

Development of Crisis Resource Management Skills Using High-Fidelity Simulation Education

by

Amanda Lucas

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfillment of the requirements of the degree of

MASTER OF NURSING

Rady Faculty of Health Sciences, College of Nursing

University of Manitoba

Winnipeg

Copyright © 2017 by Amanda Lucas

Abstract

In this repeated-measures observational study, eleven acute care and critical care registered nurse participants were evaluated at four different time points to measure the effect of an education program on observed performance of crisis resource management (CRM) skills. Performance was measured using the Ottawa Global Rating Scale and a checklist developed for this study. One-on-one semi-structured interviews also assessed nurses' perceptions of the learning that occurred in the education program. Results were mixed with statistically significant changes in mean scores occurring between time one and time two and non-statistically significant improvement in mean scores overall. Interview results indicated nurses perceived a high degree of learning through passive observer roles as well as active responder roles. This study adds to the body of evidence on the effectiveness of high-fidelity simulation education programs and highlights the need for further research in multiple areas.

Acknowledgements

I would like to express my heartfelt appreciation to those individuals who have contributed to my journey throughout this program. Without each of you, I would not have started along this path and been able to achieve my goals.

I thank my family and friends, who have been patient and encouraging throughout this process. Your help and belief in me gave me the added push to continue forward.

My advisor, Dr. Marie Edwards has guided me from the very beginning. Without her expert advice and support, I would not have been able to produce the work I am so proud of. I am honored that she agreed to take me on as a student and am grateful for her kind and gentle persistence in pushing me to achieve my goals.

My committee member, Dr. Nicole Harder has provided me invaluable knowledge and advice.

My committee member, Dr. Lawrence Gillman whose excitement about this area of study was, and continues to be, a source of inspiration.

Drs. Thomas Jacob and Tyler Friesen who were instrumental in not only helping me to conduct this research project, but also for sparking an area of interest that still fascinates me today.

Kelly Hallock for her time and effort spent evaluating videos.

Table of Contents

Acknowledgements	3
List of Tables	7
List of Figures	8
CHAPTER 1. INTRODUCTION	9
Introduction	9
Background to the Problem	11
Definitions	14
Study Purpose	21
Research Questions	22
Significance	23
CHAPTER 2. LITERATURE REVIEW	25
Introduction	25
Search Strategy	25
Search Terms	26
Inclusion/Exclusion Criteria	26
Search Outcomes	27
Characteristics of Studies	28
Sample	28
Methods	29

Education Intervention	30
Assessment measures	30
Results	33
Summary of Results	47
Gaps in Literature	49
Conclusions	51
CHAPTER 3. METHODOLOGY	52
Study Design	52
Education Program	52
Setting and Sample	56
Procedure	60
Data Collection Strategies	62
Data Analysis	65
Ethical Considerations	67
CHAPTER 4. RESULTS	71
Description of the Sample	71
Quantitative Data	72
Qualitative Data	85
CHAPTER 5. DISCUSSION, IMPLICATIONS, RECOMMENDATIONS	93
Comparison of Results to Existing Literature	93
Research Tools Used	99
Other Insights Gained	100
Implications for Practice, Research, and Education	102

AL Thesis CRM Skills	6
Limitations	104
Conclusion	105
REFERENCES	108
APPENDICES	120

List of Tables

Table 1. Outcomes from Three Separate Searches of the Literature	28
Table 2. Methods Used in Research Studies Reviewed	29
Table 3. Validated Tools Used in Studies Reviewed	32
Table 4. Tools Created by Researchers in the Studies Reviewed	33
Table 5. Ottawa GRS Mean Scores for Sample	73
Table 6. Ottawa GRS Tests of Normality	76
Table 7. Ottawa GRS Mauchly's Test of Sphericity	77
Table 8. Ottawa GRS Tests Within-Subjects Effects	77
Table 9. Pairwise Comparisons for Ottawa GRS	78
Table 10. Checklist Tool Means	79
Table 11. Checklist Tool Tests of Normality	82
Table 12. Checklist Tool Mauchly's Test of Sphericity	83
Table 13. Checklist Tool Tests Within-Subjects Effects	83
Table 14. Pairwise Comparisons for Checklist Tool	84
Table 15. Example of Category Identification	85
Table 16. Summary of Finding from the Interviews	91

List of Figures

Figure 1 Graph representing change in mean scores of Ottawa GRS over time	74
Figure 2 Ottawa GRS boxplot representing presence of outliers	75
Figure 3 Graph representing change in mean scores of the Checklist tool over time	80
Figure 4 Checklist tool boxplot representing presence of outliers	81
Figure 5 Comparison of Ottawa GRS and Checklist graphical display of mean scores	94

