CRISIS RESOURCE MANAGEMENT TRAINING:
IMPACT ON TEAM PROCESS AND TEAM EFFECTIVENESS

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Abstract

Team process is vital to patient safety and patient care quality (Kohn, Corrigan, & Donaldson, 2000). During a patient crisis, team process is unique due to the dynamic nature of the unstable patient, need for rapid decisions, and team member coordination among providers who may be unfamiliar with one another. The purpose of this experimental, statistically-powered study was to evaluate the effects of Crisis Resource Management (CRM) training on the team process variables of teamworking, task management, situation awareness, and inter-professional attitude on the team effectiveness variables of team error rate and team response time among 24 interdisciplinary teams of two student nurses and two medical students. The team effectiveness conceptual framework described by Kozlowski and Ilgen (2006) served as the theoretical framework. The experimental group demonstrated a significant improvement in team process variables compared to the control group. CRM training predicted 13% of the variance in task management (p = 0.05), 15% of the variance in teamworking (p = 0.04) and 18% of the variance in situation awareness (p = 0.03). CRM training and task management predicted 22% of the variance (p = 0.04) in team error rate; CRM training and teamworking predicted 35% of the variance (p = 0.01) while CRM and situation awareness predicted 20% of the variance (p = 0.04) in response time to chest compressions. Both control and experimental groups demonstrated a significant improvement (p < 0.001) in each variable of team process and team effectiveness from pretest to posttest demonstrating a definitive practice effect of interdisciplinary training. Results of this study have implications for health care administration, clinical practice, educational design of team training, and team effectiveness theory.
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Chapter 1

Overview

Deaths resulting from preventable medical errors surpass the number of deaths due to the motor vehicle crashes, breast cancer, or AIDS (Kohn, Corrigan, & Donaldson, 2000). An estimated 44,000 patients die each year due to preventable medical errors (Kohn et al., 2000). The highest error rates occur in the more complex and time-sensitive environments placing patients undergoing emergency care at highest risk (Kohn et al., 2000). Lack of interdisciplinary teamwork during emergent patient care is a major source of errors leading to poor patient outcomes (Finer & Rich, 2002; Marsch et al., 2004; Wears & Leape, 1999). In the landmark Institute of Medicine report, To Err is Human: Building a Safer Health System, Kohn et al. states, “people make fewer errors when they work in teams” (p. 173). Recommendations from this report include development of team training programs using evidence-based methods for effective teamwork.

In an American Heart Association publication, team training plus life support skills are identified as comprising the optimal curriculum for patient crisis preparedness training (Chamberlain & Hazinski, 2003). However, health care providers are rarely taught or have opportunity to practice teamwork (McCallin, 2001). To prepare for patient emergencies, health care providers renew basic and advanced life support certifications every two years. These required courses provide an individual-focused review of knowledge and technical skills for managing a crisis. Despite this technical expertise in basic and advanced life support skills, patient crises are frequently characterized by chaos and error, putting patient safety at risk (Frank, 1981; Maibach, Schieber, & Carroll, 1996; Hayes, Rhee, Detsky, Leblanc, & Wax, 2007; O’Brien, Haughton, & Flanagan, 2001). Therefore, the individual-focused technical skills of
advanced and basic life support are not adequate to ensure effective and safe patient care in a crisis. Teamwork within the interdisciplinary team is a necessary complement to technical skill training to maximize quality and promote safe patient care.

Recent literature on patient safety provides evidence of the need for team training that is interdisciplinary in order to reduce error and improve patient safety (Baggs, et al., 1999; Boyle, 2004; Bumpus & al-Assaf, 2003; Corser, 2004; Higgins, 1999; Horak, Pauig, Keidan, & Kerns, 2004). Casto and Julia (1994) contend that interdisciplinary training may be most influential early in professional development when role socialization is evolving. However, education of health care providers occurs primarily in program silos.

Team training programs for the health care environment are frequently borrowed from other dynamic environments such as aviation or the military. However, successful teamwork varies by the context in which the team operates (Guzzo & Dickson, 1996). The unusual characteristics of the health care team in a patient crisis include: team members without prior work relationship, heterogeneous roles of the team members, and high stake patient outcomes at risk. A team training curriculum was borrowed and adapted from the aviation industry by the medical community called Crisis Resource Management (CRM). As in aviation, CRM is a programmatic approach using simulation to teach the non-technical or teamwork of managing a crisis. Several studies have evaluated outcomes from CRM education. Initially, CRM education was taught to homogenous groups of participants such as anesthesiologists or resident physicians. Study results demonstrated high participant value for the training and improved team process (Blum et al., 2004; Howard, Gaba, Fish, Yang, & Sarnquist, 1992; Sica, Barron, Blum, Frenna, & Raemer, 1999).
Statement of the Problem

The Institute of Medicine report (2001) identifies a failure to use innovative and proven teaching methods that can ensure translation of knowledge into practice as a factor in patient care quality. Crisis Resource Management (CRM) is an internationally known educational program using simulation of patient crisis scenarios to teach successful application of teamwork. The program provides learners with a conceptual framework for the behavioral, cognitive, and affective domains of team process plus a simulated opportunity using a human patient simulator for the learner to apply team process. The content of this educational program was originally developed in the aviation industry following the unfortunate and avoidable crash of an airplane flown by expert pilots. The incident highlighted the inadequacy of pure technical skills in managing a crisis situation. That is, team process variables such as task management, teamworking, situation awareness and inter-professional attitude are necessary to team effectiveness in addition to the relevant technical skills. In complex, dynamic environments such as aviation and health care, application of teamwork combined with the technical skills of basic life support are necessary to ensure safe and efficient management of a crisis (Howard et al., 1992).

Several studies in health care have demonstrated positive outcomes from CRM education or similar team training programs; however, only a few studies have investigated interdisciplinary teams of health care providers and measured team effectiveness outcomes (DeVita, Schaeffer, Lutz, Wang, & Dongilli, 2005; Morey et al., 2002; Shapiro et al., 2004). Most studies used homogenous groups of resident physicians or medical students as the trainees for crisis management and/or non-experimental design (Sica, et al., 1999; Yee et al., 2005). Since crisis response is managed by an interdisciplinary team of nurses and physicians, it is
important to study; but, it is not known if training teams of nurses and physicians as a unit will improve outcomes during a crisis. Casto and Julia (1994) contend that interdisciplinary training may be most influential early in professional development when role socialization is evolving. To date, there have been no published results of a statistically powered experimental study of interdisciplinary healthcare teams evaluating the impact of CRM training. In addition, few studies have correlated important elements of team process such as task management, teamworking, situation awareness, and inter-professional attitude to team effectiveness outcomes such as clinical response time and error rate to build evidence for the key team processes for effective team dynamics in a crisis. Correlation of team process to number of errors and to response time for standard interventions within a sufficiently powered experimental design will demonstrate the potential clinical impact of CRM training on patient care. Lastly, standardization of the CRM curriculum is critical to the application of a consistent independent variable across studies. Therefore, to ensure effective team training and to guide measures of effectiveness, the relevant variables that influence team process and team effectiveness must be grounded in a contextually relevant conceptual framework (Rosen et al., 2008).

**Conceptual Framework**

Team process is vital to patient safety and patient care quality (Kohn et al., 2000). This study proposes that the intervention of CRM training will improve the team process variables of task management, teamworking, situation awareness, and inter-professional attitude leading to better team effectiveness through a reduction in team error rate and team response time in an interdisciplinary team. The CRM curriculum must be grounded in an evidence-based conceptual framework to scientifically frame the variables of interest. Thus, in this study, a conceptual framework proposed by Kozlowski and Ilgen (2006) will be applied.
A Conceptual Framework for Team Effectiveness.

Kozlowski and Ilgen (2006) synthesized the empirical and theoretical literature from the past 50 years on work groups and teams. They propose a conceptual framework based on this synthesis identifying the key concepts of team process and illustrating potential relationships that can inform team effectiveness. The actions undertaken by the team or the team process are influenced by three primary domains: behavioral, cognitive, and affective. According to the Kozlowski and Ilgen’s (2006) conceptual framework, these domains are the primary constructs of interest for impacting team effectiveness.

The behavioral domain includes the constructs of teamwork competency, regulation, adaptation, communication, task management, leadership, and cooperation. Each of these constructs is evident at the individual team member level and the team level in a reciprocal and dynamic state. The cognitive domain includes the thought processes and perceptions that guide behavior such as collective climate, mental models, transactive memory, and team learning. Again, each of these constructs is evident at the individual and team level in a reciprocal and dynamic state. The final domain is the affective domain which includes the interpersonal and motivational constructs such as cohesion, attitude, efficacy, mood, trust, emotion, and conflict. These constructs are relevant at the individual and group level in a reciprocal and dynamic state. Lastly, these three primary domains of behavioral, cognitive, and affective constructs influence each other in a dynamic and emerging state of team process.

According to this framework, team effectiveness is the outcome measure of interest as defined by a stakeholder. Team effectiveness is directly influenced by team process, the coordination of team actions to achieve the desired goal. The concept of task demands refers to the complexity of the task and availability of resources to resolve the presenting problem.
(Kozlowski & Ilgen, 2006). Resources can include availability of cognitive expertise for problem-solving, technical skills for task needs, or accessibility of technological support. Therefore, the task demands represent the level of challenge faced by the team that drives the team process. The team works within a larger environment with contextual features and organizational factors which influence the task demands. That is, the context can add to or minimize the task demands faced by the team. This model represents a cyclical and reciprocal process (Kozlowski & Ilgen, 2006). Alignment of the elements in this model promotes team effectiveness. That is, an environment characterized by a supportive culture and infrastructure minimizes task demands. In turn, manageable task demands with availability of appropriate resources supports team process and promotes team effectiveness.

Team training is identified as one means to influence team process ultimately enhancing team effectiveness (Kozlowski & Ilgen, 2006). An adaptation of the Kozlowski and Ilgen (2006) conceptual model is illustrated in Figure 1-1. This model was developed from the description of the Team Effectiveness Conceptual Framework as described in “Enhancing the Effectiveness of Work Groups and Teams,” by S. Kozlowski and D. Ilgen, 2006, Psychological Science in the Public Interest.
Application to the Health Care Team.

Team process.

Team process within the health care team during a patient crisis is unique and complex (Baker, Day & Salas, 2006). The unplanned crisis requires the sudden creation of a team of providers to make urgent decisions that will result in life changing outcomes for the patient. This situation demands a high reliability response; that is, a response in which the consequences of an error are life-threatening, but the risk of error is low. Baker, Day and Salas (2006) conclude “that [team process] is an essential component of achieving high reliability particularly in health care organizations” (p. 1576).
Empirical evidence of the influence of behavioral, cognitive and affective domains on health care team process is noted in the health care literature (Leggat, 2007; McCallin, 2001). However, in the health care literature, the constructs within these domains are not clearly or consistently delineated as in the Kozlowski and Ilgen model (2006). There is no consensus among team process scholars in health care on the key constructs and the relevant taxonomy in the health care literature.

**Behavioral domain.**

Strong evidence of behavioral influences to interdisciplinary team process in a patient crisis is documented from studies using videotapes of real resuscitations. Data from three different studies that total 186 videotaped resuscitations (Cooper & Wakelam, 1999; Finer & Rich, 2002; Thomas et al., 2006) support that the following team behaviors promote quality care: communication, task coordination, hands-off leadership, assertive leadership, cooperation, and adaptation. In a study of simulated resuscitations of 16 teams of intensive care physicians and nurses, leadership, task coordination, and communication were identified as key behaviors for successful resuscitation of the human simulator (Marsch et al, 2004).

In the present study, two constructs will represent the behavioral domain of team process. Teamworking and task management ratings will serve as these dependent variables.

**Cognitive and affective domain.**

The concepts notable in the health care literature within the cognitive and affective domain include collective climate, attitude, conflict, and situation awareness (Fagin, 1992; Kosnik, 2002; McCallin, 2001). Evidence of these concepts within the health care literature is presented together due to their relatedness as identified in the health care literature.
The history of the physician and nurse relationship in which the nurse has been primarily female with less education, lower socioeconomic status and focused on care over cure has created challenges to effective team process (Casto & Julia, 1994; Larson, 1999; McCallin 2001). These differences have led to a hierarchy within the team and difference in patient care focus. Additional factors that contribute to the ongoing challenge include role socialization of new physicians and nurses, separate lines of management for physicians and nurses, and lack of interdisciplinary education between physicians and nurses (Casto & Julia, 1994; McCallin 2001; Stein, Watts, & Howell, 1990). These factors cause a lack of understanding of one another’s scope of practice and expertise as valued members of a team, therefore, mutual respect among the team members is jeopardized (McCallin, 2001). Despite the push for interdisciplinary teams in health care as a means to improve care quality, recent studies continue to document discrepant inter-professional attitudes between nurses or nursing students and physicians or medical students (Curran, Sharpe & Forristall, 2007; Nadolski et al., 2006; Thomas, Sexton & Helmreich, 2003). These differences in attitude and world view can contribute to a lack of cohesion, motivation, and collective climate within the team.

In an integrated literature review, McCallin (2001) concluded that conflict within the health care team was a barrier to a collective climate and compromised patient care. In a separate qualitative study using four focus groups of emergency department nurses, conflict with physicians led to nurse failure to prevent errors while a collective climate prevented errors (Henneman, Blank, Gawlinski, & Henneman, 2006). In a summary of studies by Fagin (1992), the author concluded that collective climate improved care as evidenced by decreased patient death rates, decreased length of stay, and decreased patient care costs. More recently, Schmitt
summarized (2001) studies that correlated the collective climate with reduced patient mortality
and morbidity.

Situation awareness, a component of the cognitive domain, is a form of mental model. It
involves recognizing and understanding the relevant elements of an event with the ability to
anticipate appropriate decisions and actions needed to effectively manage the event (Baker,
Gustafson, Beaubien, Salas, & Barach, 2003; Lightall et al., 2003; Thomas, Sexton & Helmreich,
2004; Wright, Taekman, & Endsley, 2006). Situation awareness is frequently identified as a
critical attribute in team process and is associated with medical error prevention (Baker et al.,
2003; Lightall et al., 2003; Wilson, Burke, Priest, & Salas, 2005). Some authors describe an
aspect of situation awareness as vigilance or cross monitoring by members of the team which is
important for prevention of potential errors among the team and optimizing team performance
(Henneman, et al., 2006; Thomas et al., 2004; Wilson et al., 2005).

Investigators have noted an association between situation awareness and medical error.
Rothschild et al. (2005) found that 42% of errors were intercepted by a vigilant nurse in their one
year observational study of two intensive care units. Risser et al. (1999) reviewed 54 incidents
from a convenience sample of eight hospitals. The investigators judged that failures in situation
awareness were primary contributors to clinical error in over 20% of the cases reviewed. Finer
and Rich (2002) reviewed videotapes of high risk newborn deliveries and determined poor team
process was related to lack of a situation awareness during the crisis event. Clearly the cognitive
and affective influences on team process as identified by Kozlowski and Ilgen (2006) are evident
in the health care team environment.

In the present study, two constructs from the affective and the cognitive domains will
serve as dependent variables. An inter-professional attitude questionnaire will represent the
affective domain of team process and a situation awareness rating will represent the cognitive domain.

**Team effectiveness.**

According to Kozlowski and Ilgen (2006), team effectiveness involves stakeholder input. Application to a patient crisis with the expectation of a high reliability response equates to low error in the provision of clinical practice standards and a rapid response in providing patient resuscitation. However, team effectiveness in this setting is a challenge as evidenced by high errors and poor patient outcomes (Finer & Rich, 2002; Marsch et al., 2004; Wears & Leape, 1999). The conceptual framework by Kozlowski and Ilgen (2006) provides insight into the variables that influence team process leading to improved team effectiveness.

In this study, two constructs represented dependent variables of team effectiveness. Error rate and response time of the interdisciplinary team were the measures of team effectiveness.

**Task demand & contextual contingency.**

The central team task of interest in this dissertation study was management of a patient crisis. The primary imbedding context for a patient crisis in the hospital setting is the interdisciplinary team. Unfortunately, nurses and physicians are educated in silos and are unfamiliar with one another’s competencies, perceptions and patient relation (McCallin, 2001). Applying the Kozlowski and Ilgen framework to a diverse group of health care providers, this context can contribute to task demands as team members’ work against each other at the individual level rather than in a complementary and synergistic fashion (Kosnik, 2002; Leape, 1997). Therefore, the interdisciplinary context of a patient crisis increases task demands of the team due to the lack of understanding of one another’s knowledge, skills and priorities.
In this study, the context of primary interest was an interdisciplinary team of two nursing students and two medical students. The task demand was a simulated patient crisis using a high fidelity patient simulator. Team resources included resuscitation equipment and the team member knowledge and skills of basic life support.

**Team training.**

Team training via simulation–based training is one approach recommended and encouraged by Kozlowski and Ilgen (2006) to promote team process leading to team effectiveness. A high fidelity synthetic environment which can be tailored to learner needs offers an ideal team training method that can successfully engage the learner. Therefore, based on the Kozlowski and Ilgen (2006) model, the CRM training aimed at improving team process was expected to improve team effectiveness.

