Training the Code Team Leader as a Forcing Function to Improve Overall Team Performance During Simulated Code Blue Events

by

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ABSTRACT

The American Heart Association (AHA) estimates that there are approximately 200,000 in-hospital cardiac arrests (IHCA) annually with low rates of survival to discharge at about 22%. Training programs for cardiac arrest teams, also termed code teams, have been recommended by the Institute of Medicine (IOM) and in the AHA's consensus statement to help improve these dismal survival rates. Historically, training programs in the medical field are procedural in nature and done at the individual level, despite the fact that healthcare providers frequently work in teams. The rigidity of procedural training can cause habituation and lead to poor team performance if the situation does not match the original training circumstances. Despite the need for team training, factors such as logistics, time, personnel coordination, and financial constraints often hinder resuscitation team training. This research was a three-step process of: 1) development of a metric specific for the evaluation of code team performance, 2) development of a communication model that targeted communication and leadership during a code blue resuscitation, and 3) training and evaluation of the code team leader using the communication model. This research forms a basis to accomplish a broad vision of improving outcomes of IHCA events by applying conceptual and methodological strategies learned from collaborative and inter-disciplinary science of teams.

DEDICATION

I dedicate this dissertation to my husband Bill and my children Charlie and Stella. Without your support, I could have never accomplished any of this and I will now leave my office and spend all my time with you three. I also want to thank my mom and my mother-in-law Patricia for all their help, moral support, and babysitting. Thank you with all my heart and I love you all more than words could ever describe.

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LIST OF ABBREVIATIONS

ABC	: Airway, Breathing Circulation
ACLS	: Advanced Cardiac Life Support
AHA	: American Heart Association
AHRQ	: Agency for Healthcare Research and Quality
AM*t*PM	: ASU-Mayo Team Performance Metric
ASU	: Arizona State University
CCT	: Cardiac Care Team
CCOT	: Critical Care Outreach Team
CM	: Crew Member
CPR	: Cardiopulmonary Resuscitation
CTL	: Code Team Leader
DOD	: Department of Defense
ECG	: Electrocardiogram
E-RRS	: Extended Rapid Response System
FAA	: Federal Aviation Administration
FCCS	: Fundamental Critical Care Support training
GWTG-R	: Get with the Guidelines-Resuscitation
ICU	: Intensive Care Unit
IHCA	: In-Hospital Cardiac Arrest
IHI	: Institute for Health Care Improvement
IOM	: Institute of Medicine
IRB	: Institutional Review Board
ITC	: Interactive Team Cognition
MD	: Medical Doctor
MERIT	: Medical Early Response & Interventions Therapy
MET	: Medical Emergency Team

MHPTS : Mayo High Performance Teamwork Scale

NP : Nurse practitioner

OSCAR : Observational Skill-Based Clinical Assessment Tool for Resuscitation

PA : Physicians assistant

PGY : Physician Graduate Year

r : Correlation Coefficient

RMRT : Rapid Medical Response Teams

RN : Registered Nurse

ROSC : Return of Spontaneous Circulation

RRS : Rapid Response System

RRT : Rapid Response Team

RT : Respiratory Therapist

SBAR : Situation, Background, Assessment, Recommendation

SCBE : Simulated Code Blue Event

SRN : Simulation nurse

SME : Subject Matter Expert

SMM : Shared Mental Models

TEAM : Team Emergency Assessment Measure

TeamSTEPPS : Team Strategies and Tools to Enhance Performance and Patient Safety

CHAPTER 1

INTRODUCTION

The American Heart Association (AHA) estimates that in-hospital cardiac arrests (IHCA) range from 3.8 to 13.1 per 1000 admissions (Morrison et al., 2013). This equates to roughly 200,000 cardiac arrests annually. In 2004, the Institute for Healthcare Improvement (IHI) launched the “100,000 Lives Campaign”. This promotion was a challenge to the healthcare community within hospitals to reinforce its obligation to make patient safety its highest priority (Berwick, Calkins, McCannon, & Hackbarth, 2006). The campaign identified three main concerns that needed to be improved upon during resuscitation events; failure to plan, failure to communicate, and failure to recognize a patient’s deteriorating condition (failure to rescue). To address these concerns, hospitals focused on implementing multidisciplinary teams trained in advanced cardiac life support (ACLS) that could hurry to the bedside of deteriorating patients with the intention of preventing respiratory and/or cardiac arrest leading to improve patient outcomes.

History of Code Blue Resuscitiation

When these teams are aiding patients in distress, the ABC (Airway, Breathing, Circulation) mnemonic specifies the sequence of steps necessary in the resuscitative effort. A brief historical review of this mnemonic begins with the management of the airway which, was first described in 1540 when Vesalius placed an artificial airway, a reed, into the tracheas of animals (Shiber, 2016). It was not until 1871 when tracheostomy tubes were used shortly followed by the use endotracheal tubes in 1889. One of the first modern day airway management papers was published back in 1958 and discussed the topic of how to minimization the complications of endotracheal intubation (Hamelberg, Welch, Siddall, & Jacoby, 1958).

Suggestions of resuscitative breathing efforts date back much further to 1300 B.C. with Hebrew midwives breathing for babies and references in the Old Testament about the Prophet Elisha reviving a child by putting his mouth on the child’s mouth and breathing life back into him (Trubuhovich, 2006). In the 1500’s Parcellus used a bellows to artificially breath air into the noses and mouths of patients. Also describing a method of artificially breathing, The Silvester Method involves an arm lift with chest and abdominal compression to simulate breathing. During the polio epidemic Drs. Elam and Safer used manual ventilation to breath for patients and coined the term *rescue breathing*; the Red Cross endorsed it in 1960 (Safar & Elam, 1958).

The use of cardiopulmonary resuscitation (CPR) and defibrillation as part of resuscitative efforts occurred in the beginning of the 17th century. Early accounts regarding the use of external cardiac compression by stimulating a dove's heart using a finger was documented by Harvey in 1628, again using cats in 1878, followed by its use with dogs by George Crile in 1904 (Hurt, 2005). Application of external chest compressions was documented by Keen, (1904) when human cases of successful return of a pulse following external cardiac compression was documented. Kouwenhoven, Jude, and Knickerbocker, (1960) published what is considered the landmark paper regarding the application of external chest compressions and the American Heart Association endorsed CPR in 1963. Defibrillation is defined as he use of a carefully controlled electric shock, administered either through a device on the exterior of the chest wall or directly to the exposed heart muscle, to normalize the rhythm of the heart or restart it ("defibrillation," n.d.). It's use dates back to 1775 when it was used on birds, followed by the first modern day defibrillation demonstrated by Zoll in 1956 and then a safer, more effective defibrillator developed in 1962.

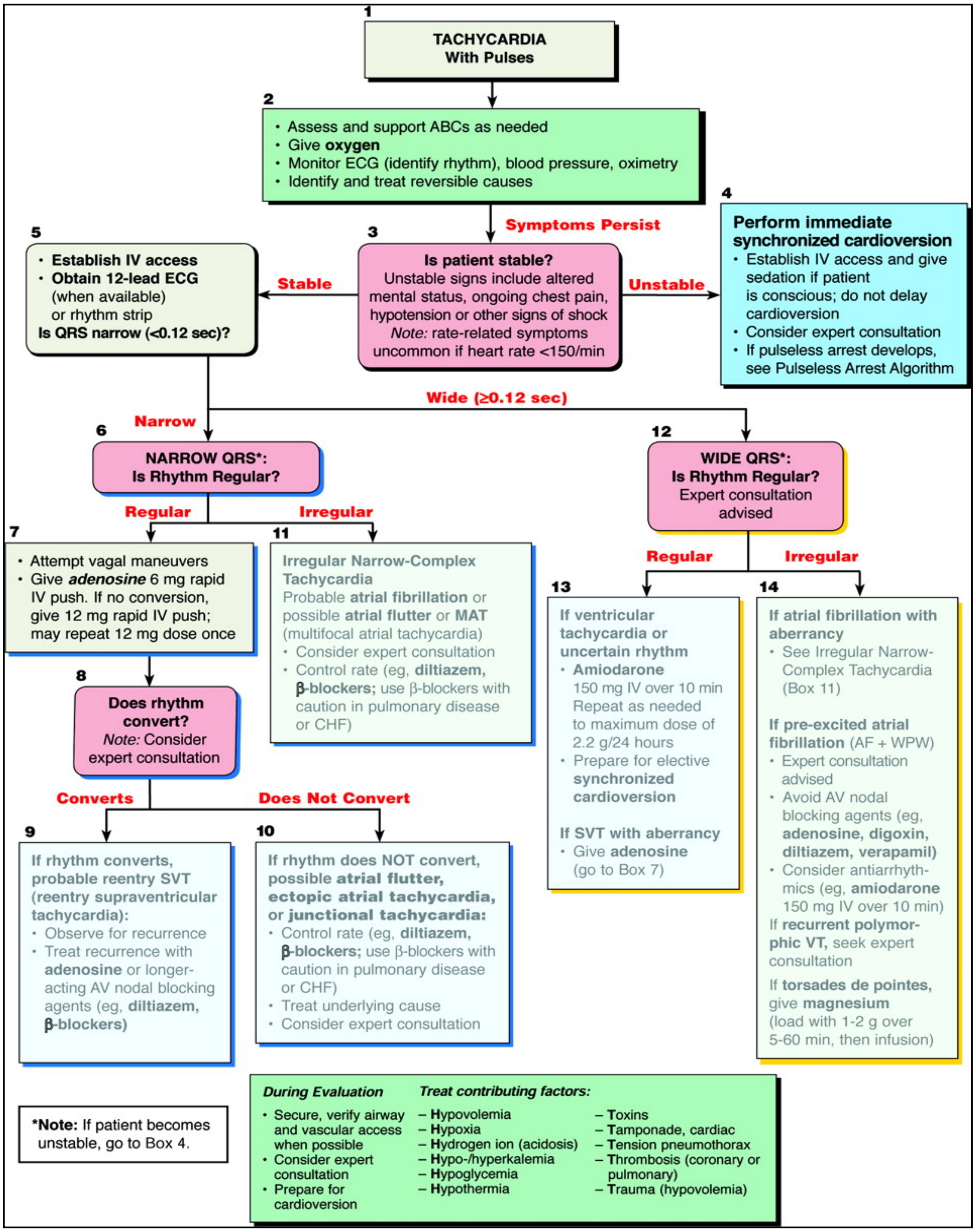
The first organized effort to respond to cardiac arrests can be traced back to Amsterdam in 1767 (Johnson, 1773). Authors suggested restraining from the current practices in resuscitation, such as, rolling a body over a cask or hanging the drowned person from their feet to allow the water to be expelled the body and instead recommended alternative therapies such as; forcing air into the drown person's mouth, tickling the person's throat, and stimulating breath by the fumigation of tobacco smoke into the person's airway. Advanced cardiac life support (ACLS) was developed in 1979 at the Third National Conference on CPR and consisted of formalized steps and sets of interventions involved in the treatment of a patient near or in cardiac arrest. The ACLS certification involves training in airway management, reading and interpreting electrocardiograms (ECGs), placing intravenous access, and understanding emergency pharmacological treatments. Typically, possession of the ACLS certification is required to be a member of a hospital's resuscitative team.

In the hospital setting, organized teams are *ad hoc* teams used to respond and assist patients requiring resuscitative efforts. These teams are referred to as many things, such as: cardiac code teams, code teams, code blue teams, medical emergency team (MET), rapid response team (RRT), rapid medical response team (RMRT), cardiac care team (CCT), critical care outreach team (CCOT), extended rapid response system (E-RRS), and a rover team, but no common name to describe these team has been adopted (DeVita, Schaefer, Lutz, Wang, & Dongilli, 2005). For consistency, we will refer to these teams as code teams. Outcome measures regarding performance and efficacy of these code teams are typically mortality rates at discharge, the reduction of cardiac arrests occurring outside of the intensive care unit (ICU), and reduction of patients transferred to the ICU. The data on team performance is focused on patient outcomes and does not suggest any true measurement of the team's performance.

Despite advances in the science of cardiopulmonary resuscitation over the past several decades, the odds of neurologically intact survival from in-hospital cardiac arrest (IHCA) remains low (Clarke, Carolina Apesoa-Varano, & Barton, 2016). Successful resuscitation following IHCA requires the immediate and coordinated efforts of multiple providers, often with different types of training and levels of experience in dealing with IHCA. Although resuscitation guidelines, such as ACLS, provide a logical, sequential, algorithmic approach (see Figure 1), it mainly emphasizes technical tasks performed by individual rescuers and does not address issues involving a team (Kohn, Corrigan, & Donaldson, 2000).