Chapter 1: Introduction and Background to the Problem

Introduction

Healthcare is a complex process, involving professionals from multiple disciplines and multiple care areas. In addition to this complexity, patient acuity within healthcare systems today has increased creating opportunities for adverse patient outcomes and errors to occur (Cooper et al., 2010). These include errors associated with the intricacies of professionals' interactions with, or responses to, each other and their environments, and how our systems shape our actions. According to Reason's (1990) Swiss Cheese Model of organizational accidents, these errors are called human factors errors and involve all those factors that can influence people and their behavior (Gordon, Mendenhall, & Blair O'Connor, 2013; Morgan, Kurrek, Bertram, LeBlanc, & Przybyszewski, 2011). They are important because they emphasize that patient crises are not primarily a result of a lack of the professional's theoretical knowledge, but rather arise due to deficiencies in performance of experiential, cognitive, and interpersonal skills (Decker, Sportsman, Puetz, & Billings, 2008; Jankouskas, Chaska Bush, Murray, Rudy, & Henry, 2007; Kim, Neilipovitz, Cardinal, Chiu, & Clinch, 2006; Reason, 1990). Teaching nurses to use these skills is vital in preventing human factors errors and potentially improving patient outcomes.

Historically, traditional nursing undergraduate and continuing education programs have been focused mainly on technical skills or pre-determined targets, such as correct doses of medications or the amount of joules when defibrillating (Andersen, Jensen, Lippert, & Ostergaard, 2010). While these programs are often based on current evidence and best practices, there is risk in teaching the learner to follow rote order without "thinking through" whether pre-determined actions are best in every situation. The challenge becomes: how can nurses continue

to follow best practices, while also using critical thinking skills to alter familiar responses as needed in unfamiliar situations? In other words, how can nurses be taught to use reasoning skills to adapt responses “on the fly” while still following tested best practices?

Recently, aviation Crew Resource Management Theory has been adapted and applied in healthcare. Crew resource management is a cognitive framework, with the primary objective of teaching “heightened awareness of the potential for human error and consequences, improving attitudes and individual and team performance, facilitating effective team work, and averting potential safety disasters” (Rudy, Polomano, Murray, Henry, & Marine, 2007, p. 220). It is an approach meant to guide a professional’s response to crisis situations in a basic and systematic way. In healthcare this is called crisis resource management (CRM) (Allan et al., 2010), and it is gaining momentum as an effective way to approach unplanned emergencies. Education programs that focus on the CRM skills of problem-solving ability, situational awareness, resource utilization, communication, and leadership have been shown to have a positive impact on learner competence in handling crisis events (Kim et al., 2006). By teaching nursing students and nurses CRM foundational skills, the cognitive and interpersonal skills that allow them to critically analyze and respond in crisis situations will be developed (Andersen et al., 2010; Bearman et al., 2012; Gordon et al., 2013; Pearson & McLafferty, 2011; White, 2012).

As stated above, these CRM skills represent the cognitive domain of adult learning and are often the most difficult to teach and to evaluate (Bearman et al., 2012). Conversely, technical skills or those within the psychomotor domain are more easily taught and evaluated, and are often the focus of nursing education programs. Herein lies the problem. How can this level of experience with CRM skills be created? How can nurses practice their responses in deteriorating patient situations in a realistic environment and without jeopardizing patient safety? High-

fidelity simulation technology has become an increasingly popular method of teaching and learning foundational CRM nursing skills. Learning programs set in these environments have been shown to be successful in translating theory into practice (Maneval et al., 2012). My goal was to use a high-fidelity simulation-based (HFS) learning program as a platform to teach cognitive skills such as problem solving, situational awareness, resource utilization, communication, and leadership. In this study, the problem of acquisition of CRM skills in HFS settings and the importance of these skills as a foundation of nursing response in crisis events are explored. I sought to answer the question, does participating in a HFS learning program lead to a change in learned behaviors, indicating improved CRM skills?

In this chapter, background information to the problem, including information related to the concepts of crisis resource management and high-fidelity simulation-based learning, are presented. Research questions for this study are also be identified.