**Summary of Conceptual Framework**

This study tested the impact of CRM training by measuring team process and team effectiveness variables using an experimental design. The interdisciplinary team was faced with the task demand of a simulated patient crisis. The simulated patient crisis was task demand embedded in the context of an interdisciplinary team of two nursing students and two medical students. The actions of the team to resolve the crisis required coordinated actions or team process. The mediation variables of teamworking, task management, situation awareness and inter-professional attitude, represented the behavioral, cognitive and affective domains of team process, respectively. CRM training was the manipulated independent variable. According to Kozlowski and Ilgen (2006), CRM training will improve team process. Improving team process with CRM training should lead to improved team effectiveness. Error rate and response time during a simulated patient crisis represented the dependent variables of team effectiveness.
Figure 1-2

Team Effectiveness Conceptual Framework with Study Variables

**Purpose**

The purpose of this study was to evaluate the effects of CRM training on the team processes of teamworking, task management, situation awareness and inter-professional attitude on team effectiveness through a reduction in team error rate and team response time among an interdisciplinary team of student nurses and third year medical students. CRM training is tailored to the unique training needs of health care providers in the setting of a patient crisis. Study findings will guide future CRM training that is empirically and theoretically grounded to potentially improve patient safety and care quality.
The four primary aims of this study were:

1. To test the efficacy of CRM training for improving team effectiveness through a reduction in response time and the number of medical errors during a simulated patient crisis.
   Hypothesis: The team trained in CRM and basic life support skills will demonstrate improved team effectiveness as measured by a decrease in response time and a reduction in the number of medical errors during a simulated patient crisis as compared to the team trained in only basic life support skills.

2. To test the efficacy of CRM training for improving team process during a simulated patient crisis.
   Hypothesis: The team trained in CRM and basic life support skills will demonstrate an increase in team process as measured by higher teamworking, task management, situation awareness, and inter-professional attitude during a simulated patient crisis compared to the team trained in only basic life support skills.

3. To evaluate the relationship between observed team process as measured by teamworking, task management, situation awareness, and inter-professional attitude and team effectiveness as measured by error rate and response time for standard interventions.
   Hypothesis: The effect of CRM training on team effectiveness will be mediated by team process.

**Definitions**

Basic life support (BLS) skills – The procedural interventions and standards of care for basic life support in cardiopulmonary resuscitation certification as published by the American Heart
Association (2006). These skills represent the technical skills needed by the health care team in a patient crisis.

**Crisis resource management** – CRM is an educational program for learning effective team process that can be applied during a patient crisis. Two key components of the curriculum are identification of a mental model for team process and application of team process in a simulated patient crisis. Teaching methods include: didactic, discussion, simulation and reflection.

**Contextual contingency** – The environmental dynamics that surround and influence a problem that requires resolution by the team.

**Error** – The failure of health care providers to follow established standards of care.

**Error rate** – The number of observed technical skills that are performed incorrectly and/or are incongruent with American Heart Association (2006) basic life support protocol.

**Interdisciplinary** – The complementary and interdependent nature of specialized knowledge, skills and attitudes between the professions of nursing and medicine (McCallin, 2001).

**Response time** – The elapsed time from the arrival of the team to the patient crisis until the critical interventions of oxygen administration, bag-valve-mask ventilation, emergency declaration and chest compressions are initiated.

**Task Demands** – The problem facing the team which includes the imbedded challenges and available resources related to the simulated patient crisis scenario.

**Team effectiveness** – This construct is the outcome from team process and is represented in this proposal as response time and error rate.

**Team process** – A dynamic interaction between cognitive, affective and behavioral domains that result in team actions to resolve task demands. These states occur at the individual and team
level in a reciprocal and emerging nature. Observable team process constructs are defined below:

**Situation awareness** – A construct in the cognitive domain of team process that includes the global assessment of a crisis event conducted by a health care provider providing an understanding of the implications of observations that inform decisions and actions (Wright et al., 2004).

**Task management** – A construct in the behavioral domain of team process which represents the interdependent and coordinated workload among team members during a patient crisis that is necessary to achieve patient care goals.

**Inter-professional attitude** – A construct in the affective domain of team process representing a team member’s discriminating perspective about the value of interdisciplinary interactions (Spencer, 1987).

**Teamworking** – A construct in the behavioral domain of team process in which team members demonstrate clear roles, effective communication, and cross-checking to achieve a mutual goal (Baker et al., 2003; McCallin 2001).

**Philosophical Assumptions**

Philosophical assumptions of adult learning are:

- All health care providers are well-trained, intelligent and motivated to improve their practice.
- Learning is voluntary and partly self-directed.
- Individuals construct their own reality which is influenced by their environment and their internal being.
Significance of the Study

The significance of this study was three-fold. First, successful team process is highly relevant to patient safety. The importance of effective team process to patient safety is articulated as a driving principle in the report from the Institute of Medicine (2001). That is, effective teams have improved patient outcomes, safer care and higher quality care. This study tested the efficacy of CRM training on team process and team effectiveness using a statistically powered, experimental design. Second, standardization of CRM training through theory-based content and learning methods is critical to clearly defining and evaluating an effective team training intervention. This study used specific content and teaching methods consistent with the CRM curriculum for team training educators and researchers. Therefore, clear identification of the independent variable and its effect on outcomes allows for consistency in future implementation studies. Third, empirical evidence correlating team process with pertinent team effectiveness outcomes in the health care setting is needed. In this study, experimental design and advanced statistical analysis was used to test the hypothesized empirical links between these variables thus informing relevant theoretical propositions. Findings from this study support an evidence-based CRM training curriculum to improve effectiveness in interdisciplinary health care teams and enhance patient safety.

Summary

The Institute of Medicine report (Kohn et al., 2000) states that errors occurring in the health care setting are a serious problem and identifies team training as one potential intervention to reduce those errors. Currently, the focus of health care provider education is on technical skills and is conducted in disciplinary silos of education. Interdisciplinary team process is seldom taught or practiced. Team process required during a patient crisis is unique due to the
dynamic nature of the unstable patient, need for rapid decisions, and team member coordination among providers who may be unfamiliar with one another. Identification of an effective CRM training curriculum is needed to reduce health care provider errors and improve response time during a patient crisis.
Chapter 2
Overview

The phenomenon of interest for this literature review is team process and team effectiveness specific to the interdisciplinary management of a patient crisis in a sample of senior nursing students and third-year medical students. A current health care provider team training program used internationally called Crisis Resource Management (CRM) will serve as the independent variable for the study. Team process variables represent the mediation variables (task management, teamworking, situation awareness, and inter-professional attitude) and team effectiveness variables represent the dependent variables of interest (response time and error rate).

Introduction to Crisis Resource Management Training

The purpose of this study was to evaluate the effects of CRM training on the team processes of teamworking, task management, situation awareness, and inter-professional attitude on team effectiveness through a reduction in team error rate and team response time among an interdisciplinary team of student nurses and third year medical students. CRM is an educational program for health care providers focused on effective team process during emergency patient care. Due to the complexity of managing the unstable patient combined with overwhelming evidence of medical errors despite accomplished technical skills of physicians and nurses, CRM is a highly relevant educational program for health care providers (Howard et al., 1992). The purpose of CRM training is to teach a coordinated team response to a patient crisis. The focus of CRM is to complement the technical skills of patient resuscitation with behavioral, affective, and cognitive team process through didactic, simulation, and critical reflection learning methods. This is purported to improve team effectiveness during a crisis situation. Although the CRM
program is taught in numerous medical institutions throughout the United States, Canada, and Europe, the content and teaching methods of the program are not standardized but are similar among institutions. Typically, the program includes three main segments: a didactic presentation of team process; videotaped scenario practice using a human patient simulator that is programmed to exhibit an emergency event; and an instructor-facilitated critical reflection of the videotaped team process during the simulated emergency event. However, the CRM program varies among different institutions in terms of the specific team process emphasized, the number of emergency scenarios used for practicing team process and the use of critical reflection. A theoretical foundation for identification of the program content of CRM has been slow to develop and potential empirical links under emphasized. Empirical linkages are essential to validate the necessary content critical to an effective CRM program. This chapter will present a literature review of prior studies related to team process, team effectiveness, and CRM training.

**Conceptual Literature Review**

The first part of this literature review focuses on the current evidence of interdisciplinary team process and team effectiveness in a patient crisis. Team process is the mediation variable and team effectiveness represents the dependent variable of interest in this proposal. The second part of this literature review focuses on an internationally known team training called CRM. CRM represents the independent variable of interest in this proposal. Databases used included: CINAHL, PubMed, Ovid, and ProQuest including dissertation abstracts. Search terms included various combinations of: teamwork, collaboration, conflict, attitude, cohesion, efficacy, crisis management, mock code, code blue, resuscitation, cardiopulmonary arrest, interdisciplinary, inter-professional, simulation, performance, emergency response, medical error, high reliability organization, and healthcare. The only limit applied to the search options was English language.
Evidence of Team Process and Team Effectiveness in a Patient Crisis

Team process during patient resuscitation is described as chaotic (Kaye et al., 1981), panicky (Jankouskas, 2001) and uncoordinated (Woodbery & Hamric, 1981). Jones et al. (1993) states that only about 10% of patients who suffer a cardiac arrest survive to be discharged and, according to Alspach (2005), that statistic has not improved since training in cardiopulmonary resuscitation began about 40 years ago. Many studies and interventions to improve team effectiveness in resuscitation have focused primarily on the technical skills of resuscitation (Funkhouser & Hayward, 1989; Jabbour, Osmond, & Klassen, 1996; Jewkes & Phillips, 2003; Nadel et al., 2000; Weaver, Ramirez, Dorman, & Raizner, 1979). Yet team effectiveness during resuscitation remains dismal (Abella et al., 2005; Alspach, 2005). Evidence-based team training is necessary for the development of highly reliable team effectiveness (Kohn et al., 2000).

O’Brien et al. (2001) used a qualitative approach to study the effects of practicing resuscitation from cardiac arrest on effectiveness and confidence in 30 medical interns. Each intern experienced a cardiac arrest simulation and two clinical skill stations followed by a debriefing. In addition, four interns, who experienced a real patient cardiac arrest within a month of the simulation education, were interviewed for their reactions and perceptions related to that event. The debriefings and interviews were videotaped for thematic analysis. Themes from the debriefings included the importance of communication between all team members, leadership as fundamental to satisfactory team process, and improvement in confidence, decision-making, and ability to prioritize following the simulation experience. Themes from the interviews included similarity of the real event to the simulated cardiac arrest scenario, lack of leadership and role confusion during the event, poor teamwork and ineffective communication during the event, and
remaining calmer and less anxious during the real event due to the prior cardiac arrest simulation experience. Interestingly, the themes from the intern interviews in the qualitative study by O’Brien et al (2001) focused on the non-technical or team process of managing a crisis such as teamwork, leadership, and communication. The interns expressed confidence in their knowledge and technical skills related to cardiac arrest following the education but the four interns who were interviewed following a real cardiac arrest recognized the significance of ineffective team process in an actual crisis.

The presence of team process (communication, leadership, task management, conflict) in 16 interdisciplinary teams was correlated with team effectiveness in a simulated cardiac arrest by Marsch et al. (2004). This was a post-test only, non-experimental design. Each team included two intensive care nurses and one intensive care physician. Evidence of team process was rated as present or absent via consensus by two of the investigators. Team effectiveness was determined by successful conversion of ventricular fibrillation to normal sinus rhythm within five minutes. Of the four team process variables studied, leadership (p = 0.033) and task management (p = 0.035) correlated with successful conversion to normal sinus rhythm within five minutes. Overall, only six of the sixteen teams studied were effective in converting the rhythm. The study was conducted at an international intensive care conference and no demographic data were collected; therefore, it is unknown which teams may have worked together professionally and which teams were unfamiliar with one another. Other potential extraneous variables of relevance but not reported include: years of experience, date of advanced life support renewal, and prior team training.

Thomas et al. (2006) videotaped 132 real resuscitations on newborn infants to study team process behaviors and team compliance with neonatal resuscitation standards of practice. Two
investigators rated frequency of six team process variables using a Likert scale of 0-4 (0-the behavior was not observed; 4-the behavior was observed consistently). Team processes of information sharing, inquiry, assertion, intent stated, teaching, evaluation plan, and leadership were noted but they were not seen with high regularity. Only the team process components of workload management and vigilance were noted regularly. Inter-rater reliability for observed team process was highly variable with a kappa statistic ranging from 0.21-0.8. Two different investigators, who were Neonatal Resuscitation Instructors, rated team compliance with standards of practice as an effectiveness measure. Mean noncompliance rate was 16% for preparation, 30% for oxygen administration, 26% for bag-mask ventilation, 24% for first intubation and 55% for second intubation. The compliance ratings were determined by consensus between the two instructors therefore; no inter-rater reliability was calculated. Interestingly, team process was inversely correlated with team non-compliance on standard of practice (Spearman rho ranged from -0.214 – -0.236, p value ranged from 0.007 – 0.014). No correlation of the findings to patient outcomes was reported.

In two additional studies of video-taped real patient situations, team process measures were correlated with team effectiveness outcomes (Catchpole, Mishra, Handa, & McCulloch, 2008; Cooper & Wakelam, 1999). Catchpole et al. (2008) used a behavioral marker system, NOTECHS, adapted from the aviation industry to measure four categories of team process variables: situation awareness, task management/leadership, teamwork/cooperation, and problem solving/decision making. These team process categories were correlated with the team effectiveness measures of total time in the operating room and error rate. The investigators observed videotapes of 48 surgical teams during one of two types of surgeries. Task management/leadership by the surgeon correlated significantly with less time in the operating
room (p = 0.046) and situation awareness by the surgeon correlated significantly with a decreased error rate in surgical technique (p = 0.001). Task management/leadership by the nurses correlated with a decreased error rate in nurse-related procedures during the surgeries (p = 0.027). Inter-rater reliability was reported as acceptable but no value was provided.

In a similar study, Cooper and Wakelam (1999) measured the team process variables of communication, adaptability, coordination, cooperation, initiative, work effort, and morale. The team process component of leadership was measured separately. These team process variables were correlated with team effectiveness measures of response time and performance errors. The investigators observed videotapes of 20 real patient resuscitations. Leadership was correlated with less error in task performance (p = 0.013) and quicker response time to intubation (p = 0.015). In addition, teams with leaders who became involved in tasks of the resuscitation, demonstrated an increase in task performance errors (p = 0.099). The other seven team process variables, as a group, correlated with less error in task performance (p = 0.034) and quicker response time to intubation (p = 0.020). Inter-rater reliability was reported as 0.60 – 0.75 on 71% of the each of the team processes and 72% of the leadership skills.

**Evidence of the Impact from Crisis Resource Management Training**

Helmreich and Wilhelm (1991) studied the impact of Cockpit Resource Management training on perceived usefulness and attitudes from airline crew members, a team training program used widely in the aviation industry to improve safety and performance in flight operations. A significant training effect (p < 0.001) was noted on the attitude survey of training participants for each scale, demonstrating that the training changed attitudes toward the team. No details on the reliability or validity of the questionnaire were provided. Team attitude is a
relevant construct in the affective domain of team process according to the conceptual model of team effectiveness by Kozlowski and Ilgen (2006).

This type of training was adapted by the medical community as Crisis Resource Management (CRM). As in aviation, CRM is a programmatic approach using simulation to teach non-technical or team process of managing a crisis. In the first health care investigation of CRM training effects, Howard et al. (1992) used a pre/posttest design in which anesthesiologists completed test questions about CRM principles plus a survey on utility of the course material immediately before and after the course. A significant increase in post-test scores ($p < 0.05$) among the residents was noted; however, experienced faculty scored high on the pretest with no significant change on the posttest.

A posttest only design was used by Blum et al. in 2004 to evaluate the utility of CRM for anesthesiologists. A sample of 148 fellows, residents and faculty physicians from four hospitals attended the CRM course. The participants completed a survey on utility of the content immediately following the course and one year later. Return rates were 100% and 71%, respectively. Utility of the course was highly rated at both measurement points. Of the 71% responders one year after the CRM course, 49% had experienced a real crisis event and reported improvement in perceived crisis management. In a similar study, Weller, Wilson, and Robinson (2003) also investigated perceived utility of CRM education. Following CRM education of 66 anesthetists, the investigators measured perceived utility 3-12 months later. With a 69% return rate, results demonstrated that 70% of the anesthetists believed the CRM education improved their clinical performance in real patient emergencies that occurred after the education.

Two additional and similar studies of CRM effectiveness assessed outcomes through effectiveness rating schemes. In 1999, Sica et al. studied a sample of 24 radiology residents who
attended a CRM program using a pre/posttest design. Two expert clinicians rated resident effectiveness on the initial scenario at the beginning of the course then again at the completion of the course on a different scenario. The order of the two scenarios was randomized and the expert raters were blinded. Inter-rater reliability was reported as within one point agreement on a 1-4 Likert scale in 73% of the ratings. A significant improvement in team process ($p < 0.03$) was noted on global assessment, use of personnel, and use of resources while the skills of role clarity and communication skills approached significance ($p < 0.06$). The utility of the course was rated close to excellent consistently by the participants.