Several solutions have been offered to improve interdisciplinary training from the team strategies and tools to enhance performance and patient safety (TEAMSTEPPS) to simulation-based training (Han et al., 2014). Code team training programs that incorporate simulations have been recommended by the Institute of Medicine (IOM) since 1999 and reinforced in 2013 with the AHA's consensus statement for improving cardiac resuscitation outcomes (Kohn, Corrigan, Donaldson, America, & (U.S.), 2000; Meaney et al., 2013).

Figure 1 Example of ACLS Algorithm from “Part 7.3: Management of Symptomatic Bradycardia and Tachycardia,” (2005).



Conclusion

Clearly the history of rescucitation is extensive but the outcomes have not proved idyllic. Despite hospitals incorporating these strategies, the quality of team performance continues to be variable and teamwork deficiencies exist. Therefore, the primary purpose of this dissertation was to evaluate code team performances in the simulated setting to develop a way to improve the team's performance. To do this a performance metric was developed that evaluates the code team based on the team's performance, taking into account factors that promote better patient outcomes. Although the AHA mandates a metric for team responses to IHCA as part of the "Get with the Guidelines" it contains a scarcity of data related to teamwork and the team's performance during the code response (Bradley et al., 2012). The new metric was used to devise a training program, targeting weaknesses identified by the metric. Following training, evaluation of the team's performance during a simulated code blue event (SCBE) was scored using the developed metric to determine if the training improved team performance.

CHAPTER 2

BACKGROUND LITERATURE

What is a Code Team?

To determine efficacy of a team one must define what a team is, the tasks it performs, and what is needed to measure team performance. Swezey and Salas (1992) define a team as a "distinguishable set of two or more individuals who interact dynamically, adaptively, and interdependently; who share common goals and purposes; and who have specific roles or functions to perform" (pp. 3-29). As previously stated, these teams are referred to as many things, such as: the medical emergency team (MET), rapid response team (RRT), rapid medical response team (RMRT), code teams, code blue teams, cardiac care team (CCT), critical care outreach team (CCOT), extended rapid response system (E-RRS), and a rover team, but no common name to describe the team has been adopted (DeVita et al., 2005). Whereas the purpose of code teams is reasonably distinct, team composition, member roles, and responsibilities of members are mentioned fleetingly in a majority of the research regarding the efficacy of the teams. Currently, ideal team member composition is not mentioned in any study and the team's tasks can vary.

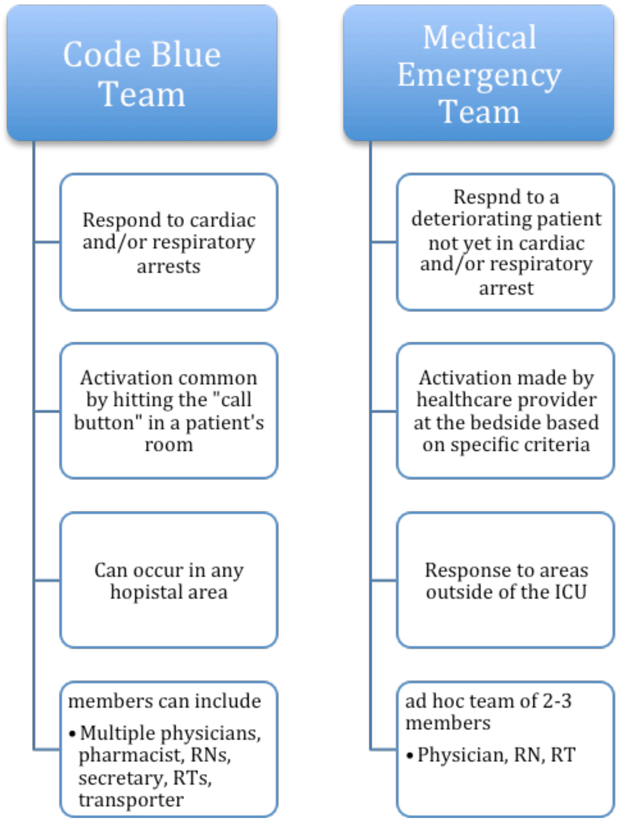
Code teams are *ad hoc* teams, not intact teams, so determining a training strategy that is best suited to improve team performance is difficult. Because of the *ad hoc* nature of these teams it is also a logistic challenge in training an entire team all at once. By definition code team formation and response within hospitals involves "a rapid formation, abbreviated lifespan, and often limited experience working together previously" (Weaver, Dy, & Rosen, 2014). Whereas most code teams are organized in hospitals based on the member's level of education (the physician is the team leader, the respiratory therapists assist the resident with the airway, the pharmacist gets the medications) individual team members could have limited or no experience working together on the code team. *Ad hoc* code teams are associated with poor performance in terms of critical care processes, such as CPR performance and timely defibrillation (Rea, Olsufka, Yin, Maynard, & Cobb, 2014; Marc et al., 2009).

Code teams are typically used, if not exclusively, to respond, assess, and provide medical care to a patient experiencing a medical crisis. Code teams are usually large *ad hoc* teams of nine to ten members that respond following an overhead call out for a “code blue” when a patient is already in respiratory and/or cardiac arrest. The medical emergency team (MET) is a bit different in composition and purpose. First described in groundbreaking work from researchers in Australia, the intended objective of the MET was responding to emergency calls where it was determined, based on specific trigger criteria, a patient’s condition was deteriorating but, has not yet reach respiratory and/or cardiac arrest (Lee, Bishop, Hillman, & Daffurn, 1995). Although not consistently described in the literature, members of these teams routinely include doctors, registered nurses (RN), and respiratory therapists (RT) with advanced life support skills who are capable of providing critical medical care to a patient whose condition was worsening.

The idea that some sort of a rapid response system (RRS) initiating a response from a MET to help a patient differs from the historical use of the “code blue team” that responds when a patient is already in full respiratory and/or cardiac arrest. Because of the distinction in team member numbers and patient status response criteria these two teams are compared in in Figure 2. Both are interdisciplinary teams that respond to medical emergencies and usually only respond to areas located outside the intensive care unit (ICU) environment. Outcome measures of team effectiveness are typically patient focused and are commonly mortality rates at discharge and reduction of cardiac arrest occurring outside of the ICU. Neither of these standards actually quantifies the entire team’s performance and furthermore, neither identifies areas of deficiencies where performance can be improved with training interventions. Code teams are a special kind of *ad hoc* medical team, forming quickly, working in stressful situation, with little time to reflect on team performance following a code response. These characteristics present both an evaluation and training challenges. It is likely a specific metric coupled with a special type of training will be needed to improve team performance.

Figure 2

Code team members compared with medical emergency team members



RN – Registered nurse
RT – Respiratory therapist

Empirical Evaluation of Code Teams

Evaluation of a code team should be centered on the purpose and objective of the team not just a patient-based outcome metric. For instance, to determine and evaluate the impact medical teams had on the IHCA rate for non-ICU patients, referred to in this article as a rapid medical response team (RMRT), researchers out of California retrospectively compared before (preRMRT) and after (postRMRT) data to determine if a reduction in code occurrences in non-ICU patients following RMRT implementation could be demonstrated (Gould, 2007). In addition to non-ICU code rates, outcome measurements used in this research included mortality rates and unplanned transfers of patients into the ICU. The RMRT consisted of an ICU charge RN whose role was team leader and an RT who was responsible for the respiratory needs of the patient. No physician was designated on the team, but the article suggested one would be available if called for consultation. The patient's primary RN would remain at the bedside while the RMRT assessed the patient but their role, if any, in the RMRT was not defined. Training and education regarding the RMRT seemed procedural and consisted mainly of understanding the logistics and objectives of the RMRT with no apparent focus on team training. The article pointed out the importance of communication regarding the initial call to activate the RMRT and suggested that failure to communicate led to many adverse events. This offers a potential area of focus for training. The data only included RMRT responses to the bedside of non-ICU patients. The study found a decrease in non-ICU code rate from 92 to 79 following RMRT implementation however, the overall mortality rate was unchanged.

At times, teams are used not as a typical code team, but more as a code prevention team. Although emergency patient care is the general commonality between the medical teams, some have additional responsibilities. Nevertheless, most determinations of efficiency are patient-status based. Shearer et al. (2012) carried out a study across four metropolitan teaching hospitals in Melbourne, Australia to identify patients who met the physiological criteria or triggers for activation of the MET but, for whom the team's response was not activated. This situation is termed a "missed RRS call". This data collection was accomplished by a patient chart review between 1-hour periods and compared the patient charts to the previous 24 hours of observation. A strength of this study was that the researchers were specific in their methods and excluded the patient population that was already in a critical care environment (ICU, emergency room, operating room). Chart evaluation for all unplanned ICU admissions and cardiac arrests during an eight-week time period was reviewed to identify any patients who met the code team call criteria for a minimum of four hours in the previous 24-hour period to cardiac arrest or ICU admission. Qualitative data was obtained by interviewing the clinical staff involved in all of the "missed RRS calls" to help determine the barriers to MET activation. Five hundred and seventy charts were reviewed with 23 patients fulfilling MET call criteria. However, only 13 MET calls were activated, meaning 10 patients met the call criteria but the team was not activated. From the interviews, which were very limited, the researchers identified sociocultural factors and intra-professional hierarchies, such as feeling they had the situation under control, no ICU bed available, and poor communication by the medical team, as reasons why the call was not made and the MET was not activated.

In an attempt to overcome the theme of delayed activation and underutilization of code teams as exhibited in the research published by Gould, 2007; Howell et al., 2012; and Shearer et al., 2012, researchers from an 813-bed tertiary teaching hospital in Seoul, Korea examined the hypothesis that more patients could be saved if the code team was activated in an automatic manner (Kwak et al., 2014). The Hanyang Rapid Response Team (HaRRT), likely named after the Hanyang University Hospital where the research was performed, is described as an extended rapid response system (E-RRS) that searches for patients at risk of deteriorating or coding, rather than wait for a RRS activation to initiate a response. Using a computerized alert system with a electronic chart sharing system, lists of patients perceived as “at-risk” were identified based on the typical code team activation criteria using abnormal vital sign criteria along with laboratory findings and clinical manifestations. The E-RRS could either be activated by an emergency call from the primary medical personnel attending to the patient or activated by the screening from an E-RRS team member. The team was available during the hours of 07:00 a.m. to 8:00 p.m. daily and consisted of an intensivist, an interventional cardiologist, an internal medicine resident, and an ICU RN. There was also a night duty (8:00 p.m. to 7:00 a.m.) internal medicine resident that called the rest of the team in if needed during evening hours. For a 2- year period IHCAs were evaluated; with the first year considered the prior to E-RRS implementation and the second year the E-RRS was in place. The paper suggests that a typical code team was not in place prior to the implementation of this E-RRS. The E-RRS missed 22 IHCAs but with the way the team searches for at-risk patients using their criteria, it seems inherent that patients who go from stable to cardiac arrest could be missed. Moreover, software development needs accompanied with such a seemingly labor and staff intensive team seems unrealistic for wide spread implementation in an already logistically challenged realm of *ad hoc* code teams. Especially when some have suggested code teams do not reduce mortality and may just increase hospital costs with patients requiring a higher level of care following a code team response with the subsequent transfer of patients into the ICU (Young, 2010; Rashid et al., 2014).

In conclusion, despite the implementation of code teams in countless hospitals the overall survival from respiratory and/or cardiac arrest has remained unimproved for decades (Peberdy et al., 2003). Patient outcomes and a code team's effectiveness are likely connected. However, there is need to assess a team's performance independently of patient outcome in order to identify areas in which improvement is needed and the type of training needed to improve the team performance and conceivably lead to improved patient outcomes.

Challenges Involved with Training Code Teams

Training during ACLS courses describes the value of good team leadership, but no structured curriculum for leadership training currently exists. Although ACLS guidelines provide a logical and sequential algorithmic approach to resuscitation, they have mainly emphasized technical tasks performed by individual rescuers and have not addressed issues of adapting to the complex nature of most actual resuscitations. In fact, evidence that ACLS courses improve patient outcomes following IHCA is minimal (Hamilton, 2005; Semeraro, Signore, & Cerchiari, 2006; Mancini et al., 2010; Wolfe et al., 2014).