Background to the Problem

The roots: Crew resource management. Crew resource management is a set of principles developed in the 1970s and 1980s in response to identified errors that led to devastating consequences in the aviation industry. These principles encompass a range of cognitive and interpersonal knowledge, skills, and attitudes that are aimed at creating an environment of improved efficiency, teamwork, and safety (White, 2012). Research into human error in this field yielded an understanding that airplane accidents are not a result of deficiencies in technical proficiency, but rather a result of humans interacting with each other and evolving environments (Gordon et al., 2013). In other words, these accidents can be attributed to cognitive skills and interpersonal skills. Cognitive skills and interpersonal skills are the mental processes needed for effective problem solving or critical thinking, achieving situational awareness or

remaining aware of the “big picture”, working as part of an effective team, and effective communication (Lewis, Strachan, & McKenzie-Smith, 2012; Pearson & McLafferty, 2011; White, 2012). These guiding principles will be defined in the next section with application and examples related to healthcare contexts. For now, it is important for the reader to know that the “underpinning philosophy relates to safe and efficient practice” (Pearson & McLafferty, 2011, p. 399), and it is this theme that is embedded within all levels of this industry’s education and day-to-day functioning, ensuring that each member of a flight team (e.g., pilots, flight attendants, ground crew) is able to respond in a crisis as a member of an effective team.

Since the early 2000s, flight simulation centers have been in existence, offering crew resource management programs for the purpose of training flight crews to achieve “mission effectiveness under time constraints and stress” (Messmer, 2008, p. 320). Technological advances in simulation have allowed educators to recreate extraordinary situations, allowing aviation staff to practice improved cognitive and interpersonal responses in a controlled and realistic environment. This training is intuitively believed to prevent aviation mishaps but cannot be validated by accident rates because they are so infrequent (Rudy et al., 2007). While there is no published literature that proves this belief, Helmreich, Merritt, and Wilhelm (1999) report that random line audits have shown that ongoing crew resource management education produces desired changes in behavior. Salas, Burke, Bowers, and Wilson (2001) carried out a review of studies evaluating the effectiveness of crew resource management training programs in aviation. The benefits identified from crew resource management training included: heightened awareness of potential for errors and consequences; improved attitudes and individual and team performance; and facilitation of effective teamwork and averting potential disasters. Application

of this type of education has led to ensuring “real-life” threats to public safety are identified early and mitigation strategies are deployed early.

The adaptation: Crisis resource management. Patient safety concerns have led to increased attention to healthcare issues. According to the Swiss Cheese Model, in any system there are many levels of defense. For example, in a deteriorating patient situation, perceptions of heightened acuity and adherence to emergency protocols ensure a level of defense against drastic consequences. However, each of these levels has little “holes” in them, caused by, for example, design flaws, decision-making procedures, lack of training, or limited resources. If enough holes are aligned over successive levels of defense, like slices of Swiss cheese, they create an opportunity for an error to occur (Reason, 1990).

While numbers and percentages vary, it is estimated that a vast number of patients die from what are perceived as preventable errors in healthcare settings (Rudy et al., 2007). Nurses and other healthcare professionals must have an increased appreciation for healthcare safety as well as how to care for a patient when extraordinary clinical problems arise. In the past ten years, teaching and learning strategies adapted from *crew* resource management have led to development of a new focus in medical education. Called *crisis* resource management (CRM) in the healthcare industry (Flanagan, Nestel, & Joseph, 2004; Messmer, 2008; Nickerson, Morrison, & Pollard, 2011; Rudy et al., 2007; Van de Ven et al., 2010), this training methodology has the potential to reduce adverse outcomes and lead to greater collaboration and teamwork in patient care (Messmer, 2008).

Crisis resource management (CRM) principles have gained increasing popularity as a training methodology within healthcare disciplines to perform in high-stress, life-threatening crises. Cognitive skills have become the focus of critical event education and just as aviation

crew resource management advocates application of non-technical skills concepts, the healthcare CRM model helps professionals acquire and use non-technical skills in handling crises. Gaba, Fish, and Howard (1994) at Stanford University introduced the first CRM model in the early 1990s. Originally used in anesthesia, other professions, such as nursing, have found the framework particularly useful in the development of non-technical cognitive and social skills that complement technical psychomotor skills.

The purpose of CRM is to teach the concepts of “teamwork, assessment skills, role responsibilities, assertiveness, communication, support, and resource management” (Rudy et al., 2007, p. 220) so that the healthcare professional is able to function in an emergency. The key non-technical skills of CRM training include: (1) problem solving or critical thinking, (2) situational awareness or remaining aware of the “big picture”, (3) resource utilization or using the tools at hand, (4) communication, and (5) leadership skills. Definitions of these concepts will be discussed in depth below. These skills are meant to guide the clinician in making sound clinical judgments while also optimizing interactions within a team in order to yield positive outcomes for patients.