Yee et al. (2005) investigated the effects of CRM using the Anaesthetists’ Non-technical Skills system (ANTS) in a sample of 20 anesthesia residents. The ANTS system is a behavioral marker rating scale for team process. Following didactic presentation and discussion of CRM concepts, participants managed three patient crisis scenarios in groups of three. Each scenario was followed by a facilitated debriefing. At one month and two months post training, each small group of anesthesia residents managed an additional three patient crisis scenarios, each followed by a facilitated debriefing. Blinded expert anesthesiologists who were trained in CRM and the ANTS system, rated the videotaped scenarios. There was significant improvement ($p < 0.005$) between each of the three one month intervals on the mean ANTS scores. Inter-rater reliability was 0.53. The absence of a control group in this study allows for a maturation effect. Without a control group, it is impossible to discern if the increase in team process resulted from the CRM training or from the repeated team practice across the three scenarios.

Thomas et al. (2007) improved on the latter studies by implementing an experimental design in a sample of residents. Seventeen teams were randomly assigned to a treatment of Neonatal Resuscitation Program (NRP) certification plus team training while 15 teams were
randomly assigned to the control group of only (NRP). The focus of NRP is the technical skills of neonatal resuscitation. Observed team process were rated by blinded raters using a team process scale systematically developed and validated in previous neonatal resuscitation studies conducted by Thomas and colleagues (Thomas et al. 2004, 2006). Inter-rater reliability on the elements of the observational team process scale ranged from 0.54-0.87. The treatment group demonstrated a significant increase in five of the six observed team processes (information sharing, $p = 0.002$; inquiry, $p = 0.008$, assertion, $p < 0.001$; teamwork behavior, $p < 0.001$) on the scale following CRM plus NRP education compared to the NRP education only control group. Use of a low fidelity manikin in this study increases the potential risk of inconsistent instructor-participant interaction which may pose a threat to external validity. With a low fidelity manikin the instructor is forced to be present during the scenario to provide scenario information which can lead to temptations to cue participants. In contrast, high fidelity simulators provide participants with all vital patient information such as heart rate, respiratory rate, and pulses which allows the instructor to be screened from the scenario.

**Evidence of CRM Training Impact on Interdisciplinary Team Training**

As popularity and positive outcomes were published on CRM training, recent application of CRM to interdisciplinary groups with outcome evaluation is found in a few studies. Lighthall et al. (2003) studied CRM course evaluation responses from 23 interdisciplinary groups of four intensive care unit (ICU) residents, a nurse, a respiratory therapist, and sometimes an ICU fellow. The CRM program included didactic instruction on CRM principles, discussion of two crisis scenarios, then team management of a crisis simulation followed by a debriefing using videotape review of the simulation. Participant evaluations were highly positive regarding relevancy and value.
A study of team effectiveness from 10 interdisciplinary team training sessions for nurses, physicians and respiratory therapists was conducted (DeVita et al., 2005). The team training focused on roles and responsibilities which is more limited in focus than CRM training concepts. Participants completed a web based tutorial prior to the training. The training included a didactic review of roles and responsibilities followed by three simulations and debriefings. Team effectiveness measures were number of expected tasks completed as defined for each scenario and “survival” of the simulated patient. Survival depended on delivery of minimum supportive resuscitation interventions. Survival of the simulator improved across the three scenarios from 0% to 90% (p = 0.002) and the mean tasks completed across the three scenarios improved from 31% to 89% (p = 0.001). No inter-rater reliability was performed as raters used consensus in assigning a rating on the tasks completed. Each of the ten courses had from 10-20 participants which is too large to ensure adequate scenario involvement of each participant. This poses a potential selection/instrument interaction which is an internal validity threat. In addition, the team training focus on only roles and responsibilities is substantively narrow. Since team process was not measured and there was no control group, it is difficult to determine if the improvement in team effectiveness was due to team process or due to skill practice across the three scenarios.

A convenience sample of pediatric nurses, pediatric residents, and anesthesia residents was used for a non-experimental pre/posttest design (Jankouskas et al., 2007). This pilot study included seven simulation sessions with different multidisciplinary groups of 3 pediatric nurses, 2 pediatric residents and one anesthesia resident who attended a three hour CRM program. First, each group worked through a patient crisis scenario imbedded with problems on the human patient simulator (HPS) that was video recorded for post-scenario reflection. Next, team process
was presented (resources, task management, communication, global assessment and leadership) and discussed followed by a facilitated debriefing of the video-taped scenario. Then the group repeated a different but equally challenging scenario on the HPS that was video recorded for post-scenario reflection. Pre/post measures included the Collaboration and Satisfaction about Care Decisions instrument (CSACD) (Baggs, 1994) and a blinded rating using the Anaesthetists’ Non-Technical Skills System (ANTS) (Fletcher et al., 2003). Both tools had documentation of acceptable levels for reliability and validity by the instrument developers. No inter-rater reliability was calculated for the ANTS system as ratings were determined by consensus of the two blinded investigators. Results of the pilot study demonstrated a significant difference in perceived collaboration (p < 0.001; power 99%). However, the lack of a control group poses a potential interaction effect between the pretest collaboration survey and the team process of the ANTS system. In addition, the close proximity of the pretest to the posttest can influence the posttest answers. One team process component on the ANTS system, teamworking, demonstrated a significant increase following the CRM training (p = 0.0051; power 94%). Findings for each of the other three team processes which included task management, situation awareness and decision making, showed increases but these changes were not statistically significant. This lack of significance could have been due to the small sample size or due to difficulty in rating these elements based on video viewing.

In a large multi-center, quasi-experimental study, Morey, et al. (2002) evaluated outcomes from a type of CRM training specific to emergency care providers entitled the Emergency Team Coordination Course (ETCC). This course covered similar concepts of a typical CRM training but did not include simulated patient emergency team practice. Nine hospitals’ emergency departments participated with 3 self-selecting into the control group due to
limitations in meeting the intervention group expectations. Self-selection is a threat to internal validity of study results. In this design, the intervention groups were those emergency department team members who attended the ETCC training. A total of 374 participants were in the control group and 684 in the intervention group. Outcome measures used prior to the training and 5 months following the training included:

**Team process**

Team Dimension Rating by trained experts during regular team working hours

Team attitude survey completed by participants

Subjective workload index completed by participants

**Team effectiveness**

Observed errors noted by simulation instructors during regular team working hours

Admission process evaluation by patient admissions personnel

Patient satisfaction survey completed by emergency room patients

All tools in the Morey et al. study (2002) had acceptable ranges of reliability (≥ 0.81 Cronbach’s alpha) and reported construct validity. Inter-rater reliability on team dimension rating ranged from 0.61-0.81 and was 0.69 for observed errors. Raters were not blinded. Results were aggregated by hospital for comparison and independent samples t-test applied. Paired t-test was applied to evaluate within group change between pre and post measures. Significant improvements were found in the intervention group on the team dimension rating (p = 0.012). A reassessment of the experimental group on the team dimension at 10 months following the intervention suggested a sustained performance of the team dimension that approached significance (p = 0.07). There were significant improvements found in the experimental group including a decrease in error rate from 30.9% to 4.4% (p = 0.039) and an increase in team
attitude ($p = 0.047$). No change was evident in subjective workload, patient satisfaction, or the admission process.

Shapiro, et al. (2004) improved on the latter study in a sample of multidisciplinary emergency department teams by using an experimental design. Four randomly selected teams of one physician, one resident, and three nurses were randomized into two control and two treatment groups. However, the purpose of this study was to compare the impact of ETCC training with and without simulated patient emergency team practice. The treatment groups attended an eight hour ETCC class. The four teams were rated on team process using a behaviorally anchored rating scale (BARS) metric in the emergency room environment during real emergency care prior to the ETCC training and two weeks post ETCC training. This scale was previously validated and inter-rater reliability in this study was reported as 0.67. Raters were blinded to control and treatment group. Results on the team process rating scale approached significance ($p = 0.07$). Participant surveys from the treatment group on the value of the course were highly positive. Nine of the ten participants rated the training as “excellent” and one participant rated the training as “very good” ($p = 0.001$). In this study, the small sample size was a limitation and may have had an impact on the lack of significant findings.

In a large experimental study across 15 hospitals, 1300 labor and delivery staff members were trained in CRM (Nielson et al., 2007). Each of the seven hospitals randomized to the treatment group held CRM trainings conducted by their own internal instructor who had attended a train-the-trainer CRM program. This poses the potential of inconsistent delivery of the CRM program intervention at the treatment hospitals due to the use of seven different instructors. Each hospital was aware of the assignment to treatment or control which poses a threat to internal validity. In a pretest/posttest design, a total of 28,500 deliveries were evaluated for the
following team effectiveness outcomes: maternal outcome, neonatal outcome, adverse outcome index, and response times for important interventions. There was no team process measures included in the study. The maternal outcome of response time from the decision to perform a cesarean section until the incision was performed was significantly different between the control and treatment group (p = 0.03). However, the lack of a team process measure and the potential inconsistent delivery of the independent variable (the CRM education) at each treatment group hospital are major flaws in study design. Thus, there is an inability to determine if the lack of significance was due to ineffective CRM delivery on resulting team process.

**Summary of Conceptual Literature**

The need for team training in a crisis is supported by the evidence of poor team process in real crises as documented by O’Brien et al. (2001) and by Thomas et al. (2006) and the correlation between team process and team effectiveness outcomes (Catchpole et al., 2008; Cooper & Wakelam, 1999; Marsch, 2004). Numerous studies have documented the high perceived value of CRM training from participant survey (Blum et al., 2004; Helmreich & Wilhelm, 1991; Howard et al., 1992; Lighthall et al., 2003; Shapiro et al., 2004; Sica et al., 1999). Most of the studies have been based on team training of homogenous groups of physicians which does not represent the typical emergency response team in a patient emergency (Blum et al., 2004; Howard et al., 1992; Lighthall et al., 2003; O’Brien, et al. 2001; Sica et al., 1999). Only a few studies have evaluated the impact on an interdisciplinary team (DeVita et al., 2005; Jankouskas et al., 2007; Morey et al., 2002; Shapiro et al., 2004). Although there is beginning evidence of a positive effect of CRM training on team process and team effectiveness, each of these interdisciplinary team studies has weaknesses in design and/or measures that serve as threats to internal or external validity. Many of these threats can be corrected with an
experimental design using a sample of interdisciplinary teams, appropriate statistical power, and measures that are reliable and valid.

Consistency and clarity of the independent variable is critical to documenting the specific nature of the intervention. In each of these studies, CRM education was the independent variable or the intervention applied to evaluate the impact on team process. However, across these studies, CRM education was not standardized. The key concepts of CRM education were originally borrowed from the team training conducted in the aviation industry. Most CRM programs consisted of some didactic information about team process and simulated emergency patient scenario practice followed by debriefing and critical reflection; but the program content and teaching methods varied considerably or were not clearly reported among studies. Programs varied from ½ day in length to a full day. Some programs included patient emergency scenario practice and others did not. Scenario practice within a program ranged from two scenarios to six. A few programs did not include video-tapeing of the scenarios for debriefing and critical reflection. Therefore, although the findings from CRM education across studies demonstrated high perceived utility, increased team process, and improved team effectiveness, it is not clear exactly what learning methods and content are critical to replicating those results.

Summary

The independent variable, the CRM curriculum, is an educational intervention aimed at improving team process and team effectiveness. The mediation variables of teamworking, task management, situation awareness and inter-professional attitude represent the behavioral, cognitive and affective domains of team process, respectively, while the dependent variables of error rate and response time represent team effectiveness. These variables are informed by the conceptual model described by Kozlowski and Ilgen (2006).
In the current study, a sufficiently powered experimental design with conceptually grounded variables was used to demonstrate the value of CRM training for improving interdisciplinary team process and team effectiveness during a patient crisis. Furthermore, this design allowed for causal statistical analysis of the independent, mediator and dependent variables. A sufficiently powered experimental design with causal analysis was important to expand the science in CRM training not previously tested.
Chapter 3

Overview

The research methods utilized for this study support the purpose of the study: to evaluate the effects of CRM training on the team process variables of teamworking, task management, situation awareness, and inter-professional attitude on team effectiveness through a reduction in team error rate and team response time among an interdisciplinary team of student nurses and third year medical students. The study design, proposed sample and experimental procedure used improve upon the weaknesses of prior studies related to this phenomenon of interest. The experimental design, sample inclusion/exclusion criteria, statistical power calculation, reliability and validity of measures, and the procedure details are presented.

Methodology

Design

This study utilized an experimental design. The target population consisted of teams of nursing students and medical students who respond to a patient crisis. The unit of study was the interdisciplinary team. Two medical students and two nursing students represented the team. The teams in the control group experienced a review of basic life support skills. The teams in the experimental group experienced a review of basic life support skills plus CRM training. The CRM training provided an additional 30 minutes of didactic information emphasizing team process.

Sample and Setting

The experimental and control group teams were formed using a convenience sample of two baccalaureate senior-year nursing students and two third-year medical students per team recruited from Penn State University, Hershey Medical Center Campus. This sample of students
was used to minimize error variance because it was assumed that the students should be at the novice level of practice experience. Basic competencies such as understanding the scope of their role, beginning clinical competence, having a positive attitude and the ability to problem-solve should be evident at this point in student development. Barriers such as role socialization, role history and differences in educational level were assumed to be minimal at this point in student development. Penn State Milton S. Hershey Medical Center is a 600 bed tertiary care and level I trauma center located in rural, south-central Pennsylvania. The medical center serves as a Special Mission campus for medical and nursing students during their undergraduate experience.

**Inclusion/Exclusion Criteria**

Inclusion criteria included: Third-year medical students and senior year nursing students enrolled at Penn State University, Hershey Medical Center Campus for the spring and fall of 2009 and who held current Basic Life Support Certification. Exclusion criteria planned were: prior participation in any health care team training, prior participation in a rapid response team, instructor status in any of the life support courses, licensed registered or practical nurse, a physical disability preventing full psychomotor participation in the simulation, or certification as an Emergency Medicine Technician or Paramedic.

**Sample Size**

The planned sample size consisted of 26 teams with each team comprised of two nursing students and two medical students for a total of 104 subjects. The primary outcome variables of response time and error rate were team-related variables based on the sample size of 26 teams. The mediation variables of team process (teamworking, task management, situation awareness) were also based on the sample size of 26 teams. Inter-professional attitude was an individual level mediation variable based on the sample size of 104 subjects.
The statistical power calculation for each variable of interest was based on a one-tailed study with alpha level of 0.05. The basis for a one-tailed study is supported by significant results from prior studies as discussed in the literature review. These prior studies demonstrated significant differences in team process, team effectiveness and error rate (Jankouskas, et al., 2007; Morey et al., 2002; Shapiro et al., 2004; Yee et al., 2005). From these studies, directional hypotheses were developed for this study. A one-tailed study is consistent with directional hypotheses (McNeil, 1997). The power calculation for each variable of interest with supporting evidence is discussed and charted below.

Table 3-1

Power Calculations for Variables of Interest

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>Effect size</th>
<th>N</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Time</td>
<td>1.0</td>
<td>0.6</td>
<td>1.5</td>
<td>26</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>Error Rate</td>
<td>5.0</td>
<td>2.0</td>
<td>2.5</td>
<td>26</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>Teamworking</td>
<td>0.8</td>
<td>0.46</td>
<td>1.74</td>
<td>26</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>Task Management</td>
<td>0.5</td>
<td>0.96</td>
<td>0.52</td>
<td>26</td>
<td>55%</td>
</tr>
<tr>
<td>Situation Awareness</td>
<td>0.3</td>
<td>0.74</td>
<td>0.41</td>
<td>26</td>
<td>40%</td>
</tr>
</tbody>
</table>

Measures

Response Time – Nadel et al. (2000) measured the difference in response time to key interventions in a simulated resuscitation between treatment and control groups to evaluate the effectiveness of a technical skills training curriculum. Based on the results of this study, an estimated effect size for response time is 1.5. With a sample size 26 for a one-tailed study with alpha level of 0.05, the power estimate was planned to be > 90 percent.
Error Rate – Morey et al. (2002) measured the difference in clinical error rate between emergency department teams. The treatment groups received a special team training course. Based on the results of this study, an estimated effect size for error rate was 5.0. With a sample size of 26 for a one-tailed study with alpha level of 0.05, the power estimate was planned to be > 90 percent.

Teamworking/Task Management/Situation Awareness – In a pilot study, Jankouskas et al. (2007) used an observational rating scale to measure the difference in teamworking, task management, and situation awareness following team training in a non-experimental design. The effect sizes for each variable varied with teamworking at 1.74, task management at 0.52 and situation awareness at 0.41. With a sample size 26 for a one-tailed study with alpha level of 0.05, the power estimate was planned to be > 90 percent for teamworking, 55 percent for task management and 40 percent for situation awareness.

It was anticipated that the low effect size for task management and situation awareness should be improved with the stronger design of the current study for several reasons. First, this was an experimental design using a sample of students instead of experienced practitioners which provided somewhat tighter control of variance. In addition, training of the raters on the observational rating scale was intensified to maximize inter-rater agreement. Statistical analysis was done using one-way ANOVA to decrease the error in the model and to maximize effect size.

Procedure

Participants were nursing and medical students from Penn State University. Twenty-four of the planned 26 interdisciplinary teams were formed. Each team was composed of two nursing students and two medical students. Students were informed of the study by the principal investigator at the end of the fall 2008 semester, at the beginning of spring 2009, and, again at
the beginning of fall 2009 semester during their regularly scheduled class. Appendix A contains a summary of the information provided. During that time, the names with contact information of interested students were collected using the Subject Inclusion Form (Appendix B). Eligible students were contacted by the principal investigator to schedule a training session. The students were randomized to attend an experimental or non-experimental training session using a table of random numbers. Permuted blocks were applied to the randomization to ensure a balanced design. The training sessions were scheduled from 6:00 pm – 9:00 pm on weekdays and on the weekends to avoid conflicts with classes and clinical. A phone call and e-mail reminder was conducted one week and repeated 24 hours prior to the scheduled training. An absence of any of the four team members required rescheduling of the session. Rescheduling occurred rarely.