Training entire *ad hoc* code teams can be challenging with high costs, difficulty in coordinating a time that works for multiple team members, and pulling staff away from the bedside to perform simulated training. Simulation is regularly used in the healthcare setting to evaluate code teams (Mondrup et al., 2011). The advantages of simulated emergencies include: no patient risk, errors can be allowed to occur, psychomotor skills can be assessed, teamwork, leadership, and communication can be explored, and recording of the sessions is possible (Lloyd, Kendall, Meek, & Younge, 2007).The use of simulation has proven to be a powerful training strategy for team-based health care and provide excellent opportunities to improve team performance. It has been suggested that the use of high fidelity patient simulation has the biggest effect on improving physician education, which could lead to improved patient outcomes (Sahu & Lata, 2010). On the contrary, a recent study of simulation-based code training for physician team leaders found it yielded no significant improvement in the following key processes of cardiac arrest care: time to initiation of CPR, time to administration of cardiac medication and time to defibrillation (Han et al., 2014). This is an example of how just simply running codes is not training. Specific strategies must be applied in order to improve the team's performance. Specialized leadership training is more logistically attainable and practical way to conceivably influence and improve overall team performance. This type of training would not be the typical training seen currently in the literature, but instead a method of training the leader as a coordination agent who will subtly train other team members during codes. The leader is a constant in all code teams and leader specific training offers a viable option as a training strategy. Likely, an important component of this will be the leader's ability to coordination and effectively communication information to the entire team.

Measuring a code team's performance should include metrics for timing and sequencing of events coupled with the evaluation of behaviors that promote effective performance, not a measurement base exclusively on patient outcomes. Unfortunately, standardization of outcome measures for code teams does not exist. Further, the ability to generalize different studies in order to parse out a training strategy in high performing teams is difficult because the majority of research is from single-centered studies, the team member roles, responsibilities, and composition are different, or not defined, and the data elements are not standardized (Beitler, Link, Bails, Hurdle, & Chong, 2011; Chan et al., 2008; Cooper, Janghorbani, & Cooper, 2006; Hatler, 2009; Karpman et al., 2013; Kenward, Castle, Hodgetts, & Shaikh, 2004). In an attempt to overcome this problem, the Medical Early Response and Interventions Therapy (MERIT) study performed a cluster-randomized control trial that evaluated the MET system in 23 hospitals in Australia to determine whether a reduction in cardiac arrests, unplanned ICU admissions, and deaths occurred after its implementation (Chen, Flabouris, Bellomo, Hillman, & Finfer, 2008). As a note, the MET nomenclature is predominately used in studies out of Australia and will be used to identify the teams in this section. Based on the statistical analysis by the MERIT investigators, no significant reductions in the study categories were found. Because the MERIT used and compared before and after statistical effects following implementation of medical teams at numerous hospital systems it was thought the differences between facilities and how they implemented the medical teams could have skewed the data outcomes. To overcome this system dependent variable Chen, Flabouris, Bellomo, Hillman, and Finfer (2009) re-evaluated the MERIT data using linear and quadratic-modeling techniques to determine whether the statistical analysis tool used could alter the study findings. When regression modeling techniques were used to analyze the data, a reduction in cardiac arrests, unplanned ICU admissions, and deaths was seen following the implementation of the MET system.

Perhaps in one of the most comprehensive meta-analysis published regarding the efficacy of code teams to improve patient outcomes, 18 studies between January 1950 through November 31, 2008, which included a sample size of more than 1,200,000 admissions, aimed to assess the influence code teams had on overall hospital mortality rates (Chan, Jain, Nallmothu, Berg, & Sasson, 2010). A strength of this meta-analysis was its utilization of three inclusion criteria and search methods, which encompassed: data extraction standards, criteria used to assess the quality of a searched article, and data synthesis. Despite a reduction of 33.8% in non-ICU cardiopulmonary arrests, overall hospital mortality rates were unchanged following implementation of code teams. It should be noted that this meta-analysis included a pediatric patient category, which if isolated, did show a reduction in hospital mortality rates. The cause of pediatric IHCA is most commonly attributed to respiratory failure, which may contribute to misleading code team successes in mortality rate reductions (Berg, Nadkarni, Zuercher, & Berg, 2008). Further skewed success rate data in pediatrics may also be contributed to the lack of comorbidities in the pediatric population as compared to adults (Nadkarni et al., 2006). Code team evaluation may need to be evaluated based on hospital location and specialty, such as rural hospital versus urban trauma center, obstetrics, pediatrics, and the post-surgical patient population, to determine its true efficacy in mortality rate reduction.

At the time of its publication, research by Beitler et al., (2011) was one of the largest studies that demonstrated a reduction in mortality rates following implementation of code teams. The researchers hypothesized that an emphasis on using clinical judgment regarding patient condition along with activation criteria, such as a patient's vital signs, would lead to more activation of code teams, which in turn, could lead to improved clinical outcomes. Results showed a hospital-wide decrease in mortality from 15.5 to 13.74 per 1,000 discharges following code team implementation with the number of hospital deaths decreasing by 139. Non-ICU code rates also decreased following code team implementation dropping from 3.28 to 1.62 per 1,000 discharges.

This demonstrated improvement of outcomes following code team implementation is not typically seen in the literature (Chan et al., 2010). Chan et al., (2010) attributed the improvement in the Beitler et al., (2011) study to wide use and activation of code teams with contributing factors including: familiarity of the PGY-3 as team leader and salaried attending physicians promoting a culture of shared patient care responsibility. Another factor was the use of nurses' clinical judgment as a trigger to activate the code team which led to the nurses feeling "empowered". This suggests that sociocultural barriers exist as they relate to code team activation (Tee, Calzavacca, Licari, Goldsmith, & Bellomo, 2008). Stereotypic perceptions that professionals hold regarding members of other disciplines may increase the hierarchical divisions and have detrimental effects on inter-professional collaboration during a code team response (Mariano, 2006). This hierarchy in medicine should even be taken into account when training code teams.

Evaluation of efficacy of code teams should be an ongoing process and was demonstrated in a lengthy study in 2007 researchers evaluated the incidences, outcomes, and potentially avoidable causes of IHCA in an academic hospital with medical teams that had been in place for 16 years (Galhotra, DeVita, & Simmons, 2007). The data collection and event analysis for this study was done through an in-depth chart review.

The overall cardiopulmonary arrest rate did decrease from 5.4/1000 admissions to 3.26/1000 in the 2005 study year. However, only 26 patients survived to discharge and no mention of overall mortality rate compared the statistics of before RRS implementation was specified. Changes were made to help improve outcomes based on the findings of this study but none were related to team training limiting any possibility for its implementation in other hospital systems as a way to improve patient outcomes or team efficacy measures. However, with no formal training strategy mentioned, its usefulness as a tool to direct training the code team is diminutive and makes clear the need for formal team training.

Team Performance Measurement

As previously stated, outcome measures of code team effectiveness are typically mortality rates at discharge and reduction of cardiac arrest occurring outside of the ICU, neither of which suggest any true measurement of team performance. Researchers address this issue as it relates to IHCA survival rates looking at hospital variation to identify areas needing improvement, as well as recognizing the factors at particular hospitals that contribute to increased survival following IHCA so that these "best practices" could be used to improve other hospital outcomes (Merchant et al., 2014). The data source used was the American Heart Association's Get with the Guidelines-Resuscitation (GWTG-R) registry. This multicenter cohort study included adult patients enrolled in the registry from January 1, 2001 through December 31, 2010. As per the standard, the outcome measure was survival at time of hospital discharge. Although a variation rate of survival following IHCA of up to 42% was found depending on which hospital the patient was admitted to, what contributed to this variation, could not be determined. However, the authors did propose that utilization of a medical team prior to respiratory and/or cardiac arrest could be a contributing factor in successful patient outcomes. It would be interesting if similar statistical analysis were performed on before-and-after RRS implementations studies to determine what factors played a role in their success in reducing patient mortality rates. Some studies have demonstrated that poor code team performance is associated with poor patient outcomes following cardiac arrest (Clarke, Carolina Apesoa-Varano, & Barton, 2016). Improving code team performance requires the ability to evaluate that performance. The tools currently used to evaluate these teams are discussed next.

The Team Emergency Assessment Measure

In a study specific for teamwork performance during resuscitation attempts, an Australian research group aimed to develop a tool to measure teamwork during emergency resuscitation (Cooper, et al., 2010). The Team Emergency Assessment Measure (TEAM) (see Appendix A) was developed in five stages with the objective of providing a teamwork assessment tool that observers could use to evaluate team effectiveness during resuscitation events in both the simulated and clinical settings. The rating system consists of 11 items that are rated from 0 to 4 (never/hardly ever to always/nearly always, respectively) with a 12th scale that is rated 0 to 10 and is the overall global rating of the team's performance. The TEAM was tested using second year medical and nursing students who completed an intermediate life support class the day before. They were placed in teams of five and observed in real time using high fidelity mannequins. Experts reviewed this tool and found it to be valid, reliable, and possibly useful for clinicians to measure their teamwork during resuscitation.

Cooper and Cant, (2014) expanded the use of the TEAM in a 2014 publication. Their original study looked at teamwork in the scenario of emergency resuscitation. Applying the same teamwork assessment tool, they instead observed teamwork performance in the deteriorating patient setting. Two studies were performed with one looking at teamwork in 97 final year nursing students from three Australian universities and the other using 44 RNs (medical or surgical nurses) from a regional Australian hospital. The 97 nursing students were placed in groups of three and two trained clinicians rated their performances in three 8-minute deteriorating patient scenarios using a standardized patient. The registered nurses were also placed in teams of three and required to first identify, and then manage a deteriorating patient. The study indicated validity and reliability when measuring teamwork skills using TEAM during a deteriorating patient setting of both final year nursing students and registered nurses.

Observational Skill-Based Clinical Assessment Tool for Resuscitation

The observational skill-based clinical assessment tool for resuscitation (OSCAR) (see Appendix B for communication portion) was developed with the objective of assessing team behaviors and non-technical skills during a cardiac arrest attempt for each of the core team members (Walker et al., 2011). The researchers in this study defined non-technical skill behaviors as: communication, cooperation, coordination, monitoring, leadership and decision-making. The OSCAR tool rates each six behaviors on a scale of 0 to 6 separately for the three distinct members of the team. Unfortunately, OSCAR does not evaluate teamwork as a behavior, it is not a behavior they defined as a non-technical skill, and the team is not assessed as a whole with this tool.

The Mayo High Performance Teamwork Scale

Not specific to teams during resuscitation, the Mayo High Performance Teamwork Scale (MHPTS) rates leadership, teamwork, communication and adaptability using 16 categories rated from 0 to 2 (never or rarely to consistently, respectively) (Malec et al., 2007). This scale is more of a crisis resource management tool than a team performance during resuscitation teamwork metric (see Appendix C).

A Dichotomous Checklist

Originally develop as a performance and assessment tool but converted into a checklist Andersen, Jensen, Lippert, Østergaard, and Klausen, (2010) designed a dichotomous list of yes/no responses to aid in the assessment of learning of cardiac arrest teams (see Appendix D). Because of its heavy focus on medicine and lack of team cognitive process measurements this checklist is not used as a team performance metric in this research. The three evaluation tools applied to code teams during this experiment are compared in Table 1.

Although the AHA mandated metrics for IHCA is collected as part of “Get with the Guidelines”, there is a scarcity of data related to teamwork and team performance. While training courses like ACLS discuss the value of good team coordination and leadership, there is no standardization or objective assessment of the human factors of a code team’s response and performance. Based on the current evaluation tools it is evident gaps in team performance metrics exist. A metric needs to be able to identify gaps in performance so training can be utilized to target deficient performance areas.

Table 1

Comparison of current team performance evaluation tools

Team Emergency Assessment Measure (TEAM)
Description
• A rating system consists of 11 items that are rated from 0 to 4 with a 12th scale of 0 to 10 overall global rating of the team's performance
Potential Benefits
• Contains and overall team rating
• Specific for team evaluation during resuscitation
Possible Drawbacks
• Lacks a specific communication category
The Observational Skill-Based Clinical Assessment Tool for Resuscitation (OSCAR)
Description
• Rates communication, cooperation, coordination, monitoring, leadership and decision-making on a scale of 0 to 6 separately for three distinct group members of the team
Potential Benefits
• Developed from and extensively validated tool used in the operating room setting
Possible Drawback
• Does not evaluate teamwork as a behavior, nor is it a behavior they defined as a non-technical skill
• Does not assess the team as a whole
Mayo High Performance Teamwork Scale (MHPTS)
Description
• Rates leadership, teamwork, communication and adaptability using 16 categories rated from 0 to 2 (never or rarely to consistently, respectively).
Potential Benefit
• Can be used as a crisis resource management tool in a variety of situations
Possible Drawbacks
• Not specific to teams during resuscitation

Summary

While tested metrics for code team evaluation exist there are still gaps in measurments. TEAM has been tested and validated however it is still lacking. It utilizes a subjective Likert scale, no timing-related behaviors are included, and coordination of communication and information transfer is not clear. OSCAR is lengthy with key timing, coordination, and leadership aspects all measured separately. Focus on the team's interactions in a metric is paramount and failure to evaluate a team's performance as a whole makes its ability to measure the team behaviors in context difficulty.The MHPTS has little use as a specific metric for teams in resuscitation and the dichotomaous checklist is too medicine focused with no true cognitive process measurements. Identifying the gaps in current measurement tools and offering a viable option that includes a metric for team performance and areas in which training should be targeted.