Definitions of CRM Concepts

Problem solving. Daily practice requires nurses to be organized and to prioritize care based on fluctuating patient needs. Often, they are met with barriers, like fluctuating demands of care related to patients and/or family and staffing shortages. Finding solutions to these barriers requires creativity. Furthermore, it is an expectation that staff are able to react quickly and appropriately if a crisis arises. Thus, the clinicians’ problem-solving strategies used in these situations must not only take into account the need to act quickly and deal with the most life-threatening problems first, but clinicians must also remain aware of the “big picture”. In CRM,

this concept is referred to as “concurrent management” (Kim, Fox-Robichaud, & Wax, 2009, p.2).

In nursing, problem solving is sometimes referred to as “critical inquiry” which is “the process of purposive thinking and reflective reasoning” (College of Registered Nurses of Manitoba [CRNM], 2013, p. 4). If applied to a crisis situation, practicing critical inquiry includes use of nursing skills that encompass concurrent management principles like initiating a primary assessment, airway, breathing, and circulation (ABC) survey and rapid life-saving treatments, while continually re-evaluating changing priorities. This ensures the basics are covered while the life-saving treatment is implemented at the earliest possible time (Kim et al., 2009, p. 5). This concept seems intuitive, however, it is well documented that nurses often lack the ability to recognize clinical urgency and/or fail to react when they note signs of deterioration (Cooper et al., 2011).

For the purposes of this study, problem solving, clinical reasoning, clinical decision-making, critical thinking, and critical inquiry are synonymous. According to Fero et al. (2010), key elements within the multiple definitions of problem solving include “an individual’s ability to seek and comprehend relevant information and an association with knowledge, reasoning, cognitive skills, identification, and exploration of alternative frames of reference” (p. 2183). It is suggested that high-fidelity simulation (HFS) learning offers an ideal environment for the development of problem-solving skills. Teaching in this setting immerses the participant in a clinical environment, thus building on past experiences and fostering a higher level of critical thinking. It helps learners integrate knowledge acquired from other venues through practice in application of learned skills (i.e., classes, readings, performing psychomotor skills, and clinical practice) (Cato & Murray, 2010; Kaddoura, 2010).

Situational awareness. Situational awareness describes the extent to which a person appreciates the seriousness of the crisis at hand. It also refers to the ability to remain aware of important events that are occurring and the surrounding environment (Flanagan et al., 2004) or the “perception of the environmental elements” (Cooper et al., 2013, p. 377). According to Lewis et al., it is “what is going on in any given situation and involves the individual’s perception and understanding of what is happening, and their prediction of what may happen in the future” (2012, p. 86). In order for nurses to be good clinicians, they must be able to use situational awareness and perceive information from the environment, appreciate this information, and apply meaning to it (Kim et al., 2009). Thus, situational awareness requires knowledge of activities and events taking place in the moment and being aware of the “big picture” in order to problem solve effectively.

There are three steps to effective situational awareness: physiologic perception, comprehension, and projection. Perception involves receiving information from the senses. Healthcare professionals must rely on assessment data, history taking, and monitoring equipment in order to be fully situationally aware. Comprehension is the ability to appreciate what the information gathered from the senses means. It involves being aware of the significance of sensory inputs from the environment (e.g., changes in noises from monitors and accompanying changes in patient condition). Projection entails making the greatest use of information that is both perceived and comprehended. In CRM, the clinician must use these skills and attempt to predict the patient’s response and also predict the team’s next steps (Kim et al., 2009).

Resource utilization. An important aspect of CRM is knowledge and understanding of resources available. This includes being efficient and effective in using equipment, medications, monitors and, most importantly, the human resources at hand. Resource utilization means to

“allocate attention wisely and use all available information” (Flanagan et al., 2004, p. 5). There are at least three keys to success in resource utilization. The first is calling for help early. Often additional help is delayed; therefore, in order to ensure that appropriate tasks are initiated at the earliest possible time, evaluating the need for assistance should be considered even when, by all appearances, the situation is under control. The second key is distributing workload and delegating appropriately. Resource utilization is essentially workload management, “the implementation of a strategy to balance the amount of work with appropriate time and resources available” (Gordon et al., 2013, p. 119). CRM is meant to take full advantage of all the resources available. This involves ensuring that workload is distributed and delegated appropriately. The third key is understanding the gifts and talents of those at hand. As with distributing workload to match individual skills, tasks in crisis events should also match personality styles. For example, a person who is generally shy or withdrawn may not be comfortable acting as a leader in a high-stress event (Kim et al., 2009).