Contamination of the control group is a potential risk with any educational intervention particularly with students in professional schools (Eva, 2004). This risk is inherent because motivated students who are in the control group want to know the intervention education and it is unethical to withhold potentially useful education. Therefore, the control group received the didactic content of crisis resource management information at the very end of the training session after all outcome measures were completed. It was expected that the students may be more likely to maintain requested confidentiality of the training if they received the teamwork training, although it occurred in a different order. Appendix C provides a comparative diagram of the procedure for the experimental and non-experimental groups.

**Control group.**

The control group received one three-hour training session in the following order. FIRST, upon entering the lab, the team was introduced to the simulation environment, human patient simulator (HPS) capabilities and each team member was given an opportunity to feel the
pulses and listen to the heart and breath sounds on the HPS. SECOND, the team managed a patient crisis on the HPS while being videotaped on two cameras. One camera was used to show the team in action and the other to show the bedside telemetry. This first scenario performance served as the pretest which was later analyzed for teamworking, situation awareness, task management, response time, and error rate by blinded raters. A brief time period to allow emotional reactions to the simulated scenario experience was provided. No instruction or feedback was given by the simulation instructor during this time. THIRD, the intervention occurred which was a review of basic life support skills. Refer to Appendix D for the didactic outline for the basic life support content used with the control group. The principal investigator facilitated group reflection on the videotaped crisis response to critically analyze application of basic life support skills. FOURTH, the team returned to the HPS to manage a second patient crisis scenario that was videotaped. This second scenario served as the posttest for the study which was later analyzed for teamworking, situation awareness, task management, response time, and error rate by blinded raters. A brief time period to allow emotional reactions to the simulated scenario experience was provided. No instruction or feedback was given by the simulation instructor during this time. The principal investigator facilitated reflection of the second scenario with the team. All reflection was facilitated using a technique described by Rudolph, Simon, Dufresne, and Raemer (2006). This technique constructively facilitates the critique of behaviors in a non-blaming manner. The facilitator guided the identification and inquiry of basic life support skills to assist the learners to explore the impact of their behaviors. Next, each participant completed the inter-professional attitude scale. Prior to leaving the session, the principal investigator presented Crisis Resource Management team process content to the non-experimental group (Appendix E).
Experimental group.

FIRST, upon entering the lab, the team was introduced to the simulation environment, HPS capabilities and each team member had an opportunity to feel the pulses and listen to the heart and breath sounds on the HPS. SECOND, the team managed a patient crisis on the HPS while being videotaped on two cameras. One camera was used to show the team in action and the other showed the bedside telemetry. This first scenario performance served as the pretest which was later analyzed for teamworking, situation awareness, task management, response time, and error rate by blinded raters. A brief time period to allow emotional reactions to the simulated scenario experience was provided. No instruction or feedback was given by the simulation instructor during this time. THIRD, the intervention, a presentation of content on the CRM concepts of team process in addition to a review of basic life support skills, was given by the principal investigator. A video of poor team process with a fatal outcome based on a true story was viewed for emphasis of the relevance and application of CRM concepts. Appendix E contains the didactic content for the primary concepts of CRM. The principal investigator facilitated reflection on the videotaped crisis response to critically analyze application of CRM concepts and basic life support skills. FOURTH, the team returned to the HPS to manage a second patient crisis scenario that was videotaped. This second scenario served as the posttest for the study which was later analyzed for teamworking, situation awareness, task management, response time, and error rate by blinded raters. A brief time period to allow emotional reactions to the simulated scenario experience was provided. No instruction or feedback was given by the simulation instructor during this time. The principal investigator facilitated reflection of the second scenario with the team. All reflection was facilitated using a technique described by
Rudolph et al. (2006). Prior to leaving the training, each participant completed the inter-professional attitude scale.

**Scenarios.**

The pre and post scenarios were planned to be different but equally challenging and were randomized to be the pre or post scenario with each group. The same two scenarios were used for the experimental and control groups (Appendix F). A method for creation of congruent scenarios described by Bush et al. (2007) was applied during scenario development. A content expert, W. Bosseau Murray who is a certified Simulation Instructor with 10 years of experience in simulation learning and CRM, reviewed the scenarios for congruency and recommended changes were incorporated. Although the pretest and posttest scenario were developed to be equally challenging, the scenario order was randomized using a table of random numbers to balance the potential threat to validity of one scenario being more difficult for the students to manage or order of treatment effect. In each scenario, the HPS simulated a standardized and timed deterioration in four stages: hypoxia, apnea, bradycardia, then asystole. Each stage had a maximum time frame; however, if the expected interventions for any stage were initiated prior to the maximum timeframe, then the HPS immediately transitioned to the next stage. Upon team arrival, the principal investigator presented the patient history verbally as written in Appendix F.

The scenarios were rehearsed for accuracy and consistency of presentation prior to the study. Physiological changes in the HPS were programmed to occur at maximum times in the scenario. Immediately after the patient’s history was verbalized by the principal investigator, the HPS scenario timer was initiated. Appropriate interventions initiated by the team were timed on the HPS.
Two health care providers were hired to review the videotaped crisis scenarios of each team. The selected reviewers were basic and advanced life support instructors. Reviewers were blinded to the scenario order of presentation and to the treatment condition for each team.

**Instruments**

**Anaesthetists’ Non-Technical Skills (ANTS) System**

The ANTS tool is an observational marker system for measuring the team process of interest (Appendix G). This tool was developed by industrial psychologists and anesthesiologists during a four year project between the University of Aberdeen Industrial Psychology Research Centre and the Scottish Clinical Simulation Centre in Aberdeen, Scotland (Flin, Glavin, Maran, & Patey, 2004). The team process taxonomy listed within this tool was identified via psychological research techniques and structured into a meaningful hierarchy. Task management, teamworking, situation awareness, and decision-making are the four categories of the tool. Each category has three to five behavioral elements. Each element is scored on a scale: 1 (poor), 2 (marginal), 3 (acceptable), 4 (good) or N (not observed). The element values are totaled and averaged for a final category score; therefore, an element that is not observed does not impact the final categorical score. The unit of analysis in the application of this tool was the interdisciplinary team.

**Validity and reliability.**

The ANTS system has evidence of content validity, internal consistency and inter-rater reliability. Content validity was demonstrated from a review of 50 expert anesthesiologists from 17 institutions across Scotland (Fletcher, Flin, McGeorge, Glavin, Maran, & Patey, 2003). Although the ANTS system was developed by anesthesiologists, the team process represented in the system are generic to all areas of health care practice and all types of practitioners.
The authors report an internal consistency (Cronbach’s alpha) between scale elements of 0.79-0.86. Inter-rater reliability for each category of the tool has been reported at:

- Task management: 0.65
- Teamworking: 0.65
- Situation awareness: 0.56
- Decision-making: 0.61

Improvement in the inter-rater reliability results to an acceptable range of > 0.8 was desired for this study. To promote improvement three initiatives were planned. One, a list of expected behaviors based on the study scenarios was provided to the raters for each behavioral element in the ANTS system. The list of expected behaviors for each element (Appendix F) was identified using the descriptions provided in the ANTS handbook (Flin et al., 2004). This list was validated as appropriate by a content expert, W. Bosseau Murray, a certified Simulation Instructor with ten years experience in teaching CRM. Two, the videotapes were randomly assigned to each rater. The raters were asked to stop the videotape every five minutes and assess ratings.

The decision-making skill category was not used in this study for two reasons. In the pilot study (Jankouskas et al., 2007), this skill was difficult to visualize on video and, therefore, difficult to rate. In addition, this element is not widely evident in the team process concepts derived from the health care literature for the conceptual framework of this study. Although the skill of decision-making clearly has a role in a patient crisis, it does not appear to be consistently linked to team process in a crisis.
Training.

For the current study, two raters were trained to use the ANTS tool in viewing the videotaped pretest and posttest scenarios. Training of the raters in the use of this tool included: differentiation of basic life support skills versus team process, a detailed review of the ANTS tool based on the published handbook by Flin et al. (2004), a discussion of the principles in using psychometric tools for rating performance (halo effect and errors of leniency, severity, and central tendency), and practice in using the tool while scoring teams in videotaped patient crisis scenarios from the pilot study which was followed by a discussion facilitated by the principal investigator (Jankouskas et al., 2007). A goal of a 0.80 inter-rater reliability with the principal investigator ratings of the pilot study videotaped crisis scenarios of interdisciplinary teams was expected through training. Ratings were planned in 10 percent of the videotaped scenarios intermittently across the study period where the two raters rated the same videotaped scenario independently. Then the principal investigator was to facilitate discussion of variances in scoring of that scenario with the raters to maintain consistent scoring and inter-rater reliability of 0.80 throughout the study.

Inter-Rater Reliability

In this study, one of two blinded raters performed a rating using the ANTS and the error rate instrument while viewing each video-recorded pre and/or posttest scenario of each interdisciplinary team. Each scenario videotape was randomized to a rater. Randomization was conducted in permuted blocks of every four scenarios to ensure an even distribution of videotapes between raters. Across the 10-month study period, the principal investigator held three interspersed sessions with the raters to review video-taped scenarios to prevent drift of scoring and provide an ongoing frame of reference. Inter-rater reliability was conducted on
seven of the 48 videotapes or 14% of the sample across the 10-month study period. Reliability checks are recommended on a minimum of 10% of the video-recorded behavioral data throughout a study (Haidet, Tate, Divirgilio-Thomas, Kolanowski & Happ, 2009).

The ANTS instrument contains three categories of team process measures: task management, teamworking, and situation awareness. Inter-rater reliability demonstrated using Pearson correlation for task management was .96, for teamworking was .49, and for situation awareness was .66. The error rate instrument contained 16 standards of cardiopulmonary resuscitation. Inter-rater reliability demonstrated using Pearson correlation was .93 for total error score.

**The University of the West of England Interprofessional Questionnaire**

The purpose of this questionnaire is to assess attitudes related to interdisciplinary team process and related training of students in a healthcare field (Appendix H). This questionnaire was developed by Pollard, Miers and Gilchrist (2004) to annually assess student attitudes across a health care curriculum. Three categories of questions were identified by an interdisciplinary team of healthcare experts following a review of relevant literature: communication and teamwork, inter-professional learning, and inter-professional interaction. A fourth category, inter-professional relationship, was identified in a second study (Pollard, Miers & Gilchrist, 2005). Exploratory factor analysis demonstrated a loading of > 3.5 on one factor with one exception. The inter-professional relationship category revealed two factors; however, the two factors demonstrated a correlation of $r = 0.95, p< 0.001$ (n=713). This finding deemed the category acceptable despite evidence of two factors. Each category includes eight or nine statements that require a Likert scale rating from strongly agree to strongly disagree.
Validity and reliability.

Results from tests of reliability and validity of the questionnaire are listed in the table below (Pollard et al., 2004, 2005). For the inter-professional interaction category, no alternative questionnaire was identifiable to establish concurrent validity. However, content validity exists for each category based on the method of tool development with the input of experts from the health fields of nursing, physiotherapy, social work, psychology, and epidemiology in addition to the evidence-based literature review. Results of the factor analysis, as previously described, demonstrate construct validity for each category.

Table 3-2

Reliability and Validity Data: The University of West England Inter-professional Questionnaire

<table>
<thead>
<tr>
<th>Category</th>
<th>Test-Retest Reliability</th>
<th>Internal Consistency</th>
<th>Concurrent Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication and Teamwork</td>
<td>r = 0.78</td>
<td>n = 90</td>
<td>r = 0.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n = 813</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r = 0.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n = 40</td>
</tr>
<tr>
<td>Interprofessional Learning</td>
<td>r = 0.86</td>
<td>n = 90</td>
<td>r = 0.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n = 836</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r = 0.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n = 40</td>
</tr>
<tr>
<td>Interprofessional Interaction</td>
<td>r = 0.77</td>
<td>n = 90</td>
<td>r = 0.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n = 825</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n/a</td>
</tr>
<tr>
<td>Interprofessional Relationships</td>
<td>r = 0.83</td>
<td>n = 38</td>
<td>r = 0.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n = 694</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>r = 0.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n = 40</td>
</tr>
</tbody>
</table>

Response Time

Response time was the time in seconds that it takes the team to initiate certain expected and important interventions identified in the scenario that were critical in basic life support. There were four of these expected interventions for both scenarios that were programmed into the HPS computer: oxygen administered, bag-valve-mask ventilation (BVM) initiated, emergency called, chest compressions initiated. The HPS continuously tracked time on the computer. The timer was started by the principal investigator immediately following the
verbalization of the patient’s history in each scenario. When the programmed interventions were observed by the principal investigator, then the principal investigator clicked on that intervention in the computer program to mark the time. The principal investigator continuously monitored the scenario and the HPS computer. This responsibility was practiced in a rehearsal of the scenario prior to the study. The response times for the four interventions of oxygen administered, BVM initiated, emergency called, and chest compressions initiated were downloaded from the simulator and documented by the principal investigator on the Response Time Form (Appendix I).

**Error Rate**

Negligence by the team in performing the expected Basic Life Support (BLS) standards of care was counted as an error. There were 16 expected interventions for each scenario. The raters who rated the team process watched the video a second time to count the number of missed BLS standards or errors then documented these errors on the Error Rate Form (Appendix J). The unit of analysis for error rate was the interdisciplinary team. In 10 percent of the videotaped scenarios intermittently across the study period, it was planned for the two raters to rate the same videotaped scenario individually. Then the principal investigator would facilitate a discussion of variances in error rate of that scenario with the raters to maintain consistent scoring and inter-rater reliability of 0.80 throughout the study.

**Demographic Data**

A demographic data form was completed by each participant (Appendix K). Demographic characteristics included: gender, role, month/year of most recent CPR certification, perceived equality of scenarios, presence of friends on the team, and number of real
patient experiences in performing CPR. All data and videotapes were coded with a group code. No participant names appear on any data collection forms.

**Training Session Face Sheet**

A training session face sheet was completed by the principal investigator for each training session team to ensure consistent adherence to the study procedure and quality collection of data (Appendix L).

**Planned Analysis**

Data were entered into the Statistical Package for the Social Sciences (SPSS®) by the principal investigator. Descriptive data (frequencies, means, and scatter plots) were computed to become familiar with the data by noting distribution and shape, outliers and asymmetries. Specific variables were examined as follows:

a. gender – histogram.

b. number of friends on the team – histogram, mean, median, mode. (Friend is defined as someone with whom time is spent by choice.)

c. number of months since CPR renewal class and number of real patient CPR experiences – histogram, mean, median, mode.

d. error rate, response time, individual attitude score, teamworking, situation awareness, task management – box plot.

Change scores were calculated and independent samples t-test applied to test the difference between the control and experimental groups on each outcome measure for change in error rate, response time, inter-professional attitude score, teamworking, situation awareness, and task management to test the following a priori hypotheses.
Hypothesis 1

The team trained in CRM and basic life support skills will demonstrate improved team effectiveness as measured by a decrease in response time and a reduction in the number of medical errors during a simulated patient crisis as compared to the team trained in only basic life support skills.

Hypothesis 2

The team trained in CRM and basic life support skills will demonstrate an increase in team process as measured by teamworking, task management, situation awareness, and interprofessional attitude during a simulated patient crisis following training compared to the team trained in only basic life support skills.

Variables to be analyzed will be scenario order (scenario A first or scenario B first), the highest number of friends on the team identified by any team member, number of real patient CPR experiences and the number of months since the most recent CPR certification of any team member. Line plots of the dependent variables and the scenario order will be reviewed to evaluate for potential interactions.

Hypothesis 3

The effect of CRM training on team effectiveness will be mediated by team process.

Scatterplot combinations and correlations were performed to identify potential relationships between the variables. The following correlations were evaluated:

a. Change in error rate * response time
b. Change in error rate * teamworking
c. Change in error rate* situation awareness
d. Change in error rate* task management
e. Change in response time * teamworking
f. Change in response time* situation awareness
g. Change in response time* task management

Linear regression was used to measure the mediation effect of team process. Each of the dependent variables, error rate and response time, was regressed with CRM training as a predictor.

**Protection of Human Rights**

Approval from the Institutional Review Board at the Penn State Hershey Medical Center was obtained prior to initiation of the study. The study was explained by the principal investigator to nursing students and medical students during scheduled classes (Appendix A). The purpose of the study was presented as a three-hour scenario-based educational training in the Simulation Lab using the human patient simulator (HPS) to evaluate effective ways to reduce medical errors and improve patient safety. Interested students were asked to complete the Subject Inclusion Form (Appendix B) collected by the principal investigator.

Upon arriving for the educational training, the purpose and duration of the study was reiterated. The importance of confidentiality of the performance of fellow students during the training was emphasized to the participants. All data were coded with an identification number to ensure anonymity of subjects. The benefit of the study was explained as providing outcomes from scenario-based simulation education intended to reduce medical errors and improve patient safety.