Training Code Teams

Theories of Team Cognition and Code Teams

In order to identify a training strategy that best suits *ad hoc* code teams, two of the main theoretical perspectives of team cognition, which provide a foundation for understanding team learning and effectiveness, must be examined; shared mental models and interactive team cognition. Salas, Cooke, and Rosen, (2008) define team cognition as the relationship between processes, such as, learning, planning, reasoning, and decision making, as they occur at the team level and will be discussed in the following section of this dissertation. Also reviewed is the literature relevant to team performance and training for code teams, which, will allow us to postulate a possible training strategy. We will begin by defining and examining code teams in the context of the science of team training using the main perspectives of team cognition.

Shared Mental Model/Team Mental Models

Shared mental models (SMM), also referred to as team mental models, in the medical setting have their foundation in the aviation industry (Carbo, Tess, Roy, & Weingart, 2011). The SMM as it relates to team cognition gained prominence in the medical literature with the introduction of a collaboration between the Agency for Healthcare Research and Quality (AHRQ) and the Department of Defense (DOD) called the TeamSTEPPS (Alonso et al., 2006). Shared mental models suggest the dependence of team performance with individual team member knowledge and that cognition of the team is simply a sum of each team member's knowledge. Its plausibility of use in *ad hoc* code teams with varying roles and knowledge makes it a questionable perspective on effective teamwork.

Interactive Team Cognition

To contrast the shared mental models theory of team cognition, interactive team cognition (ITC) describes team cognition as more than just a sum of individual team member knowledge (Cooke, Gorman, Myers, & Duran, 2013). It proposes three components of team cognition and suggests that team cognition is an activity, that it should be measured and studied at the team level, and that it is inseparably tied to context. Team member knowledge is still an important part of effective team performance, but ITC implies that when attempting to improve a team's performance, training strategies need to focus on how the team functions and how it performs as a unit, not just the combined knowledge and skill factors of its individual members. Its focus is on the interactions of the team rather than individual knowledge. Interactive team cognition goes further to imply that with well-coordinated communication and information processing, not all the team members need all of the information. The team just needs a way to pass the information to the team member who needs it, ITC implies that team training should address this team interaction. Applying the science of human factors with its focus on decision-making, task analysis, team science, and simulation is a novel approach to code team training with potential to improve patient outcomes.

Leadership Training

The role of the team leader during a code blue team response is known to be pivotal, as the leader is the person responsible for the distribution and coordination of subtasks, ideally using clear and explicit communication (Fernandez Castelao, Boos, Ringer, Eich, & Russo, 2015). It has been demonstrated that the lack of good leadership may impact the team's overall performance and possibly lead to poor patient outcomes (Cooper, 2001; Hunziker et al., (2011). The Hunziker et al., (2011) research further determined five behaviors for effective CPR leadership: (1) consider situational demands, (2) facilitate contributions of the non-leading team members, (3) ask problem related questions, (4) keep hands-off, and (5) promote exchange of information. Leadership training can be done effectively in a short period of time as shown in research utilizing only a two-hour training session (Mahramus, Penoyer, Waterval, Sole, & Bowe, 2016). Six code teams consisting of physicians, nurses, and respiratory therapists were studied in a pretest and posttest experiment. It was determined a shortened 2-hour training session had similar results as longer training programs. The authors stated the reasoning behind two-hours time frame were the challenges of scheduling all the different disciplines, time constraints, and cost. Interestingly, code team members in this study stated that they perceived teamwork during codes as insufficient in the areas of training, leadership, and communication.

Because *ad hoc* medical teams and aviation teams share similarities, such as: team centered activities, some procedures they perform are risky, and their work is often performed in a time-pressured situation, it is hypothesized that similar training tools and strategies could be used to train code teams in simulation and improve teamwork. The importance of team training has been recognized in the domain of aviation. This influence and its implications on the training of code teams will be discussed in the next section.

Communication Training from Crew Resource Management

Communication and coordination training are common in the field of aviation and are directly aligned with interactive team cognition. Crew resource management (CRM) is a type of training program utilized in aviation. Its communication training focuses on establishing common language, establishing interpersonal relationships, and predictable behavior patterns.

On average, the Federal Aviation Administration (FAA) estimates there are approximately 7,000 aircraft over the United States at any given time. In 2014, there were only 29 accidents involving 121 aircrafts with zero fatalities (*2014 NTSB US Civil Aviation Accident Statistics*, 2015). To accomplish this level of safety, air traffic controllers, pilots, co-pilots, and ground crews work together as a team. The work they do is multifaceted and cannot be accomplished by a single individual team member alone. Sharing the cognitive load allows for improved team work and desirable outcomes.

The idea of developing training tools for medical teams similar to those used in aviation to improve safety has been suggested. Flin & Maran, (2004) focused on medicine’s tendency to utilize *ad hoc* teams, similar to teams in commercial aviation. Despite the fact that resuscitation of a patient is a team endeavor, the medical knowledge and skills needed to perform resuscitative efforts are taught and practiced at the individual level during ACLS and CPR training courses (Morrison et al., 2013). The need for team training is unmistakable.

Aeronautical crew training approach principles should be able to be implemented in the medical realm when training *ad hoc* code teams. Using the non-technical skills identified as fundamental components of CRM training, Flin et al., (2003) described system components and placed then into four categories: cooperation, leadership and managerial skills, situation awareness, and decision making. These categories can be used to depict how aviation team training can be integrated in the training of medical teams. Commercial pilots and crews in both the United States and Europe participate in mandatory team training. Many large airlines use team-training packages that were developed to assist aircrews in error prevention, identifying errors, and how to diminish the consequences of errors (Helmreich, Merritt, & Wilhelm, 1999).

Communication Training in Medicine

Human error, more specifically, communication error, is the number one cause of error in both aviation and medicine (Brindley & Reynolds, 2011). Verbalization of intent, assertiveness, confirmation of task completion utilizing a "call out" are additional behaviors that improve communication during a code event which, may improve team performance (Dunn et al., 2007). Training sessions do not need to be involved and lengthy. Studies have demonstrated brief communication training can be effective in improving overall *ad hoc* team performance. Seventy-three code team members consisting of physicians, nurses, and respiratory therapists were studied in a pretest/posttest experiment that demonstrated only two hours of teamwork training can improve team performance (Mahramus et al., 2016). The code team members even stated that following this brief training their perception of teamwork during codes was improved. The study also confirmed a shortened 2-hour training session had similar results as longer training programs, with the actual educational portion of this study lasting only 45 minutes.

Continuing to examine the idea that team training can be done in abbreviated sessions as well as the idea regarding the influence communication breakdowns have on a majority of adverse medical events, a prospective study observed the impact team communication training had on *ad hoc* trauma teams performing resuscitation in the simulated settings (Roberts et al., 2014). Of the 17 team and leader behaviors targeted, 15 showed improvements after brief training. Researchers did observe communication breakdowns such as; the team leader frequently did not identify him/herself and vague orders were not clarified. This is a fundamental component in CRM training and should be done by all team leaders.

Overview and Conclusion

After analyzing and considering on all to the training types, *ad hoc* code team dynamics, and the logistical constraints of training an entire code team, it seems plausible that a training combination of leadership and communication may be a reasonable option. Despite the evident challenges involved in training a code team it is evident a formal team training strategy and process is needed. Providing essential information can be challenging and requires practice. Relevant portions of fundamental information need to be communicated by the code team leader within seconds of the team's arrival. All of this is done while the team begins their primary survey of the patient and other tasks associated with the resuscitation. The code team leader can be trained to orchestrate this process of information transfer and redirect the messenger if irrelevant data are provided. Currently, there is no formal training process described in the literature that trains the leader to efficiently transfer information during the code blue process and will be the target of this research.

CHAPTER 3

THE ASU-MAYO TEAM PERFORMANCE METRIC

Introduction

Because outcome measures of code team effectiveness based on mortality rates at discharge and reduction of cardiac arrest occurring outside of the ICU are not a true representation of the team's overall performance, it was central that this metric differs from the current metrics used in that it must integrate aspects of team performance in order to target behaviors specific to code team performance. Development of a metric targeting specific errorful team behaviors that fall into teamwork categories will allow for the scoring of them during a simulated code blue events (SCBEs). In turn, this may allow for the identification of performance gaps that can be targeted for training interventions. This behavior-oriented metric will also provide specifc feedback for post-code debriefs. To accomplish this portion of the research we worked with the Mayo Clinic Hospital in Phoenix, Arizona and utilizes videos of SCBEs from their code blue drill program.

Research Question 1

Can we develop a code team metric that identifies specific performance gaps?

Methods

Participants

Participants in videos were employees of The Mayo Clinical Hospital who voluntarily participated in a SCBE as part of Mayo's Code Blue pilot program and included physicians, nurses, respiratory therapists, and pharmacists. All participants signed Mayo's consent form for authorization to photograph, videotape, or film employee, resident, student, or trainee. The SME used in this and subsequent experiments all have more than 10 years critical care experience running codes and evaluating and training code team leaders.

Study Design and Setting

A retrospective examination was conducted on ten SCBEs that occurred at the Mayo Clinic Hospital in Phoenix, Arizona from June 6, 2013 thru November 10, 2015. Each of the codes consisted of similar patient scenarios following a sequence of: the patient developing unresponsiveness, need to call a code blue, patient requiring resuscitation, and the electrocardiogram (ECG) displaying a shockable rhythm. The SCBE lasted eight minutes with a debriefing period following the code. It should be noted that the debriefing portion of the simulated code was not evaluated in this portion of the research. Two of the ten codes were used as a baseline for metric category development that was used to develop the preliminary version of the ASU-Mayo metric. The errors in this preliminary version of the ASU-Mayo metric fell into four categories relevant to team performance: leadership, role clarity, workflow and coordination, and communication.

While watching the two baseline codes with subject matter experts (SMEs) it was noticed they commented on the errors that occurred during the code and not what the teams did correctly. Therefore, knowledge was elicited from the SMEs as they watched the two SCBE videos to determine what errors should be included in the metric that would be relevant to team performance. The SMEs re-evaluated and iterated on the preliminary version of the metric to develop a secondary version. This secondary version of the metric was then developed and used to evaluate the two baseline SCBEs, which resulted in the elimination of errors determined to play little to no role in overall team performance. Additionally, components of the metric were reinforced with timing factors from the “Get With the Guidelines – Resuscitation” to ensure components proven to improve patient outcomes during resuscitation were taking into account (Cunningham, Mattu, O’Conner, & Brady, 2012). The secondary version of the metric was developed into the current version of the metric, which in this research, will be referred to as the ASU-Mayo Team Performance Metric (AM*t*PM) (see Appendix E).

Unlike the additive team measurement scales utilized in TEAM, OSCAR, and the MHTPS, the newly developed AM*t*PM is a scoring tool that subtracts points for errors the team commits occurring by the team members in the four subcategories: leadership, role clarity, communication, and workflow and coordination. The subcategory scores are added up to get a total team performance score, with 100 points being the highest score a team can receive during the SCBE evaluation.

Code Evaluation and Scoring Procedure

The procedure involved in code evaluation and scoring took place in two steps: evaluation and scoring using TEAM, OSCAR, MHPTS, and the AM*t*PM and, second, the SME evaluation of the overall team performance of the codes.

TEAM, OSCAR, MHPTS, and the AMtPM Procedure. The eight SCBEs were each viewed three times and then on the forth viewing they were each scored using TEAM, OSCAR, MHPTS, and the AM*t*PM. Because TEAM, OSCAR, and the MHTPS all utilize different rating systems resulting in optimal team performance scores producing varying ranges, the score the SCBE received following evaluation were converted to a 100-point scale so it could be compared to the AM*t*PM.

Subject Matter Expert Evaluation Procedure. Four SMEs were asked to view the eight codes only once, continuously, without pausing or rewinding. The SMEs scored categories of overall teamwork, leadership, role clarity, workflow and timing/coordination, and communication using an overall 1 to 5 rating with 1 being very poor and 5 being excellent. The overall scores were converted to a 100-point scale so they could be compared with the other four metrics.