Communication. One of the major system problems that leads to crisis events in hospitals is the failure to communicate effectively (Sittner, Schmaderer, Zimmerman, Hertzog, & George, 2009). Communication problems have been identified as a leading cause of sentinel events resulting in death (Maxson et al., 2011). There are five CRM strategies used to prevent communication errors. The first, directed communication, ensures the intended recipient of the message is listening. Using names and eye contact to direct others’ behaviors are examples of directed communication. The second strategy is to be specific, as general instructions can lead to misunderstanding and other undesirable outcomes. The third strategy is to use read back, “having the recipient of the message relaying that they have understood the direction by repeating back what they heard” (Kim et al., 2009, p. 18). The fourth strategy is closing the loop. This process

involves the person being assigned a task to follow up once the task has been completed. The final strategy is to flatten the hierarchy and encourage open communication. Healthcare teams are composed of members with differing levels of education and expertise. Some members may not feel comfortable speaking up in this environment and may need to be invited to share important information or observations. Flattening the hierarchy by inviting suggestions (i.e., as a leader) or offering ideas (i.e., as a follower) is important to ensuring the welfare of the patient (Kim et al., 2009).

Leadership. Effective leadership is essential to working as a member of a large team. Teams are “social entities that use shared knowledge, skills, attitudes, goals, and monitoring of own and others’ performance to achieve high quality teamwork” (Lewis et al., 2012, p. 84). The leadership role includes explanation of the goals of the situation while still inspiring others to perform at a higher level. According to Cooper and Wakeham (1999), there are two factors used to describe leadership behavior. These are consideration, “the extent to which leaders show consideration towards the members of the team” (p. 28), and initiating structure, which is the “the extent to which a leader defines, initiates, and organizes the activities within the team” (p. 28). In CRM, there are three essential qualities for effective leadership. These are the ability to remain calm in a crisis, be decisive even with uncertainty, and maintain a global perspective (i.e., a view of the “big picture”) (Kim et al., 2009).

Incorporating teamwork and leadership exercises in a simulation-based training curriculum allows nurses to define their role as members of a collaborative team. It also allows them to understand the role of others so that the combination of competent professionals creates a more cohesive group.

High-fidelity simulation. Simulation can be defined as process that is used to “amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world” (Gaba, 2007, p. 126). Simulation is essentially a dress rehearsal for actual clinical events. Simulation, as an educational technique, has been used in the space program, the nuclear power industry, and automobile industry (Nickerson et al., 2011). These industries and healthcare professions, like nursing and medicine, have been using simulation to test systems and skills that would otherwise carry too much risk in an actual setting. In healthcare these simulation methods vary in degrees of fidelity, also known as degrees of reality. And, as technology has evolved, so has the ability to increase the levels of fidelity and recreate “real-life” scenarios.

Nursing simulation began as early as 1911 with a model that had jointed hips, elbows, and knees. This model was updated over several years to include more natural-looking skin, and different body orifices (Nickerson et al., 2011). More sophisticated manikins emerged in the 1980s and 1990s. These full-scale patient simulators, used primarily by physician groups in anesthesia, emergency, intensive care, surgery, trauma, and pediatrics, “began to offer the means to create dynamic patient situations that fully mirrored the actual clinical setting” (Nagle, McHale, Alexander, & French, 2009, p. 19). In the year 2000, the Institute of Medicine published *To Err is Human*, a report on medical errors (Kohn, Corrigan, & Donaldson, 2000). This report led to more development in medicine, nursing, and other healthcare disciplines of patient-safety and teamwork focused simulation-based education (Nagle et al., 2009; Nickerson et al., 2011; Strouse, 2010).

As discussed above, the degree of fidelity can vary between simulation methods. There are full and partial body models with low and high technology features, called “task-trainers”. These allow the learner to acquire psychomotor skills or procedural skills (e.g., venipuncture or

suctioning technique). There are also patient actors called “standardized patients” used for educating clinicians on interactive skills like interviewing and assessment (Nagle et al., 2009). Human-patient simulators (HPS), a form of high-fidelity simulation (HFS), are computerized manikins that have realistic anatomy and responses to nursing interventions. “They can mimic diverse parameters of human physiology, such as changes in cardiovascular, pulmonary, metabolic, and neurological systems” (Lapkin, Levett-Jones, Bellchambers, & Fernandez, 2010, p. e 209).