**Summary**

This study used an experimental pretest/posttest design using a statistically powered target population of medical and nursing students to form interdisciplinary teams of four
members. The independent variable was CRM team training plus BLS review. The control group only received BLS review. The mediation variables were the team process variables of task management, teamworking, situation awareness and inter-professional attitude. The dependent variables were team error rate and response times. Each variable was measured at the team level. Analysis was conducted to determine the impact of CRM training on team process and team effectiveness. In addition, analysis was performed to determine potential mediation effects of the team process variables on team effectiveness.
Chapter 4

Results

In this chapter the results of the descriptive and hypothesis testing analyses are presented. First, the sample demographic information will be presented. Second, equality between the control and experimental groups will be demonstrated for demographic and pretest data. Third, primary analysis for the three hypotheses will be presented. Fourth, secondary analysis on variables of interest will be presented.

The purpose of this study was to evaluate the effects of crisis resource management (CRM) training on team process and team effectiveness in an interdisciplinary team of senior nursing students and third year medical students. This was an experimental design using a convenience sample of 24 interdisciplinary four-person teams of medical and nursing students. The planned sample size of 26 teams was not achieved due to the ending of the 2009 fall semester for the target population. The independent variable, the CRM curriculum, was an educational training intervention. The mediation variables of teamworking, task management, situation awareness, and inter-professional attitude represented the behavioral, cognitive and affective domains of team process, respectively, while the dependent variables of error rate and response time represented team effectiveness.

Demographics of the Sample

Ninety-six students participated in the study over a 10 month period, 46 third-year medical and 50 senior-year nursing students. There were 30 male and 66 female student participants. Of the males, 27 were medical students and three were nursing students. Three teams contained 3 nursing students and one medical student; 21 teams contained 2 medical and 2 nursing students. Table 4-1 illustrates the details of role and gender in the study sample. Eleven
of the 24 teams were spring semester 3rd year medical students and senior nursing students. Thirteen of the 24 teams were fall semester 3rd year medical students and senior year nursing students. There were 10 students who had prior emergency medical technician certification, 9 students who had prior CRM training, 4 students who had advanced life support certification and one student who was a physician assistant. These advantages were originally planned as exclusion criteria; however, the frequency of these advantages among the target population required inclusion of these variables in the analysis. Data were collected on these potential confounding variables to ensure randomization would maintain equality of groups. There were 12 teams in the control group and 12 teams in the treatment group.

Table 4-1

Gender and Role of the Sample

<table>
<thead>
<tr>
<th>Role vs. Gender</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing Students</td>
<td>3</td>
<td>47</td>
</tr>
<tr>
<td>Medical Students</td>
<td>26</td>
<td>20</td>
</tr>
</tbody>
</table>

Equality of the Groups

The experimental and control groups were examined for equality. Relevant variables included: number of friends on the interdisciplinary team, prior date of basic life support (BLS) certification, number of males on the team, and an advantage score. The prior date of BLS certification was converted to a team score by calculating the difference of months since certification from the month of the CRM training for each team member. The advantage score was the sum of potential advantages within a team of students. Noted advantages included: prior CRM training, past emergency medical technician training, or advanced life support certification. Each advantage was counted as one. The advantage score was a sum of the count
of advantages within each team. Descriptive statistics and independent samples t-tests indicated equality between the experimental and control groups on each of the relevant variables as shown in Table 4-2.

Table 4-2

Descriptive Data of the Sample

<table>
<thead>
<tr>
<th></th>
<th>Control vs. Experimental</th>
<th>Mean</th>
<th>S.D.</th>
<th>S.E.</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friends</td>
<td>control</td>
<td>0.75</td>
<td>0.32</td>
<td>0.09</td>
<td>-0.47</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>experimental</td>
<td>0.83</td>
<td>0.52</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BLS certification</td>
<td>9.0</td>
<td>3.6</td>
<td>1.0</td>
<td>-1.9</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>control</td>
<td>12</td>
<td>3.2</td>
<td>0.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>experimental</td>
<td>12</td>
<td>3.2</td>
<td>0.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>1.5</td>
<td>0.90</td>
<td>0.26</td>
<td>1.4</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>control</td>
<td>1.0</td>
<td>0.85</td>
<td>0.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>experimental</td>
<td>1.0</td>
<td>0.85</td>
<td>0.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advantage</td>
<td>1</td>
<td>0.85</td>
<td>0.25</td>
<td>-0.17</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>control</td>
<td>1.1</td>
<td>1.44</td>
<td>0.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>experimental</td>
<td>1.1</td>
<td>1.44</td>
<td>0.42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Advantage was the total sum of the following credentials among team members: emergency medical technician, physician’s assistant, advanced life support certification, prior crisis resource management training.

The control and experimental groups were evaluated on equality on the pretest scenario for each team process and team effectiveness variable. Each team managed two different patient crises using the human patient simulator. The first crisis served as the pretest occurring prior to the independent variable, CRM training. There was no significant difference identified between the groups on team process or team effectiveness variables on the pretest as shown in Table 4-3.
Table 4-3  
Pretest Data of Control vs. Experimental Group on Variables of Interest  

<table>
<thead>
<tr>
<th></th>
<th>Control vs. Experimental</th>
<th>Mean</th>
<th>S.D.</th>
<th>S.E.</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>2.38</td>
<td>0.822</td>
<td>0.237</td>
<td>1.4</td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>1.95</td>
<td>0.600</td>
<td>0.181</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teamworking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>2.63</td>
<td>0.738</td>
<td>0.213</td>
<td>0.89</td>
<td>0.38</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>2.36</td>
<td>0.715</td>
<td>0.215</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Situation awareness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1.92</td>
<td>0.571</td>
<td>0.165</td>
<td>0.54</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>1.76</td>
<td>0.818</td>
<td>0.247</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error rate total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>7.25</td>
<td>4.35</td>
<td>1.26</td>
<td>0.00</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>7.25</td>
<td>2.99</td>
<td>0.862</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response time: Oxygen placement</td>
<td></td>
<td></td>
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<tr>
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<tr>
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<tr>
<td>Response time: chest compressions</td>
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<tr>
<td>Control</td>
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Primary Analysis

**Hypothesis 1.**

The team trained in CRM and basic life support skills will demonstrate improved team effectiveness as measured by a decrease in response time and a reduction in the number of medical errors during a simulated patient crisis as compared to the team trained in only basic life support skills.

A change score from the pretest scenario to posttest scenario was calculated for each dependent variable. A box plot of each variable was reviewed for normalcy of distribution. It was notable in the box plot review that the experimental group showed less change score variance in each of the team process and team effectiveness variables compared to the control group. This is illustrated in Figures 4-1 through 4-4.
Figure 4-1 Oxygen Placement Response Time (seconds) Change Score

Figure 4-2 Bag-valve-mask Ventilation Response Time (seconds) Change Score
Each team process and team effectiveness variable demonstrated normalcy of distribution and Levene’s test for equality of variance showed no significant differences; therefore, an independent samples t-test was applied to test this hypothesis. There was no significant difference between the control and experimental group in response time to placement of oxygen (p = .32), bag-valve-mask ventilation (p = .12) or chest compressions (p = .11). The negative change score of response time data represents a decrease in the response time from pretest to posttest scenario. This decrease represents an improved response. The oxygen placement and
bag-valve-mask ventilation were not demonstrated during the pretest scenario in some teams which is reflected in the missing data for those variables. The change score for response time of calling for help was demonstrated consistently in only 4 teams; therefore that variable was not included in any further analysis. There was no significant difference in error rate ($p = 0.43$) between the control and experimental group. These data are illustrated in Table 4-4.

Table 4-4

Comparison of Team Effectiveness Change Scores

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Range</th>
<th>S.D.</th>
<th>S.E.</th>
<th>t</th>
<th>Sig.</th>
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<tr>
<td><strong>Response Time: Oxygen Placement</strong></td>
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<td>56.5</td>
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<td><strong>Response Time: Bag-valve-mask ventilation</strong></td>
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<td></td>
<td></td>
</tr>
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<td>188</td>
<td>79.3</td>
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<td></td>
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<tr>
<td><strong>Response Time: Chest compressions</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>control</td>
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<td>66.9</td>
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<td><strong>Error rate</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>control</td>
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<td>4.43</td>
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<td>0.167</td>
<td>0.43</td>
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<td>-3.42</td>
<td>8</td>
<td>2.71</td>
<td>0.78</td>
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<td></td>
</tr>
</tbody>
</table>

Interaction effects between CRM training and the team process variables of task management, teamworking, and situation awareness were investigated based on principal investigator observations of team member interactions within the control group teams. The principal investigator observed the occurrence of team process discussions among the team members without stimulation or facilitation by the principal investigator during the debriefing following the first crisis scenario. Figures 4-5 through 4-13 illustrate that interactions were present between CRM training and the team process variables. For each team process variable, a given score corresponded with mixed effects on the team effectiveness variables when comparing control group to experimental group.
Figure 4-5 Interaction: CRM Training + Task Management

![Error Rate Change Score vs Control and Experimental Groups](image1)

Non-estimable means are not plotted.

Figure 4-6 Interaction: CRM Training + Task Management

![Bag-valve-mask Response Time (seconds) vs Control and Experimental Groups](image2)

Non-estimable means are not plotted.
Figure 4-7 Interaction: CRM Training + Task Management

Figure 4-8 Interaction: CRM Training + Teamworking
Figure 4-9 Interaction: CRM Training + Teamworking

Figure 4-10 Interaction: CRM Training + Teamworking
Figure 4-11 Interaction: CRM Training + Situation Awareness

Figure 4-12 Interaction: CRM Training + Situation Awareness
Hypothesis 2.

The team trained in CRM and basic life support skills will demonstrate an increase in team process as measured by teamworking, task management, situation awareness, and inter-professional attitude during a simulated patient crisis following training compared to the team trained in only basic life support skills.

A change score from the pretest scenario to posttest scenario was calculated for each dependent variable. A box plot of each variable was reviewed for normalcy of distribution. It was notable in the box plot review that the experimental group showed less change score variance in each of the team process and team effectiveness variables compared to the control group. This is illustrated in Figures 4-14 through 4-16. Each variable demonstrated normalcy of distribution and Levene’s test for equality of variance showed no significant differences; therefore, an independent samples t-test was applied to test this hypothesis.
Figure 4-14 Task Management Change Score

![Task Management Change Score Diagram](image1)

Figure 4-15 Teamworking Change Score

![Teamworking Change Score Diagram](image2)
There was a significant difference between the control and experimental group in the change scores for team process variables of task management (p = 0.046), teamwork (p = 0.017) and situation awareness (p = 0.014). The reduced sample size in two teams in the control group for task management, teamwork, and situation awareness resulted from a lack of audio in the video-recording which prevented the blinded raters from performing accurate ratings of those variables. This led to missing data and prevented analysis of change score. The interdisciplinary attitude variables of communication and teamwork, inter-professional learning, inter-professional interactions, or inter-professional relationships were measured once at the end of the training. There was no significant difference between the control and experimental group on the attitude variables. These data are illustrated in Table 4-5.
Table 4-5

Comparison of Team Process Change Scores

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>Range</th>
<th>S.E.</th>
<th>t</th>
<th>Sig.</th>
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<tr>
<td>Task management control</td>
<td>12</td>
<td>0.19</td>
<td>1.80</td>
<td>-0.75-1.8</td>
<td>0.52</td>
<td>-1.67</td>
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<tr>
<td></td>
<td>10</td>
<td>1.18</td>
<td>0.50</td>
<td>0.25-2.0</td>
<td>0.16</td>
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<td></td>
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<tr>
<td>Task management experimental</td>
<td>12</td>
<td>0.37</td>
<td>0.79</td>
<td>-1.2-1.2</td>
<td>0.23</td>
<td>-2.19</td>
<td>0.02</td>
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<tr>
<td></td>
<td>10</td>
<td>0.98</td>
<td>0.44</td>
<td>0.2-1.8</td>
<td>0.14</td>
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<td>Teamworking control</td>
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<td>0.75</td>
<td>0.75</td>
<td>1.0-1.3</td>
<td>0.22</td>
<td>-2.34</td>
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<tr>
<td></td>
<td>10</td>
<td>1.47</td>
<td>0.67</td>
<td>0.0-2.3</td>
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<td></td>
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<tr>
<td>Situational awareness control</td>
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<td>22.5-25</td>
<td>0.23</td>
<td>0.77</td>
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<td>21.5-25.8</td>
<td>0.36</td>
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</tr>
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<td>24.2-26.5</td>
<td>0.24</td>
<td>-0.66</td>
<td>0.25</td>
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<tr>
<td></td>
<td>12</td>
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<td>0.66</td>
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<td>1.18</td>
<td>20.5-24.7</td>
<td>0.34</td>
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<td></td>
</tr>
</tbody>
</table>

Two patient scenarios were randomized to the pretest leaving the second scenario as the posttest. Five of 12 teams in the control group had scenario A first and seven of 12 teams in the experimental group had scenario A first. Therefore, despite randomization of teams to scenario A or B first, the groups were not equivalent on scenario order. Only two students of 96 marked the scenarios as unequal in level of challenge. However, initial review of the plots of the two different scenarios versus outcomes suggested that scenario A was more challenging for teams than scenario B. Therefore, repeated measures ANOVA was conducted on each team process and team effectiveness variable to evaluate potential interaction between scenario order and pre/post outcomes. Graphic illustrations are presented in Figures 4-17 through 4-23. Interaction effects were evident between scenario order and pre/post results for the team process variables of task management, teamworking, and situation awareness. No interactions were noted for the dependent variables of error rate or the response times as seen in Figures 4-17 through 4-23. In Figures 4-17 through 4-19, scenario A represented a more challenging scenario with a more
acute post-test response in the mediation variables of task management, teamworking, and situation awareness. Specifically, a lower pretest score followed by a greater magnitude of an effect was noted when scenario A was the pretest. In contrast, when scenario B was the pretest, the pretest score was higher and the effect was of less magnitude.

Figure 4-17
Task Management Change Score Interaction with Scenario Order

Figure 4-18
Teamworking Change Score Interaction with Scenario Order
Figure 4-19

Situation Awareness Change Score Interaction with Scenario Order

![Graph showing Situation Awareness Change Score Interaction with Scenario Order](image)

Figure 4-20

Error Rate Change Score Interaction with Scenario Order

![Graph showing Error Rate Change Score Interaction with Scenario Order](image)
Figure 4-21

Oxygen Placement Response Time (seconds) Change Score Interaction with Scenario Order

Figure 4-22

Bag-Valve-Mask Ventilation Response Time (seconds) Change Score Interaction with Scenario Order
Hypothesis 3.

The effect of CRM training on team effectiveness will be mediated by team process.

Correlation and linear regression analyses were conducted between the variables to test the final hypothesis. CRM represented the independent variable. Team process was represented by the variables of task management, teamwork, situation awareness, communication and teamwork, inter-professional interactions, inter-professional learning, and inter-professional relationships. Team effectiveness was represented by the variables of error rate and response times to oxygen placement, bag-valve-mask ventilation and chest compressions. CRM training was correlated with task management (p = 0.05), teamworking (p = 0.02) and situation awareness (p = 0.02). Situation awareness was significantly correlated with error rate (p = 0.03). Task management and teamworking were correlated with response times for bag-valve-mask ventilation (p = 0.03 and p = 0.05, respectively) and chest compressions (p = 0.03 and p = 0.01, respectively). Two of the measures on The University of the West England Inter-professional Questionnaire, inter-professional interactions and inter-professional relationships, were
significantly correlated with the response times of oxygen and compressions, respectively.

These correlations are shown in Table 4-5 and 4-6. A review of the scatter plots of these significant correlations revealed that most plots demonstrated a loosely linear relationship between the variables. However, the correlations between task management and the response times of bag-valve-mask ventilation ($r = -0.41$) and compressions ($r = -0.42$) and the correlation between teamwork and bag-valve-mask ventilation ($r = -0.36$) did not appear linear on the scatter plots. There were no significant correlations between CRM and the team effectiveness variables.