Results

The results indicated that the new AM*t*PM was highly correlated with MHPTS (r (6) = .71), TEAM (r (6) = .84), and OSCAR (r (6) = .89) metrics as well as the ratings of the subject matter experts (r (6) = .88) (see Table 2).

Table 2

Correlations of the team performance metrics and SME ratings for eight codes

	ASU-Mayo Metric	*MHPTS*	*TEAM*	*OSCAR*	*SME Rating*
AM*t*PM	1				
MHPTS	0.71	1			
TEAM	0.84	0.92	1		
OSCAR	0.89	0.80	0.85	1	
SME Rating	0.88	0.84	0.96	0.88	1

The AM*t*PM identified that of the total 128 errors that occurred across the 8 codes, 33 leadership errors occurred, 38 communication errors occurred, and 42 workflow/coordination errors occurred (see Table 3). The identification of the subcategories, which led to the weakest overall team performance, determined the targeted team behaviors for which training interventions would be introduced. Evaluation of the scores in the subcategories of leadership, role clarity, communication, and workflow and coordination using the AM*t*PM indicate that leadership and communication errors were related to lower overall team performance scores. With the difficulties involved in the coordination of training for *ad hoc* code teams, focusing on a communication the code team leader could use is a viable training option. For the four highest performing teams, leadership errors occurred six times with communications errors occurring 16 times as compared to the four lowest performing teams with 22 leadership errors and 22 communications errors (see Table 4).

Table 3

Overall team performance as it relates to number of errors

Code Number	Total Number of Errors	Number of Leadership Errors	Number of Role Clarity Errors	Number of Workflow/ Coordination Errors	Number of Communication Errors
Code 1	19	5	3	7	4
Code 2	18	7	2	4	5
Code 3	7	2	1	2	2
Code 4	15	3	3	5	4
Code 5	14	3	0	5	6
Code 6	12	1	1	6	4
Code 7	24	7	2	8	7
Code 8	19	5	3	5	6
Totals	128	33	15	42	38

Table 4

Correlation of leadership and communication errors in highest and lowest performed codes

Code Number	Total Number of Errors	Number of Leadership Errors	Number of Communication Errors
Highest 4 Scoring Codes			
Code 3	7	2	2
Code 4	15	3	4
Code 5	14	3	6
Code 6	12	1	4
Total	48	6	16
Lowest 4 Scoring Codes			
Code 1	19	5	4
Code 2	18	5	5
Code 7	24	7	7
Code 8	19	5	6
Total	80	22	22

Conclusion

Before we attempted to improve training for code teams, it is crucial we delineated the problems associated with code team performance. The AM*t*PM is an objective measurement of team performance based on leadership, role clarity, communication, workflow, and coordination, and overall team performance along with measurements aligned with the “Get with the Guidelines” standards for resuscitation from the American Heart Association. It is a novel and robust team assessment tool that we propose will facilitate the building of high-performance code teams.

By incorporating the ability to measure coordination of team process, communication, information transfer, and leadership, the AM*t*PM is a code team evaluation tool that facilitated the identification of specific performance gaps in teamwork that the current tools, such as TEAMs lack of communication category and OSCARs overall lack of team evaluation as a whole, fail to recognize. Using the AM*t*PM determined that the main weaknesses in team performance fell into the categories of leadership and communication, which in turn, drove the development of the communication model and leadership training that will be used in the subsequent research sections of this dissertation.

CHAPTER 4

THE COMMUNICATION MODEL DEVELOPMENT

Background

Communication can be defined as the transmission of information between one person to another person or group and achieves four purposes: (1) building and maintaining team structure, (2) coordination of team processes, (3) information exchange, and (4) facilitation of interpersonal relationships (Robinson, 2016; Fernandez Castelao, Russo, Riethmüller, & Boos, 2013). These four purposes were taken into account when developing the AM*t*PM. Moreover, the metric's use in the evaluation of eight codes determined that leadership and communication errors resulted in the lowest scores in team performance. Although role clarity is important, most hospitals use *ad hoc* teams and with assigned roles based on licensure level with the physician typically designated as the code team leader. The development of the communication model was intended to convey only the essential information that needs to be communicated for the team to be effective. Issues, such as clarity of communication, flow pattern, and content are important and will also be incorporated into the communication model (Bogenstätter et al., 2009; O'Brien, Haughton, & Flanagan, 2001).

Overall Approach to the Communication Model Development

Using team performance scores and the AM*t*PM described in chapter 3 of this dissertation the patterns of communication utilized in the four highest performing teams were used to establish the ideal pattern of communication and its essential components. Using an if-then communication strategy demonstrated to improve team performance in a synthetic teammate study developed by Demir et al., (2015) we developed a communication model applicable for use in the simulated code environment by the CTL. This communication model included the essential information that must be communicated to and from the CTL with contingencies related to the if-then coordination of communication and tasks necessary to promote optimal team performance.

Research Question 2

What is the essential information communicated during codes and who communicates to whom and when in high performing code teams during a simulated code blue event?

Hypothesis 1

Content lacking and ineffective communication patterns during a SCBE result in weak team performance and ultimately poor patient outcomes in the absence of formal team leader training.

Methods

Video Review

Using the same eight codes described in Chapter 3 for the metric development, a retrospective re-examination and evaluation of the codes was utilized to determine the essential information content and patterns utilized by the top four scoring code teams.

Communication Content and Pattern Determination

Following re-examination of the codes it was determined the communication content present in the four highest scoring codes included: code team leader identifying him/herself upon entering the room, the CTL standing at the foot of the bed, patient history determination happening immediately upon code team arrival and included inquiring about the ABCs, CPR monitoring throughout the code, establishment that advanced monitoring is in progress, and timing cues correlating with shock delivery or medication administration. Also observed was the use of the situation, background, assessment, recommendation (SBAR) technique by the CTL. This manner of talking out loud to the room, periodic review of quantitative data, and double-checking crucial pieces of information are all signs of effective team communication (Hunziker et al., 2011). The code team member that the CTL communicated most frequently with during the code was a code team RN.

Communication content and patterns observed in the four lowest scoring codes were: code team leaders failing to identify themselves upon entering the room, orders originating from multiple team members, monitor placement not in the line of site of the CTL, multiple microconversations occurring with no direct feedback given to the CTL relating to the patient's condition, and confirmation of task completion not being verbalized to the CTL.

Communication Model Development

Based on the re-evaluation of the eight codes a code blue communication model draft 1 was sent to the SME for revision (see Appendix F). Two SME where asked to deliberate about running the perfect code and what was the essential communication needed for the team to perform successfully and asked to revise the draft. The SME revision of first draft of code blue communication model can be found in appendix G.

Results

Although the SME revision of the first code blue model was very inclusive and detailed, the objective of this research was to develop a code blue communication model that focuses on whether the CTL can communicate minimal information to improve the team's overall performance. More specifically, the critical part of the concept is to have the leader act as a forcing function who could vicariously train the team by requesting information when he or she does not get it. The ASU research team and the SMEs revised the SME draft to develop the final version of the code blue communication model (see Table 5).

Table 5

Final version of code blue communication model

TIMING		SENDER	RECEIVER	COMMUNICATION
Role Clarification at CTL arrival	Code Team arrival to bedside	CTL	Code Team	1. Introduces self as code team leader 2. Clarifies who bedside RN is
Immediately upon CTL arrival	Ideal communication	Code RN	CTL	1. Bedside RN must give a brief history, code status, and confirm advanced monitoring is established
	Contingency	CTL	Code RN	**IF:** Bedside RN does not immediately give the CTL a brief history, code status, and confirm advanced monitoring is established **THEN:** CTL must directly ask the bedside RN for the information
Workflow and Coordination	Within 30 seconds of arrival to code	CTL	Code Team	1. Asks about ABCs
	Contingency Time to first assisted ventilation must by <= 1 minute	CTL	Code Team	**IF:** No one person is performing CPR or performing bag mask ventilating upon arrival of CTL **THEN:** CTL must direct code team member to immediately perform CPR and the RT to bag the patient
	Once monitoring is established	CTL	Code Team	1. Asks for ACLS therapies as indicated
	Contingency Time to first shock must be <=2 minutes of event recognition	CTL	Code Team	**IF:** Medication or shock delivery is delayed more than 10 seconds after identification of rhythm **THEN:** CTL must directly as pharmacist or RN do deliver the meds and/or shock
	constant feedback	CTL	Code Team	Asks if there are any problems, so CTL can troubleshoot or delegate task to another person, keeps team on task, should be in SBAR format
Results	**constant feedback**	Code Team	CTL	Identifies improvement or deterioration 1. Clarifies ROSC/stabilization of ABCs 2. OR clinical worsening
	Contingency	CTL	Code Team	**IF:** Code team does not clarify ROSC/stabilization of ABCs OR clinical worsening **THEN:** CTL must clarify disposition (i.e. transfer to ICU, need for more advanced therapies, discontinuation of efforts, etc.)

Conclusion

An identifiable leader with good communication skills, the ability to distribute tasks, gather information, and maintain an overview without getting involved in practical code tasks is essential for a code team leader to be effective**.** Contrary, a lack of detail and sparse communication containing nonessential information can be problematic. Therefore, a code team leader's ability to effectively communication and elicit communication from other team members when needed all while maintaining attention on the overall situation and managing the team was the focus of the targeted training in this part of the research. This also aligns with the conclusion reached following a review of training strategies and theoretical components of team science.

Superficially, the communication model seems procedural in nature. However, the model's ability to facilitate the sharing of the minimum necessary information does not limit a specific response and the directives the CTL gives following the received information will depend on the patient's current status. Adaptability in a code team is essential because variability exists in clinical situations that may influence patient outcomes. In the next study training of the CTL to use the model will be done. Then we will determine if use of the model during code events can subtly training the other team members.

CHAPTER 5

TRAINING AND EVALUATION OF THE CODE TEAM LEADER

Background

Teams may be *ad hoc* but a prepared communication model with modifiable elements may help the team leaders improve the communication structure and flow for the entire team. The *ad hoc* nature of the teams accompanied by the logistical restrictions of training the entire code team suggests the foremost influence on the team's performance may exist in the role of its leader. Training the CTL to act as a forcing function, or the individual on the team that coordinates the passing of information and manages the team's interactions, is an idea that is currently unpublished in the code team training literature.

By definition a forcing function is "any management device or tool used to limit user errors by prohibiting specific actions without prior use of necessary safety procedures"(forcing function, n.d.). It has been used in medicine in certain technical areas. An example of a forcing function is the need for a practitioner to enter a patient's vital signs and allergies before the Pyxis system will dispense medication for that patient.

A forcing function has also been used in medicine as a safety mechanism to help prevent inadvertent administration of the medication vincristine that when given intrathecally typically leads to death (Reddy, Brown, & Nanda, 2011). Using a forcing function as a way to improve computerized orders regarding patient restraints has also been studied with researchers finding an improved variability in restraint orders (Griffey, Wittels, Gilboy, & McAfee, 2009). However, some felt using the technology in this matter could have unintended and catastrophic outcomes (Bisantz & Wears, 2009).

Using the CTL as a forcing function in the context of a SCBE is intended to be a training strategy to improve communication flow and train patterns of interaction that would transfer essential information at the proper time to prevent team errors. Therefore, this could improve overall team performance by ensuring proper communication and actions take place. With this approach, the team leader's request of information from code team members could subtly train them by forcing the transfer of relevant information at the proper time. Subsequently, the next time the team member performs they would give the information at the correct time without needing to be asked for it.

Methods

Participants

Ten participants that were currently not a part of the hospital's code team were recruited by an attending physician to participate as a CTL in a simulated experiment regarding a code blue event. The physician in charge of recruiting asked the prospective code team leaders participants questions from the simulated code blue questionnaire to aid in the division of the groups based on years of experience, current practicing level, training, and PGY level (Appendix H). Based on the responses to the questions asked during the recruitment process, five CTL participants were placed in the control group and the other five were place in the trained group (see Table 6). The intentions of the group divisions were to equate experience level across conditions. The subject matter experts used to develop the training and code blue communication model were excluded from participating as a CTL in this study. Two of the scheduled CTL participants, one physician assistant (PA) and one nurse practitioner (NP) were unable to participate due to patient care responsibilities. Four additional non-leader code team members were recruited to participate in the experiment and included two ICU nurses, one respiratory therapist, and one simulation nurse educator, all of who had code team experience. They participated in their usual roles during all eight of the codes (one for each of the 8 CTLs) and were unaware of the research objectives. Participants, with the exception of the simulation nurse, as she is a paid staff member of the simulation lab, were compensated with gift cards. All participants signed Mayo's consent form for authorization to photograph, videotape, or film employee, resident, student, or trainee.