Combined with well-planned clinical scenarios, HFS provides the learner with the greatest amount of reality or fidelity possible without involving actual patients. Thus, the risk to patients is minimized. The goal is to use experiential learning to provide learners the opportunity to practice clinical episodes that alter one’s way of understanding and perceiving future clinical situations. The experience is meant to guide the participant to develop skills by mirroring the true contextual environment and situation (Decker et al., 2008). In nursing, practice is a key component to skill-based learning.

Debriefing. Simulation-based programs focusing on CRM skills that produce effective learning outcomes provide a medium for repetitive practice and take place in a learner-focused environment. An important feature of this type of program to ensure these elements are successfully implemented is the ability to provide feedback to learners (Kim & Wax, 2006). Simulation-based learning is unique in that there is an ability to give this feedback after each simulated scenario. Feedback and debriefing are essential components to the simulation experience. Debriefing ensures that recall of events is accurate and that the most important educational points are covered. Development of self-analysis or reflective practices is encouraged. This is important to nurses as professionals because reflection is an essential

component to demonstrating a commitment to required continuing competency (Canadian Nurses Association [CNA], 2004).

An expert instructor or facilitator usually leads debriefings. The purpose is to help participants learn, understand and apply insights from the simulated experience to actual clinical episodes (Cooper et al., 2011). Debriefings are meant to be non-judgmental and safe with emphasis on accurate feedback. While there are several different methods used during debrief sessions, the method used for this thesis study included the Advocacy Inquiry method, which seeks to understand the rationale behind a learner's behaviour and allows the facilitator to provide more effective feedback, and the Directive Feedback method, which provides feedback around a specific action (Cheng et al., 2016

Study Purpose

Practicing nurses are increasingly challenged with higher acuity patients in evolving environments. Patients are at higher risk for deterioration, potentially leading to crisis events and poor outcomes. Crisis events can be stressful for nurses, especially when they do not have the opportunity to develop a level of competence with these non-routine situations. Moreover, research has shown that many errors occurring in healthcare settings are not as a result of lack of experience or expertise, but because of deficiencies related to crisis resource management skills like problem solving, situational awareness, resource utilization, communication, and leadership (Cooper et al., 2011; Kim et al., 2006; Lewis et al., 2012; White, 2012). Nurses who are competent in these skills are ideally positioned to provide safer patient care (Bearman et al., 2012; Pearson & McLafferty, 2011; White, 2012), with the potential to substantially impact patient outcomes.

If CRM skills are thought to improve patient outcomes in a crisis situation, how can educators be sure that what they are teaching in the simulation environment is translating into changed behavior? Participants in HFS learning programs from multiple disciplines, including nursing, have expressed satisfaction. But how effective are these learning programs? Are nurses actually performing the desired changes in behavior after participating in HFS learning programs? Therefore, the purpose of this study was to evaluate the impact of participating as a primary nurse responder and as an observer in a high-fidelity simulation-based learning program that guides nurses to develop CRM skills.

Research Questions

Two research questions were posed.

- What differences, if any, are evident over time in acute care nurses' CRM skills performance scores (i.e., problem solving, situational awareness, resource utilization, communication, and leadership), measured using the Ottawa Global Rating Scale (GRS) and the checklist tool, in a high-fidelity simulation-based learning program?
- What are participants' impressions/ perceptions of the contribution to overall learning of CRM skills through participation in each of the respective nursing roles of primary nurse and observer?

Assumptions Underlying the Study

In order to proceed with the study design, there were three assumptions made. The first was that crisis resource management skills could be taught to nurses. This assumption was based on previous studies that provide evidence that CRM skills have been taught to other professionals in the aviation industry as well as in other healthcare disciplines. The second was that CRM behaviours were observable and therefore measureable in the high-fidelity simulation

setting. And the third assumption was that the degree of learning CRM skills that occurred would differ depending on whether the participant was active or passive during the scenario (i.e., learning that occurred by “doing” contributed differently than learning that occurred through “seeing”).

Definition of Terms

Acute care nurses. In the current study, this is a nurse currently employed in a clinical area that provides care to acutely ill patients. Hirshon et al. (2013) define acute care as all “promotive, preventive, curative, rehabilitative or palliative actions, whether oriented towards individuals or populations, whose primary purpose is to improve health and whose effectiveness largely depends on time-sensitive and, frequently, rapid intervention” (para. 3).

CRM skills performance scores. This is defined as the quantitative measurement of participant performance of CRM skills. Performance of CRM skills was scored using two instruments. The first, the Ottawa Global Rating Scale (GRS), is a tool meant to quantify performance of CRM skills using a Likert scale. The second is a score-based checklist (Appendix A) designed to quantify performance of key behaviors.