Table 4-6

Correlations between Team Process and Team Effectiveness Change Scores

<table>
<thead>
<tr>
<th>Task management</th>
<th>Response time: Oxygen placement</th>
<th>Response time: Bag-valve-mask ventilation</th>
<th>Response time: Chest compressions</th>
<th>Error Rate</th>
<th>CRM training</th>
</tr>
</thead>
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<tr>
<td>Sig. 0.06</td>
<td>-0.41</td>
<td>0.03</td>
<td>0.03</td>
<td>0.16</td>
<td>0.05</td>
</tr>
<tr>
<td>N 15</td>
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<td>22</td>
<td>22</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Teamworking</td>
<td>r -0.19</td>
<td>-0.36</td>
<td>-0.47</td>
<td>-0.19</td>
<td>0.44</td>
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<tr>
<td>Sig. 0.24</td>
<td>0.05</td>
<td>0.01</td>
<td>0.19</td>
<td>0.02</td>
<td></td>
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<tr>
<td>N 15</td>
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<td>22</td>
<td>22</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Situation</td>
<td>r -0.26</td>
<td>-0.19</td>
<td>-0.32</td>
<td>-0.41</td>
<td>0.46</td>
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<tr>
<td>Awareness</td>
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<td>0.07</td>
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<td>0.01</td>
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<td>N 15</td>
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<td>22</td>
<td>22</td>
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<tr>
<td>Communication</td>
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<td>0.06</td>
<td>0.07</td>
<td>0.09</td>
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</tr>
<tr>
<td>and teamwork</td>
<td>Sig. 0.20</td>
<td>0.40</td>
<td>0.37</td>
<td>0.34</td>
<td>0.22</td>
</tr>
<tr>
<td>N 15</td>
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<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
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<td>-0.09</td>
<td>-0.24</td>
<td>0.19</td>
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<td>0.33</td>
<td>0.13</td>
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<tr>
<td>N 15</td>
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<td>24</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Inter-professional relationships</td>
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<td>-0.47</td>
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<td>-0.17</td>
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<tr>
<td>Sig. 0.49</td>
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<td>0.01</td>
<td>0.49</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>N 15</td>
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<td>24</td>
<td>24</td>
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</table>
Table 4-7

Correlations between CRM Training and Team Effectiveness Change Scores

<table>
<thead>
<tr>
<th></th>
<th>Response time: Oxygen placement</th>
<th>Response time: Bag-valve-mask ventilation</th>
<th>Response time: Chest compressions</th>
<th>Error rate</th>
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<td>-0.13</td>
<td>0.25</td>
<td>0.26</td>
<td>-0.04</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.32</td>
<td>0.12</td>
<td>0.11</td>
<td>0.44</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
<td>23</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

Based on the correlations that demonstrated significance or approached significance, the common threads for potential team process mediation variables between CRM training and team effectiveness were as follows:

- CRM training ------- Situation awareness ------ Error rate
- CRM training ------- Task management -------- Bag-valve-mask ventilation response time
- CRM training ------- Task management -------- Chest compressions response time
- CRM training ------- Teamworking ---------- Bag-valve-mask ventilation response time
- CRM training ------- Teamworking ----------- Chest compressions response time

The first step in mediation analysis is to predict the dependent variables for team effectiveness using the independent variable of CRM training. Correlations between CRM training and the team effectiveness variables of error rate and the response times were not significant; therefore, further mediation analysis was not indicated. However, regression analysis was continued based on the correlations identified.

CRM demonstrated significant and positive predictive relationship with teamworking and situation awareness (p = 0.04; p = 0.03, respectively) and explained a variance of 15% and 18%, respectively. A similar relationship between CRM and task management approached significance (p = 0.05) explaining 13% of the variance. This data is illustrated in Table 4-8.
Table 4-8

Regression Analysis of CRM Training as Predictor for Team Process & Team Effectiveness

<table>
<thead>
<tr>
<th>Team Process</th>
<th>Team Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task management</td>
<td>Response time: Bag-valve-mask ventilations</td>
</tr>
<tr>
<td>Team-working</td>
<td>Response time: Chest compressions</td>
</tr>
<tr>
<td>Situation awareness</td>
<td></td>
</tr>
<tr>
<td>Error rate</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRM training as Predictor</th>
<th>Sig.</th>
<th>Beta</th>
<th>Adj. R</th>
</tr>
</thead>
<tbody>
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<td>0.05</td>
<td>0.41</td>
<td>0.13</td>
</tr>
<tr>
<td>Team-working</td>
<td>0.04</td>
<td>0.44</td>
<td>0.15</td>
</tr>
<tr>
<td>Situation awareness</td>
<td>0.03</td>
<td>0.46</td>
<td>0.18</td>
</tr>
<tr>
<td>Error rate</td>
<td>0.87</td>
<td>-0.04</td>
<td>-0.04</td>
</tr>
<tr>
<td>Response time: Bag-valve-mask ventilations</td>
<td>0.25</td>
<td>0.25</td>
<td>0.04</td>
</tr>
<tr>
<td>Response time: Chest compressions</td>
<td>0.15</td>
<td>0.30</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Results of analyses for CRM training in a regression model with each team process variable to predict team effectiveness are shown in Table 4-9. CRM training and teamworking explained 35% of the variance in response time to chest compressions ($p = 0.01$). CRM training and situation awareness explained 20% of the variance in response time to chest compressions ($p = 0.04$). CRM training and task management explained 22% of the variance for error rate ($p = 0.04$). Two other regression models approached significance. CRM training and situation awareness approached significance ($p = 0.09$), to explain 14% of the variance for error rate. CRM training and teamworking approached significance ($p = 0.06$) to explain 18% of the variance for response time for bag-valve-mask ventilation.
Table 4-9

Regression Analysis of Team Process and CRM Training as Predictors on Team Effectiveness

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Sig.</th>
<th>Error rate</th>
<th>Response time: Bag-valve-mask ventilations</th>
<th>Response time: Chest compressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRM + Teamworking as Predictors</td>
<td></td>
<td>0.63</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>Teamworking Beta</td>
<td></td>
<td>-0.24</td>
<td>-0.55</td>
<td>-0.68</td>
</tr>
<tr>
<td>CRM Beta</td>
<td></td>
<td>0.12</td>
<td>0.41</td>
<td>0.48</td>
</tr>
<tr>
<td>Adj. R</td>
<td></td>
<td>-0.05</td>
<td>0.18</td>
<td>0.35</td>
</tr>
<tr>
<td>CRM + Task Management as Predictors</td>
<td>0.04</td>
<td>0.18</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Task management Beta</td>
<td>-0.60</td>
<td>-0.42</td>
<td>-0.40</td>
<td></td>
</tr>
<tr>
<td>CRM Beta</td>
<td>0.26</td>
<td>0.34</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td>Adj. R</td>
<td>0.22</td>
<td>0.08</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>CRM + Situation Awareness as Predictors</td>
<td>0.09</td>
<td>0.24</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Situation Awareness Beta</td>
<td>-0.53</td>
<td>-0.43</td>
<td>-0.53</td>
<td></td>
</tr>
<tr>
<td>CRM Beta</td>
<td>0.26</td>
<td>0.41</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Adj. R</td>
<td>0.14</td>
<td>0.05</td>
<td>0.20</td>
<td></td>
</tr>
</tbody>
</table>

Secondary Analysis

Impact of practice.

The pretest scenario serves as an opportunity for control and experimental teams to practice an emergency response. Therefore, it was expected that each team would improve from pretest to posttest simply from the pretest practice opportunity. For this reason, a control group was essential in this design to differentiate this practice effect from the effect of the independent variable of CRM for the experimental group or the treatment effect. However, in clinical education, this practice effect also has meaning. Educational training for an emergency response may be in two different forms. One form is by simply practicing the technical skills in emergency scenarios. A second form is focused team process training such as CRM. Therefore, the impact of the practice effect was also analyzed for the significance of emergency response training.
Review of the box plot data for team process and team effectiveness variables suggested improvement from pretest to posttest scenario. The box plot of each pre and posttest variable demonstrated normalcy of distribution. Therefore, a paired samples t-test was applied to the pretest/posttest within group outcomes to determine the significance of the practice effect. Results are shown in Table 4-10. The reduced sample size of 15 for response time for oxygen placement resulted from no placement of oxygen on the manikin during the crisis scenario by some teams. All outcome variables showed a significant difference from pre to posttest scenario. This within group change represents a team practice effect.

Table 4-10

<table>
<thead>
<tr>
<th>Comparison of Pretest to Posttest Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Task management</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Teamworking</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Situation awareness</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Error total</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Response time: Oxygen</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Response time: BVM</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Response time: compressions</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Correlation of interest.

The number of males on a team showed significant or approaching significant negative correlation with the team process variables of task management (p = 0.03), teamworking (p = 0.05), and situation awareness (p = 0.09). In contrast, the number of males on a team showed a significant positive correlation with the team effectiveness variable of response time to
oxygen placement (p = .04). These data are shown in Table 4-11. There were 6 teams of the 24 teams in which all members were female. The maximum number of males in a team of 4 students was 3 males. The mean number of males on a team was 1.25 and the mode was 2 males. Ninety percent of the males in the sample were medical students.

Table 4-11

Correlation: Males vs. Outcomes

<table>
<thead>
<tr>
<th>Males/group</th>
<th>Oxygen</th>
<th>BVM</th>
<th>Compressions</th>
<th>Error</th>
<th>TM</th>
<th>TW</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>0.45</td>
<td>0.18</td>
<td>0.07</td>
<td>0.25</td>
<td>-0.41</td>
<td>-0.35</td>
<td>-0.30</td>
</tr>
<tr>
<td>Sig.</td>
<td>0.04</td>
<td>0.21</td>
<td>0.37</td>
<td>0.12</td>
<td>0.03</td>
<td>0.05</td>
<td>0.08</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
<td>23</td>
<td>24</td>
<td>24</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>

Oxygen – oxygen placement response time; BVM – bag-valve-mask ventilation response time; Compressions-chest compressions response time; error- error rate; TM – task management; TW – teamworking; SA – situation awareness

A review of means of the inter-professional questionnaire by gender and role revealed no differences in inter-professional perspective as shown in Tables 4-12 and 4-13. This questionnaire was completed once by each student after the second scenario was completed.

Table 4-12

Comparison between Inter-professional Attitude Scores and Gender

<table>
<thead>
<tr>
<th>Gender vs. Inter-professional Attitude</th>
<th>N</th>
<th>Communication &amp; teamwork</th>
<th>Inter-professional learning</th>
<th>Inter-professional interactions</th>
<th>Inter-professional relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female mean</td>
<td>66</td>
<td>24</td>
<td>32</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>SD</td>
<td>2.1</td>
<td>2.6</td>
<td>1.8</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>Male mean</td>
<td>30</td>
<td>24</td>
<td>32</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>SD</td>
<td>1.3</td>
<td>3.1</td>
<td>1.7</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>
Table 4-13

Comparison between Inter-professional Attitude Scores and Role

<table>
<thead>
<tr>
<th>Role vs. Inter-professional Attitude</th>
<th>N</th>
<th>Communication &amp; teamwork</th>
<th>Inter-professional learning</th>
<th>Inter-professional interactions</th>
<th>Inter-professional relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing student mean</td>
<td>50</td>
<td>24</td>
<td>32</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>SD</td>
<td>2.3</td>
<td>2.7</td>
<td>1.7</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Medical student mean</td>
<td>46</td>
<td>24</td>
<td>32</td>
<td>26</td>
<td>22</td>
</tr>
<tr>
<td>SD</td>
<td>1.4</td>
<td>1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary

Partial support was discovered for hypothesis two; the teams trained in CRM and basic life support skills demonstrated an increase in team process as measured by teamworking, task management, and situation awareness. However, inter-professional attitude results were not different between the control and experimental groups. Additional significant results of interest included: correlations between role/gender and team process variables and change scores on each variable due to a practice effect from pre to posttest.

Hypothesis one was rejected; the teams trained in CRM and basic life support skills did not demonstrate improved team effectiveness as hypothesized. There was no difference in response time or number of medical errors between the experimental group and control groups. Hypothesis three was rejected; the effect of CRM training on team effectiveness did not demonstrate mediation by team process variables.
Chapter 5

Overview

This chapter will first present conclusions related to each of the three hypotheses. Next, study implications from three perspectives will be discussed: clinical practice, educational design, and theoretical implications. Study strengths, limitations and suggestions for future research are presented. Implications from this study for health care administrators, educators, clinicians and researchers are recognized.

Conclusions

Hypothesis 1

The team trained in CRM and basic life support skills will demonstrate improved team effectiveness as measured by a decrease in response time and a reduction in the number of medical errors during a simulated patient crisis as compared to the team trained in only basic life support skills.

Hypothesis one was rejected as written; however, two findings from linear regression analysis provide some indirect support for hypothesis one. First, a regression model of CRM training with the team process variable of task management was predictive of error rate \( (p = 0.04) \). Second, a regression of CRM training with the team process variables of teamworking and situation awareness were predictive of response time for chest compressions \( (p = 0.01 \) and \( p = 0.04 \), respectively). These findings are congruent with the previous study findings on the association between CRM training and team effectiveness by Nielsen et al. (2007). Furthermore, the lack of significance between CRM training and each measure of team effectiveness in the current experimental study and the experimental study by Nielsen et al. (2007) supports the theory as described by Kozlowski and Ilgen (2006) that team process is a
dynamic and evolving phenomenon thus, significant changes in team effectiveness may not be realized in one static observation in time.

There are two recent studies (DeVita et al., 2005; Neilsen et al., 2007) in which investigators measured team effectiveness following CRM training of interdisciplinary teams. In the non-experimental study by DeVita et al. (2005), CRM training of 10 teams was associated with an increase in task completion (p = 0.001) and “survival” of the human patient simulator (p = 0.002) across three simulated crisis scenarios following the training. However, in this design, the practice effect cannot be separated from the CRM training effect. In the experimental, pretest/posttest study of 15 interdisciplinary obstetrical teams by Neilsen et al. (2007), four categories of team effectiveness outcomes were measured before and after CRM training: maternal, infant, adverse effects, and response times. Of these outcomes, one response time demonstrated a significant improvement in the experimental group, response time from decision to perform a cesarean section until incision.

In the current study, two additional reasons for a lack of significance between the control and experimental groups on team effectiveness are the confounding variable of scenario order and the overwhelming significance of the practice effect. The relatively small sample size prevented analysis to control for the effect of scenario order. The scenarios were designed to be equivalent to prevent this potential confounding variable; however, the interactions demonstrated that scenario order effects were not controlled. The practice effect in this study design is impossible to separate. A Solomon design or posttest only design would allow control of or elimination of the practice effect. The large sample size needed for a Solomon design makes such an approach difficult.
In summary, there is some support for hypothesis one based on the linear regression analysis for the current study. This is congruent with one finding from the experimental study by Nielsen et al. (2007). Additionally, the lack of support for hypothesis one could be explained theoretically by the evolving nature of team process and team effectiveness as described by the team effectiveness conceptual framework (Kozlowski & Ilgen, 2006). The lack of support could also be explained by study design.

**Hypothesis 2**

The team trained in CRM and basic life support skills will demonstrate an increase in team process as measured by teamworking, task management, situation awareness, and inter-professional attitude during a simulated patient crisis following training compared to the team trained in only basic life support skills.

A significant increase in teamworking, task management, and situation awareness was demonstrated in the experimental group compared to the control group. However, no difference was demonstrated between groups in inter-professional attitude. The significant results in the cognitive and behavioral domains in the current study confirm findings from prior studies. The lack of significance in the affective domain supports the need for further study.

Findings of the association between team process variables and CRM training from three recent studies (Jankouskas et al., 2007; Thomas et al., 2007 and Yee et al., 2005), support similar findings as those found in the current study. In these studies, cognitive and behavioral domains of team process were found to significantly improve after CRM training across each of these studies with significance levels $p \leq 0.008$. The current study found similar significant effects on cognitive and behavioral variables of team process after CRM training ($p \leq 0.05$) and expanded on these significant findings by applying linear regression analysis to demonstrate that CRM
training explains 13% - 18% of the variance on team process measures within the cognitive and behavioral domains.

The affective domain of team process was measured in the non-experimental design by Jankouskas et al. (2007). A significant improvement in perceived collaboration (p < 0.001) was found from pretest to posttest. The current study measured the affective domain once using the University of West England Inter-professional Questionnaire at posttest and found no significant difference between experimental and control groups. It is possible that the change in affective domain results from a practice effect rather than an effect of CRM training; therefore, no difference was noted between groups at the end of the training because the practice effect impacted both groups. A study by Robertson et al. (2009) partially supports this possibility.

Robertson et al. (2009) measured several areas of the affective domain at the individual level in a non-experimental pretest/posttest design in a sample of 22 perinatal healthcare providers who were divided into three teams. The independent variable was simulation-based CRM training. The affective domains of measure included: competence, comfort in role, confidence, and team attitude. This investigation demonstrated a practice effect on perceived competence (p < 0.004) from participation in 4 simulated crisis scenarios using a female birthing simulator. However, there was no significant difference from pretest to posttest on the three other measures.

In summary, three studies in addition to the current study now document significant improvements in the cognitive and behavioral domains of team process following CRM training. The impact on the affective domain is unclear due to the variety of self-report measures used and due to pretest versus posttest timing of the measure or potential instrument reactivity effects.
Hypothesis 3

The effect of CRM training on team effectiveness will be mediated by team process.

Correlations between CRM training and the team effectiveness variables of error rate and the response times were not significant; therefore, further mediation analysis was not indicated in this current study. In addition, there were no recent studies in health care in which investigators analyzed mediation potential of team process. However, Catchpole et al. (2008) and Mazzocco et al. (2009) demonstrated findings relevant to the relationship between team process and team effectiveness. In their study of 48 surgeries, Catchpole et al. (2008) found a positive correlation between task management by the surgeon and total time in the operating room (p = 0.046). A positive correlation between the surgeon’s situation awareness and errors in surgical technique was also found (p = 0.001). These findings are at the individual level of team process because they are measures of an individual member of an operating room team. In the current study, similar findings at the team level of team process are demonstrated. There was a positive correlation between task management and response time to bag-valve-mask ventilation (p = 0.03) and to chest compressions (p = 0.03). There was a significant and positive correlation between situation awareness and error rate (p = 0.03).

Mazzacco et al. (2009) conducted an observational study of 293 surgeries. Team process was scored for each surgical team then the corresponding patient chart was reviewed at post-operative day 30 for complications and death. Logistic regression analysis revealed that low levels of team process measures predicted patient complications or death after adjusting for patient risk factors.

In a non-health care study of work teams (Mathieu, Gilson, & Ruddy, 2006), team process was found to mediate the influence of empowerment on team effectiveness. The
investigators studied 452 workers representing 121 teams in a non-experimental pretest/posttest design. Empowerment was defined as delegation of authority and responsibility. The investigators identified empowerment as a contextual factor of the work environment.