Table 6 Demographics of code team leader participants

Control Group Leaders	Trained Group Leaders
CTL 1 MD for 3 years Internal Medicine	CTL 5 MD for 3 years Internal Medicine
CTL 2 PA for 12 years Hospital Medicine	CTL 6 MD for 2 years Internal Medicine
CTL 3 MD for 2 years Internal Medicine	CTL 7 MD for 2 years Internal Medicine
CTL 4 ran Code E MD for 1.5 years Internal Medicine	CTL 8 NP for 1.5 years Cardiology

Video Equipment and Setting

All SCBEs were videotaped using Mayo's B-line system video capture of simulations and took place on a predetermined date in the simulation lab.

Common Training

All recruited participants in this study possessed the ACLS certification as well as had attended Mayo's fundamentals of critical care support (FCCS) training (Na, 1999).

Training Manipulation for Trained Group

The day before the scheduled code blue experiment, the attending physician responsible for recruiting emailed the five participants in the trained code team leader group a copy of the communication model with instruction to read it over as much as they would like prior to the day of the experiment. No further instructions were given. Prior to the trained leaders entering the simulation room on the day of the experiment they received a "cheat sheet" shortened version of the code blue communication model to use during the SCBE (Appendix I).

Running of the Simulated Code Blue Events for the Control Condition and the Trained Condition

The code team leaders were scheduled to run the codes in 15-minute blocks with the actual simulation lasting eight minutes and the order they ran their codes is listed in Table 7. The additional non-leader participants remained the same for all eight codes. Five different scenarios were used (Code A – E) to mitigate the possibility the additional non-leader code team members' performance improved with each subsequent code team leaders. All five scenarios contained a shockable cardiac rhythm but a different patient scenario. In addition, to control for non-leader experience over the eight sessions, an attempt was made to balance trained and control teams across the sessions. Thus, in each of the first four and last four sessions there were two trained and two control teams. Also for the three scenarios that were repeated (B, D, E) two (D, E) were experienced the second time by control teams and one (B) by trained teams. Following each code, the code team leader participant was asked questions 1-9 of the simulated code blue questionnaire by the researcher with the trained participants also being ask question 10 (see Appendix H).

Table 7 Order the codes were run

Code Team Leader	**Control or Trained Leader**	**Code Scenario Ran**
6	Trained	A
1	Control	B
5	Trained	B
2	Control	C
7	Trained	D
8	Trained	E
4	Control	E
3	Control	D

Results

Six of the participants were female (3 control, 3 trained) and two were male (1 control, 1 trained). All participants held the ACLS certification an average time of approximately 4 years. All eight codes run by control and trained leaders were scored using the AM*t*PM to determine the total number of errors the control and trained groups committed. (see Table 8). In the teams with the trained leader, leadership errors occurred four times with communications errors occurring six times as compared to the teams with the control leaders that committed eight leadership errors and eleven communications errors. Each leader participant's responses to questions 4-10 on the post simulation questionnaire that related to the running of the codes are listed in Table 9.

Table 8

Overall team performance as it relates to the number of errors for the control and trained CTLs

Code Team Leader	Total Number of Errors	Number of Leadership Errors	Number of Role Clarity Errors	Number of Workflow/ Coordination Errors	Number of Communication Errors
Control CTL					
CTL 1	9	2	0	3	4
CTL 2	7	2	0	1	4
CTL 3	4	2	0	0	2
CTL 4	5	2	0	2	1
Total Errors for Control	25	8	0	6	11
Trained CTL					
CTL 5	3	0	0	1	2
CTL 6	3	2	0	0	1
CTL 7	3	1	0	1	1
CTL 8	5	1	0	2	2
Total Errors for Trained	12	4	0	4	6

Table 9

Questions and responses to the post simulation questionnaire

Question 4	**Do you typically perform as a team leader in real codes? If not the team leader what is your role?**
	Responses from Control Group
CTL 1	My typically role is a bystander, not the leader.
CTL 2	I will act as the team leader until the code team arrives.
CTL 3	No. I usually do CPR.
CTL 4	I would act as the leader only until the code team gets there, then I would just watch and help if I am asked.
	Responses from Trained Group
CTL 5	I usually act as the leader.
CTL 6	I usually act in a supportive role. I don't typically take charge and run the code.
CTL 7	I usually am just a bystander.
CTL 8	I am usually the leader in a real code.
Question 5	**Have you performed as a team leader in simulated codes? If not the team leader what is your role?**
	Responses from Control Group
CTL 1	Never acted as the leader. Mostly just act as a bystander and will do what the critical care doc asks me to do.
CTL 2	Yes. We I run simulated codes I act in the role of team leader.
CTL 3	I have acted as the leader but my role varies in the simulations stuff I have done.
CTL 4	I have acted as the leader in simulation.
	Responses from Trained Group

CTL 5	I haven’t run any simulated codes as a physician. I was a nurse before I went to med school and ran a few back then.
CTL 6	I have not run any code in simulation before.
CTL 7	In sim codes I will act as the code team leader.
CTL 8	I have acted as the lead and the RT when we run sims.
Question 6	**Have you had any formal team training?**
	Responses from Control Group
CTL 1	No.
CTL 2	No.
CTL 3	No.
CTL 4	No.
	Responses from Trained Group
CTL 5	No.
CTL 6	No.
CTL 7	Yes. I did a two-week leadership camp in high school, but that was a long time ago.
CTL 8	No.
Question 7	**What went well with today’s simulated code?**
	Responses from Control Group
CTL 1	The communication between the code team was very good.
CTL 2	CPR was started early; the team was supportive and had good communication.
CTL 3	Everyone was calm and well trained in his or her role.
CTL 4	I think everyone was clear what his or her role was in the code.
	Responses from Trained Group
CTL 5	I think always talking is important during patient care.
CTL 6	All the team contributed to running the code when I asked them for help or talked out loud about things.
CTL 7	I think everyone was clear on their role and what to do.
CTL 8	I think we worked together during the code.
Question 8	**What could have been improved in this patient’s care?**
	Responses from Control Group
CTL 1	I could have shocked the patient sooner. I think if I had a better understanding of the ACLS algorithms it would have been better.
CTL 2	I should have shocked the patient sooner. I also need to review my ACLS protocols.
CTL 3	Nothing.
CTL 4	I need to review my ACLS protocols.
	Responses from Trained Group
CTL 5	I think always talking is important during patient care.
CTL 6	I wish I asked for more about the patient’s history. I forgot to ask what the patient’s code status was.
CTL 7	I could have shocked the patient sooner. I also don’t think I did enough investigation regarding the cause of the patient’s cardiac arrest.
CTL 8	More patient history would have helped.
Question 9	**Were there any delays in therapy? If so, provide a description of the delay.**
	Response from Control Group
CTL 1	I should have shocked the patient sooner.
CTL 2	I needed to shock sooner. It was a shockable rhythm and I don’t know why I delayed.
CTL 3	I think I gave the epi a little late but everything else was fine.
CTL 4	Yes, I delayed shocking the patient.

	Responses from Trained Group
CTL 5	No.
CTL 6	No.
CTL 7	I should have shocked sooner.
CTL 8	I think I should have given epi sooner and asked for intubation quicker than I did. Maybe I should have shocked sooner.
Question 10	**Do you feel the script helped you perform better as the code team leader? Did the cheat sheet help?**
	Responses from Trained Group
CTL 5	Yes, it helped. I did like the cheat sheet. It reminded me of what to do while I was waiting for the 2-minute CPR cycle to end.
CTL 6	Yes. It jogged my memory about running codes. I did not look at the cheat sheet but it was comforting to have it if I needed to look at it.
CTL 7	The script was helpful but I didn't use the cheat sheet. It was a distraction during the code.
CTL 8	Maybe marginally useful. I didn't use the cheat sheet.

No errors in role clarity were reported; likely due to the nature of the experiment in the setting of the simulation lab where the participant is a code team leader. To further determine if the communication model helped improve the CTL performances in the areas targeted by this research, the control group and trained group requests for information as it relates to the communication model with the contingencies was compared (Table 10). All of the control group leaders and one of the trained group leaders (CTL 8) failed to identify themselves as the code team leader. This requirement is directly aligned with CRM training used by pilots. In clinical setting with the *ad hoc* nature of code teams this should always be done which is the justification of why it is tied to the first contingency in the communication model. If the bedside RN is unsure of the code team leader there may be a delay in communication transfer of vital patient information. The control group and trained group CTL 8 did walk in and ask, "what's going on" but did not directly ask for a brief patient history or direct the request to a specific code team member which, caused confusion with the non-CTL members of the team as to who should answer the question and what components of the history should be given. Although the sample was very small an independent-samples t-test was conducted to compare the errors that occurred in the control groups versus the trained group. Although there was not a significant difference in the scores for control group ($M=6.25$, $SD=2.22$) and the trained group ($M=3.5$, $SD=1$) conditions; $p = 0.06$, these results are promising considering such a small sample was used.

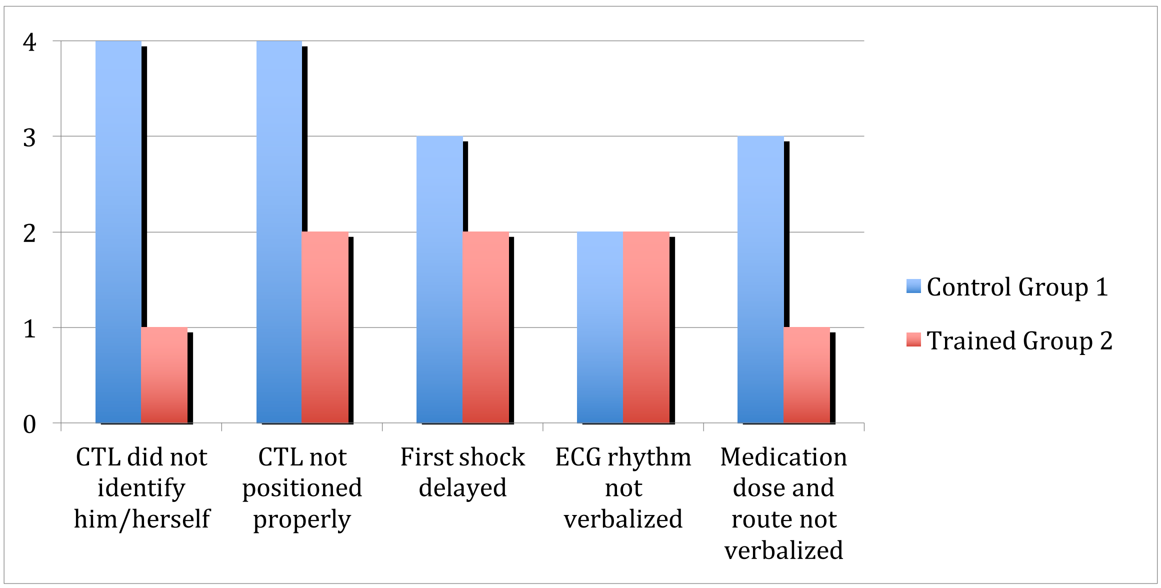
Table 10

Use of the code blue communication model for the control and trained CTLs

Code Team Leader and Overall Score	Introduced Self as CTL/Properly Positioned self	Delay in Communication of Brief Patient History	Asked For Code Status	Delay in Shock/Directed delivery of medication or Shock Delivery	Control: Followed Path Similar to script Trained: Followed Script
Control CTL					
CTL 1 92%	No/ No	Yes	No	Yes/No	No
CTL 2 94%	No/ No	Yes	No	Yes/No	No
CTL 3 96%	No/ No	No	No	No/Yes	Yes
CTL 4 95%	No/ No	Yes	Yes, 3 minutes into code	Yes/No	No
Trained CTL					
CTL 5 97%	Yes/ Yes	No	No	No/Yes	Yes
CTL 6 97%	Yes/ No	No	Yes	No/Yes	Yes
CTL 7 97%	Yes/ No	No	No	Yes/Yes	Yes
CTL 8 94%	No/ No	Yes	No	Yes/No	No

There were many commonalities between the control and trained code team leaders. Only two (one control, one trained) asked for the patient's code status. While this could be a result of the fact the simulation involved a code response, it is important the patient's code status in communicated before any resuscitation begins. Seven of the eight code team leaders practiced internal medicine. The control and trained team leaders were evenly matched for comparison. However, due to the loss of two participants CTL 2 (control) and CTL 6 (trained) we unevenly matched in years and level of practicing with CLT 2 being a PA practicing for 12 years and CLT 6 a physician with 2 years of practicing. Also, with the exception of high school leadership camp for trained CTL 7, none had any formal team training. Four (two controls and two trained) out of the eight stated they act as the leader in real codes, but would relinquish that role once the code team arrives. Five of the CTLs (three controls and two trained) have acted in the role of team leader in simulated codes with trained CTL 6 never having run any simulated codes. Five of the CTLs (three controls and two trained) felt they delayed shocking the patient or that shocking sooner could have improved the patient's care. Per the "Get with the Guideline" standards the first shock must be delivered within two minutes of identification of a shockable rhythm. This time frame is included in the AM*t*PM under the workflow and coordination error category and of the eight scored simulated codes in this experiment, five of CTLs (three controls and two trained) shocked the patient after the two-minute mark. The time spent reviewing the communication model varied from 5 minutes, 10 minutes, 30 minutes, to about an hour for CTL 5, 8, 6, and 7 respectively. The most common errors made by the two groups during SBCEs are illustrated and compared in figure 3.