High-fidelity simulation-based learning program. This is defined as an education program that utilizes high-fidelity simulation defined by Lapkin et al. (2010) as a modality to teach learning outcomes. In the context of the current study, an education program to teach CRM skills was developed and used high-fidelity simulation as its method of content delivery.

Primary nurse. In the current study, this is the nurse that is first on the scene and the nurse that is being evaluated using the Ottawa GRS tool and the checklist.

Observer. In the current study, this is a nurse that is observing the performance of the primary nurse. This nurse does not contribute to the scenario unfolding, but is expected to contribute to group discussion during the debrief.

Significance

The significance of this study lies in adding to the body of evidence around the effectiveness of HFS learning programs on performance of CRM skills. Providing evidence that HFS learning programs are not only well received among participants, but are also effective in teaching skills that are needed in patient crises, will strengthen arguments for widespread use of these programs. It may also prompt researchers to move towards studies that directly measure the effects of this type of education on patient outcomes. Since nurses often spend the greatest amount of time with patients compared to other healthcare providers, it is reasonable to assume that if they are better equipped to respond in a crisis, patient outcomes will improve overall. Evaluating performance in the laboratory setting, however, is needed first before evaluating performance in the clinical setting.

In summary, crisis resource management principles may be effective in mitigating effects of human factors errors during crisis events. Nurses have the potential to affect patient outcomes if they are taught to use CRM skills in unplanned situations. The purpose of this study was to evaluate the impact of a high-fidelity simulation-based learning program that guides nurses to develop CRM skills. In the next chapter, an analysis of the literature will explore evidence of translation of CRM skills learned in high-fidelity simulation education programs, and how effective they are in changing performance of these skills.

Chapter 2: Review of the Literature

This literature review was undertaken to identify available evidence on the effectiveness of high-fidelity simulation education interventions on development of CRM skills, with a focus on the question: have learners translated behaviors learned in the simulation environment into performance of CRM skills? In order to achieve this, a broad look at the setting and skills taught (as described in the background section) were reviewed in order to narrow the focus on more relevant submissions prior to a more critical analysis of the literature. This was addressed via the following question:

- What evidence is there to demonstrate the effectiveness of high-fidelity simulation learning programs on healthcare professionals' acquisition and performance of crisis resource management skills?

The literature review was undertaken with clear objectives and selection criteria set within a search strategy for identifying articles. Selected studies were analyzed using the Johns Hopkins Nursing Evidence-Based Practice (JHNEBP) Research Evidence Appraisal Tool for strength and quality of evidence (Johns Hopkins Hospital/ Johns Hopkins University, 2004). This tool was used to take information from the articles to critique them by systematically reviewing their relevance, validity, and applicability to the research question. In this chapter, a summary and appraisal of the current literature, including synthesis of findings and recommendations for research in this area, will be outlined.

Search Strategy

The search included all levels of evidence from studies carried out with participants from healthcare disciplines or students studying to work in healthcare disciplines (e.g., nursing students, medical students, respiratory therapy students). The intervention of interest was the use

of high-fidelity simulation education specifically delivered to teach CRM skills. Outcomes measured included performance of problem solving, situational awareness, resource utilization, communication, and leadership. The search was restricted to studies written in English in the years between January 1, 2003, and May, 2017. This time frame was chosen for practical reasons related to recentness of publication and the nature of technology used in simulation settings. For example, any older studies may not have involved the use of manikins comparable to the computerized manikin technology available today. The databases used were PubMed, the Cumulative Index of Nursing and Allied Health Literature (CINAHL), and Scopus.

Search Terms

The search terms used were: decision making/ or leadership/ or awareness/ or comprehension/ or exp communication/or problem solving/) AND (Patient Simulation/ OR Computer Simulation/) AND exp Education/ [Medline]((MM "Decision Making+") OR (MM "Decision Making, Organizational") OR (MM "Problem Solving+") OR (MM "Leadership") OR (MM "Communication+") OR (MM "Critical Thinking") OR (MM "Critical Thinking")) AND ((MM "Computer Simulation") OR (MM "Simulations") OR (MM "Patient Simulation")) AND (MM "Education+") [CINAHL]. The search was extended through review of reference lists of the articles yielded from the above search, and subsequent retrieval of relevant titles.

Inclusion/Exclusion Criteria

Studies were included if the following criteria were met.

