's self-evaluated confidence to the trainer's evaluation, finding that the trainer's scoring on perceived confidence was higher than the participant's own score HFS (Al-Kalaldeh & Al-Olime, 2022). Future projects could evaluate the impact of sharing the score comparison to further impact self- confidence. To explore the impact of HFS on interdisciplinary teamwork during a clinical cardiac arrest situation, future projects could focus on measuring perceived and observed team dynamics. Finally, with increased ETCO2 utilization, long term projects could explore the impact on patient survival rates when ETCO2 is utilized.

5.5 Summary

The goal for this project was to determine if HFS would impact ETCO2 device utilization in clinical cardiac arrests situations in conjunction with increased ED staff resuscitative confidence. The HFS sessions incorporated two identical adult cardiac arrest scenarios with a didactic portion in between. ETCO2 device utilization in ED clinical cardiac arrests was measured prior to and after HFS for skill adherence. It was shown that HFS does significantly increase emergency nurses, paramedics, RTs, and provider's resuscitative self-efficacy, however ETCO2 device utilization was not significantly impacted. HFS should be included in ACLS training to improve confidence in providing resuscitative care and further research needs to be conducted with larger sample sizes on HFS impacting ETCO2 device utilization. Continuing to improve best resuscitative practices through evidence-based interventions will lead to higher quality CPR and hopefully improved survival rates for cardiac arrest patients in emergency departments.

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APPENDIX A: DEMOGRAPHIC SURVEY

Assigned #__________ Date ________________

1. My role in the Emergency Department is… (Please choose one).
   - ☐ Registered Nurse (RN)
   - ☐ Licensed Practical Nurse (LPN)
   - ☐ Paramedic (EMT-P)
   - ☐ Respiratory Therapist (RT)
   - ☐ Medical Doctor (MD)
   - ☐ Doctor of Osteopathic Medicine (DO)
   - ☐ Physician's Assistant (PA)
   - ☐ Nurse Practitioner (NP)
2. I hold adult resuscitation certification via…. (Select all that apply).
   - ☐ Basic Life Support (BLS)
   - ☐ Advanced Cardiovascular Life Support (ACLS)
   - ☐ Other _______________________________
3. Years of clinical resuscitative experience
   - ☐ <1 year
   - ☐ 1-2 years
   - ☐ 3-5 years
   - ☐ 5-10 years
   - ☐ 10-15 years
   - ☐ 20+ years
4. I have previously participated in a high-fidelity simulation training experience
   - ☐ Yes
   - ☐ No

APPENDIX B: RESUSCITATION SELF-EFFICACY SCALE

Resuscitation Self-efficacy Scale

Resuscitation self-efficacy is defined as a judgment of perceived capability to organize and execute the process of care during resuscitation. Read each statement and then select the response that best indicates your level of agreement.

Item	1 Least confident	2	3 Neutral	4	5 Very confident
Recognition					
1. Demonstrates correct measurement, interpretation and documentation of vital signs	1	2	3	4	5
2. Initiates relevant patient monitoring (electrocardiogram, pulse oximeter)	1	2	3	4	5
3. Recognizes signs and symptoms of a critical event	1	2	3	4	5
4. Demonstrates a focused assessment following the ABC (Airway, Breathing, Circulation) principles	1	2	3	4	5
Debriefing and recording					
5. Performs debriefing or problem solving after the event	1	2	3	4	5
6. Completes quality improvement documentation	1	2	3	4	5
7. Demonstrates staying calm and focusing on required tasks	1	2	3	4	5
8. Performs re-assessment or re-evaluation	1	2	3	4	5
Responding and rescuing					
9. Performs cardiopulmonary resuscitation according to resuscitation algorithm	1	2	3	4	5
10. Demonstrates effective chest compressions (hand placement, depth, speed)	1	2	3	4	5
11. Demonstrates effective bag valve mask ventilations (volume, minute volume, pressure, etc.)	1	2	3	4	5
12. Demonstrates correct management of defibrillator	1	2	3	4	5
13. Explains clinical findings and critical lab values	1	2	3	4	5
Reporting					
14. Provides appropriate messages and information to resuscitation team member	1	2	3	4	5
15. Utilizes resources and external experts	1	2	3	4	5
16. Demonstrates use of appropriate means of communication according to the hospital's policy	1	2	3	4	5
17. Understands when to call for help	1	2	3	4	5

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APPENDIX C: REQUEST TO USE RESUSCITATION SELF-EFFICACY SCALE

Request to use Resuscitation Self-Efficacy Scale

Report

Katherine Judge an hour ago

Hello Dr. Roh,

My name is Katherine Judge, and I am currently a Doctor of Nursing Practice student at the University of North Carolina at Charlotte. My scholarly project focuses on supplemental high-fidelity simulation training to promote utilization of waveform capnography in clinical emergency department resuscitations.

I am writing to you today because I would appreciate obtaining your permission to use the Resuscitation Self-Efficacy Scale as a data collection tool for my scholarly project. The project will involve ACLS trained emergency nurses, physicians, and respiratory therapists participating in a high-fidelity simulation mock cardiac arrest. The participants will complete the scale prior to the simulation and then again after the simulation. The entire scale will be used in both instances and there will be no modification to the scale. Post simulation, clinical emergency department cardiac arrest data will be tracked to determine if there is an increase in the application of the waveform capnography device. The project is expected to be conducted at the end of this year with my final scholarly paper being completed for publishing by May 2024. My final paper will credit you and your colleagues as the developers of the scale.

I would truly appreciate your permission to use the RSES for my project and I appreciate your consideration.

I look forward to hearing from you,
Katherine

--
Katherine Judge, MSN, RN, CEN, TCRN
University of North Carolina - Charlotte | Doctoral Candidate
School of Nursing | Doctor of Nursing Practice - Post-Masters
m: (706) 614-1092 | e: kjudge@uncc.edu | Student ID: 800883409

Young sook Roh to you 13 minutes ago

Dear Katherine Judge,
Please see attached file.
Thank you
Young Sook Roh

RSES-Permission-9.docx

APPENDIX D: PERMISSION TO USE RESUSCITATION SELF-EFFICACY SCALE

23 March, 2023

Katherine Judge, MSN, RN, CEN, TCRN

Doctor of Nursing Practice student

University of North Carolina at Charlotte

Dear Katherine Judge

I give permission for you to use the Resuscitation Self-efficacy Scale for your research. Please just remember to cite us as appropriate.

All the best with your research.

Kind regards

Young Sook Roh, PhD, RN, CHSE Youngsook Roh

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