Figure 3 Common errors committed during the SCBE



Code team leader 4 (control group) asked for feedback regarding his performance in the SCBE. The attending physician took him into a private room and debriefed the leader regarding their performance. Although debriefing is typically done following a SBCE, it was not part of this experiment and no other participants asked for an evaluation and debriefing following their performance.

Conclusion

Despite the importance of the 100,000 Lives campaign and its impact on public health, few studies have focused on how to train code teams to improve team performance and subsequently improve patient outcomes and even less have looked at which training strategy would work best for code team leaders. The AM*t*PM identified the need for a training design focused on improving leadership and communication; a topic that is gaining prevalence as an important component in the team's overall performance (Rosenman, Shandro, Ilgen, Harper, & Fernandez, 2014). This experiment demonstrated on a small scale the improvement the communication model can make on team performance. It also confirmed how logistically difficult it is to coordinate training for code teams (Capella et al., 2010). Setting up simulation, obtaining time in the simulation lab, recruiting CTL physicians and other code team members, coordinating the schedules of SME to observe the codes, score the codes, and debrief the code team following the simulated codes, is expensive and time consuming. The time the trained group spent on training is minimal compared to the time it would take to train the entire team and offers a viable option for training that could improve the entire team.

CHAPTER 6

DISCUSSION

It is clear that caring for acutely ill patients is demanding and resuscitation is a task that requires coordination of team members with varying skill sets in an extremely stressful clinical environment. Many studies have discussed the negative outcomes of code teams regarding unchanged mortality rates and increasing of hospital costs, but few have offered a concrete plan to improve the team (Chan et al., 2010; Cretikos & Hillman, 2003; Howell et al., 2012; Karpman et al., 2013). The weakness in overall team evaluation seen in the TEAM, OSCAR, and MHPTS metrics were remedied with the development of the new AM*t*PM allowing for the identification and training of the code team leader in the areas performance deficiencies were identified. It is important to understand the difference between practicing and running a SCBE and the fact that actually training teams to perform more effectively during a SCBE requires implementation and evaluation of a training strategy.

Many types of training strategies exist but were not considered to be options for *ad hoc* code teams. When determining the strategy to use when training a code team the challenges these teams face needs to be examined in order to establish a viable training option. Training in the medical field is typically procedural and done at the individual level despite the fact that healthcare providers frequently work in teams. The rigidity of procedural training can cause habituation and lead to poor team performance if the situation does not match the original training circumstances. Its use as a training strategy for *ad hoc* code teams that require performance in a constantly changing atmosphere makes this type of training highly unlikely to be effective. Cross-training is another training approach commonly used and normally associated with the shared mental model perspective of team cognition. However, with teams that have such varying member knowledge (doctors, nurses, respiratory therapist) it seems impractical as an effective training strategy in code teams. Applicable in many team performance situations, team reflexivity training involves reflection on prior performances, refered to as debriefing, with the intention of using those past experiences to improve subsequent performances (Gurtner, Tschan, Semmer, & Nägele, 2007).

This is a similar concept to self-correction training. Debriefing remains unstructured and its influence on training and improving a team's performance is questionable.

The role of the code team leader during CPR is known to be pivotal, as she or he is the team member responsible for the allocation and coordination of subtasks, ideally using clear and unambiguous communication (Fernandez et al., 2008; Fernandez Castelao, Boos, Ringer, Eich, & Russo, 2015; Hunziker, Tschan, Semmer, & Marsch, 2013). Every member of the team knows what is expected of him or her. The team roles and responsibilities are predetermined, well understood, shared, and upheld. Many training strategies exist and were discussed in the dissertation. The decision to train the code team leader in the areas of communication and leadership mitigated the challenges of getting together an entire team to train. Furthermore, code teams are not usually the same members so training the pivotal member that undertakes the leader role is an ideal strategy.

Strengths and Limitations

This research focuses on the training of the code team leader and training should be instituted for participants who would be leading code teams. This training should include core principles of leadership during dynamic time-sensitive situations. Training code teams is a challenging task. If training just the code team leader could improve the overall team performance in the simulated setting one can postulate that in a real-world code event, improved patient outcomes are possible. Also, in events with a large number of people requiring some sort of coordinated response, such as the evacuation events following Hurricane Katrina in 2005, training a few key people to be leaders in evacuation effort is a realistic task whereas training thousands of people is not. Also a possible area in which a benefit of CTL training could be demonstrated is in facilities with infrequent cardiac arrests or a lack of a simulation center needed to conduct SCBE training on a regular basis (Puttha et al., 2015).

This research was an applied study in a medical setting using physicians and advanced practitioners. This limited participation pool significantly affected our sample size. Two of the participants were called away to take care of patients, which further limited our sample size. Also challenging was finding time to run our codes in the busy simulation center at The Mayo Clinic. However, even with the small sample size and minimal time spent training, an overall team performance was seen in the trained group.

Not evaluated in this research was the debriefing following the SCBE which has been demonstrated to improve a team's performance (Mahramus et al., 2016). A structured format following the code could offer areas of team deficiencies that could be targeted during training. Simulated codes were scheduled in the simulation lab and the CTL groups and non-leader members were not evaluating following an overhead "code blue" activation requiring them to respond. Geographical spread of areas of response for code teams may influence code team performance.

Future Direction and Implications

As previously stated the debriefing portion of a typical SCBE was not part of this experiment. Future studies should target this area because often the same team that takes care of a patient during a code blue response has to continue resuscitation if the patient survives and is transferred to the ICU. This may make it difficult for the team to spend adequate time to participate in a comprehensive debriefing exercise is the real-world setting.

Critical care physicians are typically the practitioners that lead code teams. But what happens to the patient in the interim of code blue call and code team arrival? Training internal medicine physicians and other practitioners to function as a code team leader may offer an area that could improve the care of the patient prior to the code team's arrival and is an area of research that should be investigated. When asked, 49.3% internal medicine residents surveyed felt they lacked the training needed to run a code (Hayes, Rhee, Detsky, Leblanc, & Wax, 2007). Targeting residency programs for training could be an area of future study. Since early defibrillation has been demonstrated to improve patient outcomes and three of the four untrained CTL delayed the first shock, training focusing on the practitioners that treat the patient while waiting for code team arrival could improve patient outcomes (Zafari et al., 2004).

Current members of the code team that participate as the code team leader were not used in this study. However, they could still benefit from training with the communication model. The addition of perturbations, or changes in the normal process of the SCBE, could prove to improve the adaptability of the entire team and improve overall performance and has been demonstrated in the aviation setting. Gorman, Cooke, and Amazeen, (2010) compared three training strategies (procedural training, cross training, perturbation training) to determine which was more effective in training an adaptive team. The results of their experiments revealed that perturbation trained teams performed better in two of the three critical test experimental missions and as good as the cross-trained teams in response to novel events. Although the setting for this experiment was simulated uninhabited air vehicle (UAV) missions, because perturbation training may produce more adaptive teams, its application to training an *ad hoc* code team in simulation may prove useful for improving outcomes. Adaptability in a code team is essential because variabilities and changes in patient condition exist in clinical situations and may influence patient outcomes.

Conclusion

Team member knowledge is still an important part of effective team performance, but interactive team cognition implies that when attempting to improve a team's performance, training strategies need to focus on how the team functions and how it performs as a unit, not just the combined knowledge of its individual members. The development of this communication model allows for the training of the entire team through the prompts from a trained code team leadeer. I hope this research will provide code team members richer feedback on performance, generate quantitative assessments of the value of SCBEs, and make simulated training exercises a more efficient training tool. The ultimate aim of building high-performing code teams would be improved patient outcomes following cardiac arrest. In this study, the trained code team leader teams showed superior performance that the control teams with an average of only 26 minutes spent on training with the communication model. Though the sample size is limited due to constraints of the hospital environment, the time that the trained leaders spent is minimal compared to the time it would take to train the entire team. There is limited data in this study but it offers a very optimistic promise of what this strategy could offer given the reduced training time needed for team performance improvement. This type of training strategy should be studied in the future with larger groups of trainees.

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APPENDIX A

Team Emergency Assessment Measure (TEAM) from Cooper et al., (2010)

Team Emergency Assessment Measure (TEAM)

Introduction

This form has been designed as a teamwork observational scale to assess the performance of emergency medical teams (e.g. resuscitation and trauma teams). The form should be completed by expert clinicians to enable accurate performance rating and feedback of leadership, teamwork, situation awareness and task management. Rating prompts are included where applicable. Please rate the first 11 items using the following scale and the last item using the 10 point scale.

Never/Hardly ever	Seldom	About as often as not	Often	Always/Nearly always
0	1	2	3	4

Team Identification

Date ________________ Time ____________ Place ____________________

Team Leader ____________________ Team ____________________

Leadership: ***It is assumed that the leader is either designated, has emerged, or is the most senior – if no leader emerges allocate a '0' to questions 1&2.***	0	1	2	3	4
1. The team leader let the team know what was expected of them through direction and command	☐	☐	☐	☐	☐
2. The team leader maintained a global perspective *Prompts: Monitoring clinical procedures and the environment? Remaining 'hands off' as applicable? Appropriate delegation?*	☐	☐	☐	☐	☐

Team Work: ***Ratings should include the team as a whole i.e. the leader and the team as a collective (to a greater or lesser extent).***	0	1	2	3	4
3. The team communicated effectively *Prompts: Verbal, non-verbal and written forms of communication?*	☐	☐	☐	☐	☐
4. The team worked together to complete tasks in a timely manner	☐	☐	☐	☐	☐
5. The team acted with composure and control *Prompts: Applicable emotions? Conflict management issues?*	☐	☐	☐	☐	☐
6. The team morale was positive *Prompts: Appropriate support, confidence, spirit, optimism, determination?*	☐	☐	☐	☐	☐
7. The team adapted to changing situations *Prompts: Adaptation within the roles of their profession? Situation changes: Patient deterioration? Team changes?*	☐	☐	☐	☐	☐
8. The team monitored and reassessed the situation	☐	☐	☐	☐	☐
9. The team anticipated potential actions *Prompts: Preparation of defibrillator, drugs, airway equipment?*	☐	☐	☐	☐	☐

Task Management	0	1	2	3	4
10. The team prioritised tasks	☐	☐	☐	☐	☐
11. The team followed approved standards/guidelines *Prompt: Some deviation may be appropriate?*	☐	☐	☐	☐	☐

Overall	1	2	3	4	5	6	7	8	9	10
12. On a scale of 1-10 give your global rating of the team's performance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Comments: ____

APPENDIX B

Observational Skill-based Clinical Assessment Tool for Resuscitation (OSCAR) from Walker et al., (2011)

Observational Skill-based Clinical Assessment Tool for Resuscitation (OSCAR)

Date: **Assessor:** **Candidate:**

0 = Team Severely Compromised	1 = Team Compromised
2 = Slight detriment to team	3 = Team neither enhanced or hindered
4 = Moderate enhancement to team	5 = High level of enhancement to team
6 = Highly effective in enhancing teamwork	

COMMUNICATION

Anaesthetic Group (A)	**Individual Behaviour Ratings**							**Global Behaviour Score (0-6)**
Informs team whether patient is making respiratory effort	0	1	2	3	4	5	6	
Informs team of any other relevant clinical signs eg dilated pupil, obvious injuries, signs of aspiration	0	1	2	3	4	5	6	
Communication to team that they plan to intubate the patient if required	0	1	2	3	4	5	6	
Requests patient history on arrival and communicates details to team, if required	0	1	2	3	4	5	6	
Physician Group (P)								
Reviews patient history and notes and communicates relevant details clearly to the team	0	1	2	3	4	5	6	
Clear instructions communicated to the team regarding the arrest protocol	0	1	2	3	4	5	6	
Encourages communication from sub-teams, and encourages team members to give opinions	0	1	2	3	4	5	6	
Nurse Group (N)								
Provides clear information about arrest events on arrival of arrest team	0	1	2	3	4	5	6	
Senior nurse provides clear, audible requests to junior nurse when requesting equipment eg additional iv bags	0	1	2	3	4	5	6	
Instructs other nurses on ward clearly how to assist with arrest or other ward duties as appropriate	0	1	2	3	4	5	6	

APPENDIX C

Mayo High Performance Team Scale (MHPTS)

Use the following scale to rate the team on each dimension:
0 = never or rarely 1 = inconsistently 2 = consistently
Please rate conservatively. Most teams that have not worked extensively together do not consistently demonstrate many of the qualities described in the scale.
Always rate the following:

	1	A leader is clearly recognized by all team members
	2	The team leader assures maintenance of an appropriate balance between command authority and team member participation
	3	Each team member demonstrates a clear understanding of his or her role
	4	The team prompts each other to attend to all significant clinical indicators throughout the procedure/intervention
	5	When team members are actively involved with the patient, they verbalize their activities aloud
	6	Team members repeat back or paraphrase instructions and clarifications to indicate that they heard them correctly
	7	Team members refer to established protocols and checklists for the procedure/intervention
	8	All members of the team are appropriately involved and participate in the activity

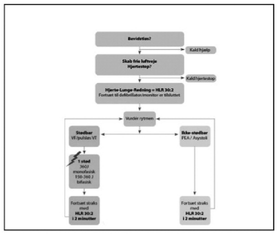
Items 9-16 may be marked “NA (not applicable)” if no situations occurred in which these types of responses were required.