In summary, no evidence to date supports mediation of health care team process between interdisciplinary team training and team effectiveness. The overwhelming practice effect and the confounding variable of scenario order in the current study could contribute to the lack of significance for mediation. However, the current and recent studies show evidence of a relationship between health care team process and resulting team effectiveness. A large sample size is necessary to adequately test mediation analysis as in the study by Mathieu et al. (2006) due to the inherent multicollinearity present between variables. Although a power analysis directed the planned sample size for the current study, the sample size of 24 teams may be insufficient for the precision demands of mediation analysis.

**Implications**

**Clinical Practice**

A significant finding for clinical practice of note to health care administrators is the impact of simulated, high-fidelity practice of an emergency patient care response among interdisciplinary providers. The “practice” that occurs in a pretest posttest design is a known factor of this type of research design. However, for this study, the findings related to practice effect hold important meaning. This practice effect in both control and experimental groups was evident in the significant improvement in all team effectiveness scores from pretest to posttest. This means, interdisciplinary “practice” improves quality of care as indicated by the significant findings of shorter response time scores. Additionally, interdisciplinary “practice” improves patient safety as indicated by the significant findings of decreased error rate. Therefore, study
findings support that protected time for practice is necessary for health care providers and should be supported.

The team process measures of task management, teamworking, and situation awareness were significantly improved in all groups from pretest to posttest (practice effect) and significantly different between control and experimental groups (treatment effect). Therefore, both CRM training and practice significantly improve team process. This implies that not only is a culture of interdisciplinary teamwork critical to team process but pointed training to promote team process is necessary to significantly stimulate team process. This training should be in the form of high fidelity scenario practice with review of technical skills and/or CRM training with facilitated reflection on team process dynamics. Again, facilitating a team-oriented culture and supporting interdisciplinary team training require committed endorsement from health care leadership.

Support for CRM training and high-fidelity emergency response practice warrants a commitment of simulation lab space, high-fidelity simulators, medical supplies and audiovisual technology. Dedicated people resources that include clinical educators, technology support, actors, and standardized patients are essential. These resources are vital for development of realistic scenarios for high fidelity practice and to support ongoing research that will lead to improvements in patient safety, advances in quality of patient care, and expansion in the science of simulation learning.

**Educational Design**

Educational programs designed for interdisciplinary team training and team practice using simulation, videotaping and reflective debriefing are effective methods for promoting team process as evidenced by the significant differences in the team process measures between the
control and treatment groups and between pre and posttests for all groups. Creative and advanced planning by educators is necessary to accommodate the schedules of various health care providers or students of differing curriculums. Perseverance and documentation of improved outcomes can harness support from leadership to help overcome challenging logistics of interdisciplinary training.

The findings of this study suggest some of the important curricular content for team training of team process dynamics and technical skills. For team process dynamics, CRM training with content on task management, teamworking, and situation awareness are important for influencing team effectiveness. Therefore, a comprehensive team training program should address each of these concepts. Inter-professional attitude measures were not significantly different. This lack of difference has implications for the timing of interdisciplinary training. Training is ideal prior to the influence of negative role socialization effects. However, since that questionnaire was only a posttest measure, a definitive conclusion regarding inter-professional attitude cannot be made. Pretest measurement with the questionnaire would have introduced potential instrument reactivity that could influence posttest response. To avoid this potential reactivity, the questionnaire was administered once at the end of the training.

Curricular content for technical skills is gleaned from the difference in the challenges presented in scenario A versus scenario B. The opposing challenges for each scenario are charted in Appendix L. In comparing the challenges between scenario A and B, one can review the equipment challenges that created more task demands. It was easier for participants to recognize that the mask on the bag-valve-mask ventilator was too small but they lacked knowledge in the appropriate size of a bag-valve-mask ventilator. It was apparent that the cart was locked when the drawers would not open so participants more easily recognized this and...
actively searched for a solution. However, they did not easily recognize they were using an empty oxygen tank. Skill training on the proper and safe use of portable oxygen is indicated. The challenges related to the noise of intravenous pumps in scenario A reflects the lack of knowledge and experience that students have with intravenous pumps compared to simply turning off the radio or TV. Use of pumps is not a focus of medical or nursing student training because each institution has different pumps. However, thorough checking of intravenous and epidural lines is a critical patient safety deficiency apparent in scenario A that required more careful investigation by the participants than simply turning the Demerol bag to view the label in scenario B. Lastly, the physical barrier of a raised litter requires students to be knowledgeable on the mechanics of these patient transport devices. Moving equipment away from the bedside requires minimal training compared to lowering a litter. Overall, the challenges in scenario A represent that students lack adequate training related to the equipment in their practice environment. This lack of knowledge is of most concern for the senior nursing students because they are facing graduation and licensure. This lack of knowledge indicates that institutions hiring new nurse graduates must provide training to the equipment in the environment to ensure patient safety and care quality. In addition, basic life support training for the health care provider should emphasize appropriate size selection of bag-valve-mask ventilators and the proper use of portable oxygen.

The social issues of gender and provider role deserve attention in facilitated debriefing to explore potential unconscious dynamics. This conclusion stems from the conflicting evidence of significant negative correlation between the number of males on a team and the measures of task management, teamworking versus the positive correlation between the number of males and oxygen placement response time. Since most of the males were medical students, this negative
gender correlation may actually be an effect of role or leadership style. Findings from this study are inadequate to develop a clear conclusion. However, an awareness of this finding among educators is cogent to facilitation of debriefing in future interdisciplinary training programs.

**Theoretical Implications**

The conceptual framework of team effectiveness developed by Kozlowski and Ilgen (2006) describes the cognitive, behavioral and affective domains of team process as dynamic and reciprocal occurring at the individual and team level (Figure 5-1). In this study, the behavioral and cognitive domains were measured at the team level using the ANTS instrument subscales of task management, teamworking, and situation awareness. The affective domain was measured at the individual level using the inter-professional questionnaire then was transformed to a team level variable by creating a sum of all team member responses. These measures of the team process domains are partial and static measures of these complex and dynamic domains. Therefore, the variance explained by the team process measures of task management (22%), teamworking (35%) and situation awareness (20%) on response time to compressions and error rate in the treatment group is not insignificant. Furthermore, due to the dynamic and reciprocal nature of team process, the systematic variance from CRM training on team process and on team effectiveness may not be fully realized immediately. In this study, team process and team effectiveness were measured immediately following CRM training from one posttest scenario. Subsequent measurements in the same interdisciplinary team may reveal further changes as the reciprocal and dynamic effects evolve within individuals and the team. Therefore, the team effectiveness conceptual framework by Kozlowski and Ilgen (2006) explains a theoretical rationale for the lack of support in this study for the first hypothesis.
The team process measures of task work and teamworking represent the behavioral domain while situation awareness represents the cognitive domain. Linear regression analyses of situation awareness and teamworking were significant for explaining team response time to chest compressions. Linear regression of task management was significant for explaining team error rate. This suggests that different domains have differing degrees of influence on different team effectiveness outcomes. Furthermore, it is important to address all the domains of team process as described in the Kozlowski and Ilgen (2006) framework to ensure a comprehensive approach to maximizing team effectiveness.

Kozlowski and Ilgen (2006) describe environmental dynamics that can impact the team situation, thereby impacting team process. The negative correlation finding between gender/role and task management and teamworking in the behavioral domain represents an interesting environmental dynamic. This dynamic between gender/role and situation awareness from the cognitive domain approached significance. The positive and significant correlation between
gender/role and one of the response time outcomes, placement of oxygen, further contributes to this unusual and conflicting finding.

The impact of situational demands as described by the conceptual model is revealed in the study by the incongruence of the two scenarios used. Planned to be equally challenging, the interaction between scenario and pretest versus posttest demonstrate that scenario A is more challenging than scenario B leading to an interaction between the level of challenge and the team response. This finding supports Kozlowski and Ilgen’s (2006) framework on two points. One point is that situational demands influence team process. The groups that had scenario A as a pretest, scored consistently lower on the team process measures supports this point. A second point is that team training has a larger effect on team process in more demanding situations. This is demonstrated by the more acute and higher response on the team process measures by the groups that had scenario A first.

In summary, the team effectiveness model (Kozlowski & Ilgen, 2006) provided a useful and parsimonious framework to analyze and interpret the results of this study. This model is potentially adaptable to additional settings and populations for team-related research and education.

**Strengths**

The strengths of this study included the design, power and methods. The planned power of 0.8 was based on a sample size of 26 teams. A final sample of 24 teams was achieved. This was an experimental design which allowed for maximizing control and minimizing threats to internal validity. Good to moderate agreement between the blinded raters was achieved on the video-recorded behavioral data: task management ($r = 0.96$), teamworking ($r = 0.49$) and situation awareness ($r = 0.66$) and on the error ratings ($r = 0.93$).
Numerous controls were maintained across the study procedure to minimize error variance and control extraneous variance. A homogenous target population was accessed for the sample. All training was conducted in the simulation lab with the same human patient simulator and related equipment. The principal investigator conducted each training session. Instruments with documented reliability and validity were used.

**Limitations**

The sample of 24 teams was obtained across 10 months. Diffusion of treatment was a risk due to the extended period of time. Two factors in this study helped to minimize this potential limitation. First, the principal investigator who conducted the training sessions with each team, reminded the participants of the importance of confidentiality of the training experience. It was expected that medical and nursing students recognize the implications of discussing the training with potential participants in an experimental study. Second, occurrence of the study from spring semester to fall semester provided for a different class of medical and nursing students. Therefore, the participants were less likely to interact since they were from different student cohorts.

Targeting students in different semesters raises the concern of different levels of professional development creating unplanned error variance among participants. This was minimized by delaying the training sessions with the fall semester students until October so they would be closer to their second semester and more similar to the spring semester participants.

Bias from the principal investigator’s direct involvement in the study is possible. The principal investigator controlled the training session for each team. The principal investigator could potentially introduce unintended bias due to the desire for the experimental group to demonstrate significant changes in team effectiveness. The principal investigator was aware of
this potential and used congruent power point presentations, equipment and procedures for each training session to maintain consistent procedures minimizing potential bias. The principal investigator controlled response time documentation using the human patient simulator computer to mark response time. Bias in marking response time is possible; however, in this study there were no significant differences in response times between the control and experimental groups. The significant differences between groups were only demonstrated for the team process measures which were measured via the ANTS ratings as scored by blinded raters.

Generalizability of findings is a limitation from two aspects. First, participants were volunteers. The training required three hours of time on a weekend day or a weekday evening with compensation of a twenty dollar gift card. Volunteer students in the target population may be more motivated and dedicated to professional development. Second, these were medical and nursing student participants with minimal experience. Students provide a relatively homogenous sample with minimal variance in health care experience for minimizing error variance in this study. Therefore, due to the nature of the sample of volunteers and students, findings cannot be generalized to other target populations.

**Future Research**

Further research on the development and measurement of situation awareness due to its relationship with error reduction is paramount. Other concepts from the cognitive domain such as team mental models and collective climate as described by Kozlowski and Ilgen (2006) may also demonstrate important relationships to team effectiveness. First, development of additional instruments with reliability and validity to measure these various concepts in the cognitive domain are needed. To this end, collaboration with experts in Cognitive Science is essential. Second, understanding how to stimulate individual and team development of these concepts in
the cognitive domain is needed. Experimental designs are necessary to provide data that will support ongoing study and implementation of the changes in education and health care needed to improve patient safety and care quality.

The frequency of team practice and CRM training required to optimize team effectiveness needs further study. It is clear that such training promotes team effectiveness outcomes, but the indicated frequency of each type of training is unknown. CRM training did not show a direct effect on team effectiveness outcomes but did show a significant effect on team process variables. CRM training may warrant more frequent training to adequately stimulate team process dynamics enough to impact team effectiveness. Therefore, a prospective, longitudinal study design to determine appropriate frequency of training is indicated.

Gender and role studies related to team process and team effectiveness in health care teams to explore the environmental dynamics are needed. The data from this study showed conflicting results of gender on the variables of interest. It is unclear if the effect was truly gender or the role of nurse versus medical student. The understanding of the social dynamics occurring can help inform interdisciplinary team training for health care providers that may lead to improved team effectiveness. Qualitative research to explore the intricacies of this dynamic are indicated.

Investigation of the systems and processes within health care institutions that contribute to increased situation demands is evident. From the results of this study, it is clear that situation demands, such as lack of knowledge about basic medical equipment, influence team effectiveness. Action research at the institutional level is indicated to explore unique situational demands that impair team process. For example, facilitated debriefing with the crisis
management team following each patient crisis can help identify and resolve systems and processes that created challenges and impaired team effectiveness.

**Future Directions**

Translation of crisis resource management research into practice is the next step to directly improving patient safety and care quality. Two longitudinal studies are appropriate to measure the effects of interdisciplinary training on real patient outcomes. A small grant study (R18) through the Agency for Health Care Research and Quality would be a logical fit for such studies.

A longitudinal study of the impact of repeated high fidelity simulation practice with a designated crisis response team is indicated. Debriefing should include discussion of both CRM and technical skills of life support. Outcomes would include team process and team effectiveness in the simulated environment plus the associated effect over time on real patient outcomes following care from the crisis response team. Real patient outcomes can include measures of morbidity and mortality following a crisis response.

A longitudinal study of the impact of early interdisciplinary training on student’s interprofessional attitude is indicated. The impact of interdisciplinary training among undergraduate medical and nursing students can be studied through a multi-center trial of experimental and control sites. The interdisciplinary training would need to be integrated into the undergraduate curriculums for the experimental sites. The team dynamics model as described by Kozlowski and Ilgen (2006) could serve as a curriculum guide.

**Summary**

Findings from this study provide important implications for health care administrators, clinicians and educators related to promoting an environment of team process while minimizing
situational demands leading to improved patient safety and care quality. The implications discussed in this chapter provide tangible interventions for clinical practice and educational design implementation. Findings support concepts described in The Team Effectiveness Conceptual Framework (Kozlowski & Ilgen, 2006) which can be used as a valuable guide for future research and education.
Reference List


*Academic Medicine, 67*, 295-303.


Simulation-based crisis team training for multidisciplinary obstetric providers.

*Simulation in Health Care, 4, 77-83.*


Appendix A

Recruitment Information

You are invited to participate in an educational training session using the human patient simulator in the Simulation Lab at Penn State Hershey Medical Center. The purpose of the study is to evaluate training methods to decrease medical errors and improve patient safety. The session will require three hours of time. You will participate in two patient scenarios with a small group of senior year nursing students and third year medical students and receive special training to improve your clinical performance. Your participation is confidential and will not be shared with faculty from the School of Nursing or Medicine. Please contact me if you have further questions. Please complete the attached information if you are interested in participating in this study.

Thank you,

Tara S. Jankouskas, MSN, RN,C, PhD candidate

531-5980 or tjankouskas@psu.edu
Appendix B

Subject Inclusion Form

Please complete the following information if you are interested in participating in the educational training session using the human patient simulator in the Simulation Lab at Penn State Hershey Medical Center. Return the completed form to: Tara Jankouskas Mail code H102 or Fax 531-8861.

1. PRINTED Name (First, Last): __________________________
2. Type of student: Medical student ☐ Nursing student ☐
3. Phone number: Cell _____-_____-_________
Other _____-_____-_________
4. Email address: ________________________________
5. Which evenings are you available from 6:00 pm – 9:00 pm to attend a training session?
   Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐

Do you have any of the following certifications?
5. CPR Yes ☐ No ☐
6. Pediatric Advanced Life Support Yes ☐ No ☐
7. Adult Cardiac Life Support Yes ☐ No ☐
8. Emergency Medical Technician Yes ☐ No ☐
9. Paramedic Yes ☐ No ☐
10. Licensed Practical Nurse Yes ☐ No ☐
11. Registered Nurse Yes ☐ No ☐
12. American Heart Association Instructor Yes ☐ No ☐
13. Other (If yes, please list) Yes ☐ No ☐
________________

Have you ever participated in any of the following trainings?
14. Crisis Resource Management Yes ☐ No ☐
15. Rapid Response Team Yes ☐ No ☐
Appendix C

Methodology

<table>
<thead>
<tr>
<th>Time</th>
<th>Non-experimental Group</th>
<th>Experimental Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-test Scenario #1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data Point: Scenario analysis of team process, response time and error rate</strong></td>
<td>15 minutes</td>
<td>The team manages one of two randomized patient crisis scenarios while being videotaped.</td>
</tr>
<tr>
<td><strong>Emotive decompression</strong></td>
<td>5 minutes</td>
<td>Allow team reactions to scenario experience to be verbalized.</td>
</tr>
<tr>
<td><strong>Intervention Educational Content</strong></td>
<td>30 minutes</td>
<td>No content provided.</td>
</tr>
<tr>
<td><strong>View &amp; reflect on Scenario #1:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>N/E group:</strong></td>
<td>15 minutes</td>
<td>Facilitated discussion on technical skills with the principal investigator.</td>
</tr>
<tr>
<td><strong>Rx group:</strong></td>
<td>30 minutes</td>
<td></td>
</tr>
<tr>
<td><strong>Post-test Scenario #2:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data Point: Scenario analysis of team process, response time and error rate</strong></td>
<td>20 minutes</td>
<td>The team manages the second of two randomized patient crisis scenarios while being videotaped.</td>
</tr>
<tr>
<td><strong>Emotive decompression</strong></td>
<td>5 minutes</td>
<td>Allow team reactions to scenario experience to be verbalized.</td>
</tr>
<tr>
<td><strong>View &amp; reflect on Scenario #2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>N/E group:</strong></td>
<td>15 minutes</td>
<td>Facilitated discussion on technical skills with the principal investigator.</td>
</tr>
<tr>
<td><strong>Rx group:</strong></td>
<td>30 minutes</td>
<td></td>
</tr>
<tr>
<td><strong>Provision of Treatment for Non-experimental Group</strong></td>
<td>N/E group: 30 minutes</td>
<td>Review of Teamwork Principles Collaboration Task management Communication Situation awareness Leadership Video of teamwork failure</td>
</tr>
</tbody>
</table>
Appendix D

Basic Life Support Content

I. Establish unresponsiveness
II. Call for Help – phone first vs. phone fast
III. Open the airway – head-tilt chin-lift vs. jaw-thrust
IV. Assess breathing
   A. Look, listen, feel
   B. Give 2 breaths
      1. BVM use
      2. Mask fit
      3. BVM size
V. Assess circulation
   A. Check pulse
   B. Provide compressions
      1. Hand placement
      2. Breaths:compressions ratio
      3. Switching compressor role
Appendix E

Crisis Resource Management Content

I. Teamwork
   A. Roles
      1. Clear delineation
      2. Even distribution
   B. Communication
      1. Introduction of self and ability
      2. SBAR use
      3. Direct communication
      4. Close loop communication
      5. Non-judgmental communication
   C. Interdependence
      1. Task support
         a. Cognitive
         b. Skill
      2. Task coordination
      3. Cross-monitoring of team members

II. Situation Awareness
   A. Leadership
   B. Global assessment
      1. State patient status
      2. Identify care goal
      3. Verbalize action plan
      4. Accept advice
   C. Hands-off position
   D. Delegation
   E. Performance quality
   F. Fixation avoidance
      1. This and only this
      2. Everything else but this
      3. Everything is O.K.