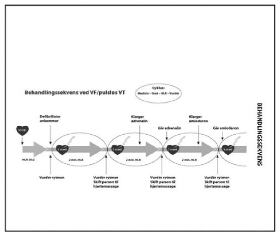
	9	Disagreements or conflicts among team members are addressed without a loss of situation awareness
	10	When appropriate, roles are shifted to address urgent or emergent events
	11	When directions are unclear, team members acknowledge their lack of understanding and ask for repetition and clarification
	12	Team members acknowledge-in a positive manner- statements directed at avoiding or containing errors or seeking clarification
	13	Team members can call attention to actions that they feel could cause errors or complications
	14	Team members respond to potential errors or complications with procedures that avoid the error or complication
	15	When statements directed at avoiding or containing errors or complications do not elicit a response to avoid or contain the error, team members persist in seeking a response
	16	Team members ask each other for assistance prior to or during periods of task overload

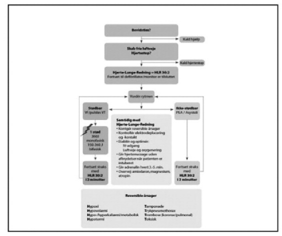
APPENDIX D

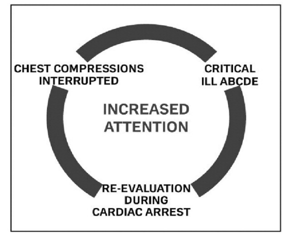
Check List from Andersen et al., (2010)

CHECKLIST









CARDIAC ARREST

INITIAL THERAPY	YES	NO
BLS established	☐	☐
Immediate safe use of defibrillator	☐	☐

CONTINUOUS LOOPS		
Monitoring	☐	☐
Time intervals	☐	☐
Stop/start compressions	☐	☐
Medication. Safe verbal procedure	☐	☐
Change of BLS strategy after intubation	☐	☐
Change of person performing chest compressions every 2 minutes	☐	☐

INFORMATION AND SUPPLEMENTARY THERAPY		
Use of cognitive aid	☐	☐
Supplementary information	☐	☐
H and T re-evaluation	☐	☐
Re-evaluation	☐	☐

CIRCULATION

SPONTANEOUS CIRCULATION		
Re-evaluation ABCDE	☐	☐
Transfer/and Monitoring	☐	☐

TECHNOLOGY AND PROCEDURES

CORRECTION				
Unnecessary hands-off time corrected	Not relevant	☐	☐	☐
Hyperventilation corrected	Not relevant	☐	☐	☐
Correction of defibrillation not performed	Not relevant	☐	☐	☐

MAINTAIN ALGORITHM		
Defibrillation	☐	☐
Medication	☐	☐
Pulse check	☐	☐

TECHNOLOGY				
Troubleshooting defibrillator	Not relevant	☐	☐	☐
Safe defibrillation	Not relevant	☐	☐	☐

APPENDIX E

ASU-MAYO team performance Metric

For each bulleted item count the number of instances of the error
(Code team leader = CTL, N = number of errors)
Teamwork SCORE = aSUB+bSUB+cSUB+dSUB

a. Leadership errors [SUBSCORE = 25-N]
    - CTL did not verbally identify him/herself upon arrival to the code
    - CTL did not position himself properly to direct code
    - CTL did not ask bedside RN for report upon arrival to the code
    - CTL failed to take charge
    - CTL does not update team if situation with the patient changes
    - Team was not kept on task by CTL
    - CTL allowed micro-conversations to interfere with the code
b. Errors in role clarity [SUBSCORE = 25-N]
    - Team members were unsure of CTL
    - Team members were unsure of their responsibilities during the code
    - If CTL change occurred, the change was not verbalized
    - Team member delayed in completing a task
    - CT member performed an incorrect task
c. Workflow and coordination errors [SUBSCORE = 25-N]
    - Initiation of chest compressions was delayed following the establishment of pulselessness
    - Bed not positioned properly prior to code team arrival by bedside RN
    - CT arrival was > 2 minutes from Code Blue overhead call
    - Chest compressions were delayed for > 10 seconds
    - First shock was not delivered within 2 minutes of identification of VF or pulseless VT
    - IV/IO Epinephrine or Vasopressin was not administered within the first five minutes of the event
    - Placement of backboard was delayed > (need a time here)
    - Time on chest for team member performing CPR was inappropriate
    - Change of team member performing chest compressions was awkward
    - Universal precautions were not followed by team members
    - All nonessential equipment was not removed from patient area
d. Communication errors [SUBSCORE = 25-N]
    - Code status was not verified and communicated to code team members
    - ECG rhythm was not verbalized
    - Medication dose and route was not verbalized
    - Medication allergies were not verbalized
    - Instructions were not clearly verbalized
    - Completion of a task was not verbalized
    - Instruction not repeated back to CTL to ensure they were heard correctly, if questioned
    - Patient status and report not given when new CT members arrived

APPENDIX F

Draft 1 of the CODE BLUE Communication model

Timing	Sender	Receiver	Essential Communication
Code team arrival to code	a. Code team leader b. Bedside RN taking care of the pt when event started c. Code team leader	a. All involved in code b. Code team leader c. Bedside RN taking care of the pt when event started	a. CTL introduces himself as the leader and confirms who the bedside RN taking care of the patient b. Gives a quick overview of the events leading up to the code call. c. IF not immediately given by bedside RN THEN the code team leader asks for a quick overview of the events leading up to the code call.
Patient connected to the ECG	a. Code team leader b. Bedside RN c. Code team leader	a. Team member performing CPR b. Code team leader c. Bedside RN taking care of the pt when event started	a. Instructs team member to stop CPR while the rhythm is interpreted. b. Once patient is connected Bedside RN communicates to the code team leader what rhythm is the patient in. c. IF the bedside RN cannot answer, THEN the code team asks anyone that can answer. Communicate the next step based on rhythm and ensure it was completed by verbal verification
2 minutes into code	a. Code team leader	a. Bedside RN taking care of the pt when event started	a. Asks the AMPLE questions
If ROSC	a. Code team leader	a. Code team RN	Transport patient to ICU

APPENDIX G

SME revision of first draft of CODE BLUE Communication Model

TIMING		SENDER	RECEIVER	COMMUNICATION
INTRODUCTION	Code Team arrival to bedside	CTL	Code Team	1. Introduces self as leader 2. Clarifies who Code RN is 3. Asks who bedside RN is
		CTL	Code RN	Ensures code cart is present and Code RN is establishing advanced monitoring
FIRST IMPRESSION ROLE CLARIFICATION		CTL	Code Team	Asks about ABCs If any not present: ensures one person is doing CPR and RT is bag mask ventilating
		Bedside RN	CTL	Tells brief history of events leading up to code
		CTL	Code Team	Delegates a member to do more investigation: Get more history, pull up EMR (allergies, meds, labs, notes, code status), look at tele, find out where primary team and family is
PROBLEM IDENTIFICATION	Once monitoring is established	Code RN	CTL	1. Tells vitals (if CPR not in progress) 2. If doing CPR - states if there is a shockable rhythm (while compressions are held)
		CTL	Code Team	Asks for ACLS therapies **as indicated** 1. Meds from pharmacist or RN 2. IV access from another RN or CCT 3. Defibrillation set-up from another RN
	During ACLS preparation	RT at head	CTL	Clarifies if BMV successful 1. If inappropriate – states change in O2 device 2. If airway unprotected or BMV inadequate, states need for advanced airway
		CTL	Code Team	Clarifies if there is a need for intubation 1. Delegates code team member to airway 2. Ensures second RT is setting up
	constant feedback	Code Team	CTL	Notifies of any problems, so CTL can troubleshoot or delegate task to another person *(i.e. place CVC, place IO, call main pharmacy, get difficult airway cart, etc.)*
ACTION	ACLS (if indicated)	CTL	Code Team	Performs ACLS as appropriate 1. Defibrillation/Cardioversion 2. Meds 3. Advanced airway
	constant feedback	Code Team	CTL	Identifies when any therapies are unsuccessful/difficult or there is a change in clinical status
FURTHER INVESTIGATION		CTL	Code Team	Asks for further monitoring as needed 1. EKG, US/Echo, ABG, labs (delegates amongst team members)
		Code Team 'Investigator'	CTL	Tells more pertinent story, labs, tele, diagnostics *(may be presented sooner if appropriate/ available)*

	constant feedback	Code Team	CTL	Clearly tell results of diagnostics
FURTHER ACTION	At any appropriate time	CTL	Code Team	Asks for other necessary therapies *(i.e. Ca, Bicarb, Fluids, Benzos, Narcan, Blood product, more vascular access etc.)*
RESULT	**constant feedback**	Code Team	CTL	Identifies improvement or deterioration 1. Clarifies ROSC/stabilization of ABCs 2. OR clinical worsening
	Dispo	CTL	Code Team Others	1. Clarifies disposition (i.e. transfer to ICU, need for more advanced therapies, discontinuation of efforts, etc.) 2. Communicates to necessary people (calls consultation if needed, speaks to family, clarifies dispo with other teams involved)

APPENDIX H

Simulated Code Blue Event Questionnaire

1. Are you a physician, RN, NP, PA? Do you have a specialty?
2. How long have you been practicing at your current level?
3. How long have your held the ACLS certification?
4. Do you typically performing as a team leader in real codes? If not the team leader what is your role?
5. Have you performed as a team leader in simulated codes? If not the team leader what is your role?
6. Have you had any formal team training? If yes how much? Explain the training.
7. What went well with today's simulated code?
8. What could have been improved in this patient's care?
9. Were there any delays in therapy? If so, provide a description of the delay.
10. Do you feel the script helped you perform better as the code team leader? Did the cheat sheet help?

APPENDIX I

CODE BLUE Communication Model “Cheat Sheet”

Arrival to code	Introduces self as code team leader
Contingency	**IF:** Code RN does not immediately give the CTL a brief history, code status, and confirm advanced monitoring is established **THEN:** CTL must directly ask the Code RN for the information
Within 30 seconds of arrival to code	Asks about ABCs **IF:** No one person is performing CPR or performing bag mask ventilating upon arrival of CTL **THEN:** CTL must direct code team member to immediately perform CPR and the RT to bag the patient
Once monitoring is established	Asks for ACLS therapies as indicated **IF:** Medication or shock delivery is delayed more than 10 seconds after identification of rhythm **THEN:** CTL must directly as pharmacist or RN do deliver the meds and/or shock
constant feedback	Asks if there are any problems, so CTL can troubleshoot or delegate task to another person, keeps team on task, should be in SBAR format
Contingency	**IF:** Code team does not clarifies ROSC/stabilization of ABCs OR clinical worsening **THEN:** CTL must clarify disposition (i.e. transfer to ICU, need for more advanced therapies, discontinuation of efforts, etc.)