III. Task Management
   A. Standardized approach
   B. Resource maximization
      1. People
      2. Space
      3. Sound
      4. Technology
   C. Task accountability
      1. Own the problem
      2. Ask for help
## Appendix F

### Patient Crisis Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Scenario A</th>
<th>Scenario B</th>
<th>Expected Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario Background Provided to the Team</strong></td>
<td>18 year old patient weighing 50 kg needs to be transported from MRI for back injury, has hydromorphone epidural infusing at 8 ml/hour and peripheral maintenance IV infusing at 88 ml/hour.</td>
<td>35 year old patient weighing 60 kg, post-operative following stabilization of a leg fracture, has a maintenance IV infusing at 100 ml/hour, had 2 doses of morphine for pain in the recovery room.</td>
<td></td>
</tr>
<tr>
<td><strong>Scenario Distractions &amp; Challenges</strong></td>
<td>1. IV pumps are beeping 2. Patient stretcher in high position with rails in up position. 3. BVM is pediatric size. 4. Epidural line is switched with IV line.</td>
<td>1. TV or radio is playing loudly. 2. Room is crowded with equipment – wheel chair and bedside table. 3. Mask on the BVM is pediatric size. 4. Demerol is infusing but label is not visible.</td>
<td>1. Take action to reduce noise. 2. Ask for assistance lowering stretcher, &amp; removing unnecessary equipment. 3. Ask for appropriate size BVM &amp; mask. 4. Check IV fluids and infusions.</td>
</tr>
<tr>
<td><strong>Assistance from Actor Provided Upon Request</strong></td>
<td>1. Check IV pumps. 2. Lower stretcher &amp; rails down. 3. Get adult size BVM.</td>
<td>1. Turn off TV or radio. 2. Move equipment. 3. Get appropriate mask for BVM.</td>
<td></td>
</tr>
<tr>
<td><strong>Stage 1 2 minutes from scenario start</strong></td>
<td>Pulse oximeter reading 91% saturation.</td>
<td>Pulse oximeter reading 91%.</td>
<td>1. Assess patient: A-B-C 2. Verbalize assessment findings. 3. Open the airway. 4. Place oxygen on patient.</td>
</tr>
<tr>
<td><strong>Stage 2 6 minutes (maximum time) from scenario start</strong></td>
<td>Patient stops breathing. Oximeter decreases to 80% saturation.</td>
<td>Patient stops breathing. Oximeter decreasing.</td>
<td>1. Assess patient: A-B-C. 2. Verbalize assessment findings. 3. Initiate BVM ventilation with appropriate BVM &amp; mask. 4. Use E-C technique for mask hold. 5. Connect to 12 L oxygen flow. 6. Delivery of 1 breath every 5 seconds with visible chest rise. 7. Call for help/code team.</td>
</tr>
<tr>
<td><strong>Stage 3 10 minutes (maximum time) from scenario start</strong></td>
<td>Heart rate decreases to 30 beats/minute.</td>
<td>Heart rate decreases to 40 beats/minute.</td>
<td>1. Assess patient: A-B-C. 2. Verbalize assessment findings. 3. Prepare to begin CPR.</td>
</tr>
<tr>
<td><strong>Stage 4 14 minutes (maximum time) from scenario start</strong></td>
<td>Asystole and pulseless. Oximeter not reading.</td>
<td>Asystole and pulseless. Oximeter not reading.</td>
<td>1. Begin compressions using 2 hands on the lower half of the sternum at a ratio of 2 breaths to 30 compressions. 2. Switch compression task among team members every two minutes.</td>
</tr>
</tbody>
</table>
Appendix G

Anaesthetists’ Non-Technical Skills (ANTS) System  (Flin, Glavin, Maran, & Patey, 2004)

<table>
<thead>
<tr>
<th>Category</th>
<th>Element</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Management</td>
<td>Planning &amp; preparing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Goal statements such as “We need to oxygenate” or “We need to ventilate”.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Verbalizes a plan out loud or asks for advice.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gets BVM ready before apnea occurs.</td>
<td></td>
</tr>
<tr>
<td>Prioritizing</td>
<td>Starts with airway first then breathing then circulation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calls for help when patient is blue.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ensures chest rise with BVM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Checks pulse with compressions</td>
<td></td>
</tr>
<tr>
<td>Providing &amp; maintaining standards</td>
<td>Follows appropriate order of the steps of CPR: open airway, look/listen/feel, give 2 breaths, etc</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uses correct BVM size and mask size.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ratio is 30 compressions: 2 breaths.</td>
<td></td>
</tr>
<tr>
<td>Identifying &amp; using resources</td>
<td>Asks for help</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lowers the stretcher and rail/moves equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Silences the noise of baby or radio.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Divides tasks of airway, circulation, IV management.</td>
<td></td>
</tr>
<tr>
<td>Team Working</td>
<td>Coordinating activities with team</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tasks are verbalized.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Team members are respectful and cooperative.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All tasks divided equally.</td>
<td></td>
</tr>
<tr>
<td>Exchanging information</td>
<td>Assessment findings are communicated aloud.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Completion of tasks are verbalized aloud.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Problems &amp; difficulties are voiced.</td>
<td></td>
</tr>
<tr>
<td>Using authority &amp; assertiveness</td>
<td>A leader is clearly designated &amp; verbalized.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader gives clear orders; delegates tasks.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader accepts any advice.</td>
<td></td>
</tr>
<tr>
<td>Assessing capabilities</td>
<td>Team members ask for help when struggling with a task.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader recognizes ineffective performance and takes corrective action.</td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Element</td>
<td>Rating</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Situation Awareness</td>
<td>Gathering information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader stands back and observes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader asks for information if not provided or verifies information.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader is in a position to visualize the monitor.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recognizing &amp; understanding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader articulates a plan of action: “The patient is not breathing, we need to ventilate.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reassessment of oxygen saturation after oxygen administered.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reassessment of A-B-C’s.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reassessment of adequacy of ventilation and compressions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Anticipating</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leader thinks aloud about the possible cause.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The leader considers the IV fluid.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The adequacy of the IV site is assessed.</td>
<td></td>
</tr>
</tbody>
</table>

Rating Scale:  
4 – Good, consistently high standard  
3 – Satisfactory standard, could be improved  
2 – Marginal, cause for concern, considerable improvement needed  
1 – Remediation require
Appendix H

University of West England Interprofessional Questionnaire (Pollard, Miers & Gilchrist, 2005)

Communication & Teamwork
1. I feel comfortable justifying recommendations/advice face-to-face with more senior people.
2. I feel comfortable explaining an issue to people who are unfamiliar with the topic.
3. I have difficulty in adapting my communication style (oral and written) to particular situations and audiences.
4. I prefer to stay quiet when other people in a group express opinions that I don’t agree with.
5. I feel comfortable working in a group.
6. I feel uncomfortable putting forward my personal opinions in a group.
7. I feel uncomfortable taking the lead in a group.
8. I am able to become quickly involved in new teams and groups.
9. I am comfortable expressing my own opinions in a group, even when I know that other people don’t agree with them.

Interprofessional Learning
10. My skills in communicating with patients would be improved through learning with students from other health care professions.
11. My skills in communicating with other health care professionals would be improved through learning with students from other health and social care professions.
12. I would prefer to learn only with peers from my own profession.
13. Learning with students from other health care professions is likely to facilitate subsequent working professional relationships.
14. Learning with students from other health care professions is likely to help to overcome stereotypes that are held about the different professions.
15. Collaborative learning would be a positive learning experience for all health care students.
16. Learning with students from other health care professions is likely to help to overcome stereotypes that are held about the different professions.
17. I would enjoy the opportunity to learn with students from other health care professions.
18. Learning with students from other health care professions is likely to improve the service for patient care.

Interprofessional Interaction
19. Different health care professionals have stereotyped views of each other.
20. The line of communication between all members of the health care professions is open.
21. There is a status hierarchy in health care that affects relationships between professionals.
22. Different health care professionals are biased in their views of each other.
23. All members of health care professions have equal respect for each discipline.
24. It is easy to communicate openly with people from other health care disciplines.
25. Not all relationships between health care professionals are equal.
26. Health care professionals do not always communicate openly with one another.
27. Different health care professionals are not always cooperative with one another.

Interprofessional Relationships
28. I have an equal relationship with peers from my own professional discipline.
29. I am confident in my relationships with my peers from my own professional discipline.
30. I have a good understanding of the roles of different health care professionals.
31. I am confident in my relationships with people from other health care disciplines.
32. I am comfortable working with people from other health care disciplines.
33. I feel that I am respected by people from other health care disciplines.
34. I lack confidence when I work with people from other health care disciplines.
35. I am comfortable working with people from my own professional discipline.
Appendix I

Response Time

Oxygen administered

Time: _____
Unable to determine □
Not seen □

BVM initiated

Time: _____
Unable to determine □
Not seen □

Emergency called

Time: _____
Unable to determine □
Not seen □

Chest compressions initiated

Time: _____
Unable to determine □
Not seen □
Appendix J

Error Rate

1. Calls for help
   Done  Not Done  Indeterminable
2. Opens the airway using head-tilt-chin lift
   Done  Not Done  Indeterminable
3. Checks for breathing
   Done  Not Done  Indeterminable
4. Begins with 2 breaths
   Done  Not Done  Indeterminable
5. Uses E-C technique
   Done  Not Done  Indeterminable
6. Checks central pulse
   Done  Not Done  Indeterminable
7. Gives 1 breath every 6 seconds (with pulse)
   Done  Not Done  Indeterminable
8. Locates correct hand position for compressions
   Done  Not Done  Indeterminable
9. Starts compressions after patient is pulseless
   Done  Not Done  Indeterminable
10. First cycle: correct ratio of 30:2
    Done  Not Done  Indeterminable
11. Second cycle: correct ratio of 30:2
    Done  Not Done  Indeterminable
12. Third cycle: correct ratio of 30:2
    Done  Not Done  Indeterminable
13. Fourth cycle: correct ratio of 30:2
    Done  Not Done  Indeterminable
14. Fifth cycle: correct ratio of 30:2
    Done  Not Done  Indeterminable
15. Rechecks pulse after 5 cycles or 2 minutes
    Done  Not Done  Indeterminable
16. Person doing compressions is switched
    Done  Not Done  Indeterminable
Appendix K

Demographic Form

Demographic Form

Please answer each of the following questions.

1. What is your gender?  
   Female □  
   Male □

2. What is your clinical role?  
   Nursing Student □  
   Medical Student □

3. List the date of your most recent CPR certification class?  
   Date _____ - _____ - _____  
   Month   Day   Year

4. How many real patient resuscitations have you actively participated? (If none, then enter a zero.)  
   Number of resuscitations __ __

5. Were the two patient scenarios used in today’s training of equal difficulty?  
   Yes □  
   No □

6. How many subjects in your group today are your friends? (ie. People with whom you choose to spend your leisure time.)  
   Number of friends in your group:  
   0 □  
   1 □  
   2 □  
   3 □
Appendix L

Training Session Face Sheet

Randomization

#1 Medical student
Phone #
Unique ID
Confirmation of encounter date one week prior
Confirmation of encounter date one day prior

#2 Medical student
Phone #
Unique ID
Confirmation of encounter date one week prior
Confirmation of encounter date one day prior

#1 Nursing student
Phone #
Unique ID
Confirmation of encounter date one week prior
Confirmation of encounter date one day prior

#2 Nursing student
Phone #
Unique ID
Confirmation of encounter date one week prior
Confirmation of encounter date one day prior

Treatment or Control group
Scenario order A vs B: Double check correctness of order used.
Rater

Advanced Preparation
Scenario set-up
Simulator checked
Four microphones checked
Recording equipment/CD placement checked
Four packets collated: Consent form/Collaboration scale/Demographic form with ID # entered
Food ordered

Encounter
Consent signed
Signed consent copied and provided to participants
Introduction to the simulator
Explanation on use of microphones
Recording started
Microphones turned on
Scenario time started
Training session completed
Each CD labeled with date, group ID, scenario A or B
Completion of collaboration form checked
Completion of demographic form checked
Response Time downloaded and recorded

Data Collection
Date CD sent with rating form to rater
Date CD & rating form returned from rater
Rating form completion checked
Label rating form with pretest or posttest based on scenario order
Date data entered
Date data verified & cleaned
Date Data backup completed
Appendix M

Scenario Challenges

<table>
<thead>
<tr>
<th>Scenario A</th>
<th>Scenario B</th>
</tr>
</thead>
<tbody>
<tr>
<td>The bag-valve-mask ventilator most visible was pediatric size. The adult bag-valve-mask ventilator was hanging on the back of the emergency cart outside immediate vision.</td>
<td>The mask on bag-valve-mask was pediatric size. The appropriate size was in the drawer of the emergency cart.</td>
</tr>
<tr>
<td>The oxygen tank on the emergency cart was empty. A full tank was available on the opposite side of the cart.</td>
<td>The emergency cart was locked with one drawer open and extended so that the entire cart appeared to be open.</td>
</tr>
<tr>
<td>The epidural line was tangled with the peripheral intravenous line and the epidural was infusing via the peripheral intravenous site.</td>
<td>A Demerol bag was piggy-backed and infusing into the maintenance intravenous line, but the Demerol bag label was positioned on the backside of the bag.</td>
</tr>
<tr>
<td>The patient litter was in a high position making it difficult to perform effective compressions.</td>
<td>The patient bedside was crowded by a wheelchair and bedside tray table.</td>
</tr>
<tr>
<td>The intravenous pumps were beeping due to air in the lines.</td>
<td>The radio or TV was playing loudly.</td>
</tr>
</tbody>
</table>
VITA

Tara Seifert Jankouskas
4 Eagle Drive
Palmyra, PA  17078
(717) 838-8290 (H) * (717) 679-3675 (W)

Academic Background
Ph.D.  Pennsylvania State University  May 2010
    GPA:  3.85
M.S.N.  University of Texas @ Austin  1991
    Minor:  Education
    Thesis:  Benefits of nitroglycerin ointment in obtaining peripheral venous access
            in children.
    GPA:  3.88
B.S.N.  Bloomsburg University of Pennsylvania  1984
    GPA:  3.75

Teaching Experience
February 2009 – present
    Assistant Professor of Nursing
    Messiah College, Grantham, PA

    Clinical Nurse Educator for Pediatric Clinical Areas
    Hershey Medical Center, Hershey, PA

January 1997 - Spring 2005
    Clinical Instructor
    Messiah College, Grantham, PA

September 2004 - December 2004
    Clinical Instructor
    Harrisburg Area Community College, Harrisburg, PA

Professional Honors, Affiliations and Grants
2009  Eastern Nurses Research Society Dissertation Award
2008-09  Chairperson, Nursing Research Council, Penn State Hershey Medical Center
2008  Nancy R. Kruger Award for Clinical Scholarship
2006  Elizabeth Powers Carlino Nursing Scholarship Award
2005, 2009  Woodward Grant, Penn State Hershey Medical Center
1984 – present  Sigma Theta Tau

Scholarly Activities
    symmetrical simulation scenarios for evaluation of behavioral skills.  Simulation in Healthcare, 2, 102-109.
    resource management: evaluating outcomes of a multidisciplinary team. Poster at The 18th Annual
    Eastern Nurses Research Society, Cherry Hill, N.J.
    Development, 17 (4).