- a) The authors reported use of high-fidelity simulation learning programs as the educational forum, based on the definition provided by Lapkin et al. (2010) discussed above.
- b) There was clear evidence of an educational intervention aimed at affecting performance in a CRM skill.

- c) The outcomes studied included one of the five CRM skills: problem solving, situational awareness, resource utilization, communication, and/or leadership.
- d) Studies were published in English, between 2003 and 2017, and available through the library systems at the University of Manitoba or Google.

Articles were excluded if: the educational forum used did not include high-fidelity simulation (i.e., patient actors, task trainers, virtual reality); CRM educational outcomes were not evaluated; they were descriptive, opinion papers, or commentaries; results were only reported in conference abstracts; or they were not available through electronic search mechanisms offered by the University of Manitoba.

Search Outcomes

As the proposal for this study was being written, a first search of the literature was carried out for the years 2003 to 2014. Through this search, 225 papers were located using the above search terms, 30 were not available for distribution through the University of Manitoba library access system or Google, including seventeen unpublished theses. Abstracts of the remaining papers were then read, excluding 81 papers where inclusion criteria were not met. The remaining papers were read in full, examined and rejected if inclusion criteria were not met. This initial search yielded 20 papers for review. The search was repeated to include citations from 2013-2016. One year of overlap was done (2013-2014) to ensure databases searched yielded late submissions from the final year of the initial search. Using the same criteria and databases, 594 citations were produced, with an additional eleven studies added to this review, for a total 31. Results up to this point were published as a literature review in *Clinical Simulation in Nursing* (Lucas & Edwards, 2017). The search was repeated for the third time to include articles from August 2016 to May 2017. This yielded another 139 citations, with one study added to this

review (see Table 1). Within the 32 papers meeting the inclusion criteria, high-fidelity simulation was used with various clinical themes, methods, and interventions. The findings from these studies will be summarized below.

Table 1

Outcomes from Three Separate Searches of the Literature

2003-2014	2013-2016	2016-2017
225 citations	594 citations	139 citations
Removal of duplicates, sources unavailable, sources that did not meet inclusion criteria	Removal of duplicates, sources unavailable, sources that did not meet inclusion criteria	Removal of duplicates, sources unavailable, sources that did not meet inclusion criteria
20 studies for review	11 additional studies for review	1 additional study for review
Total Studies Retrieved and Reviewed: 32		

Overview of Characteristics of Studies

The studies reviewed were published between 2004 and 2017. The methods used in the 32 studies are presented in Table 2, with 7 studies using an experimental design, 18 using a quasi-experimental design, and 7 using other types of designs. All of the studies used convenience samples, with sample size ranging from 6 to 228 participants. Study participants fell into three categories, with 5 studies using a physician-only sample (including medical students and residents), 20 studies using a nurses-only sample (including student nurses, graduate or novice nurses), and 7 using participants from more than one discipline (including students of different healthcare disciplines). Recruitment for most of the studies occurred in continuing education initiatives or university/college type courses. Simulation-based learning using a high-fidelity simulator was used in all of the studies reviewed.

Table 2

Methods used in Research Studies Reviewed

Type of Research Design	Studies Reviewed
Experimental Design (7) Randomized, controlled, pre-test/ post-test (3) Randomized, controlled, blinded (2) Two-group by two-times mixed model (1) Comparative correlational (1)	Jankouskas, Haidet, Hupcey, Kolanowski, & Murray (2011); Liaw, Rethans, Scherpbier, & Piyanee (2011); Maneval et al. (2012) Morgan et al. (2011); TenEyck, Tews, Ballester, & Hamilton (2010) Sullivan-Mann, Perron, & Fellner (2009) Brown & Chronister (2009)
Quasi-Experimental Design (18) Pretest/posttest (10) Two-group comparative (4) Prospective observational (2) Exploratory (1) Prospective cohort (1)	Brannan, White, & Bezanson (2008); Gilfoyle, Gottesman, & Razack (2007); Huseman (2012); Lavigne Fadale, Tucker, Dungan, & Sabol (2014); Schubert (2012); Shinnick & Woo (2013); Sittner et al. (2009); Straka, Burkett, Capan, & Eswein (2012); Wolf (2008); Wunder (2016) Bultas, Hassler, Ercole, & Rea (2014); Goodstone et al. (2013); Hall (2015); Johnson et al. (2014) Dadiz et al. (2013); Shapiro et al. (2004) Meurling, Hedman, Fellander-Tsai, & Wallin (2013) Singer et al. (2013)
Other (7) Non-experimental (3) Quality improvement (2) Mixed methods (1) Repeated measures pilot (1)	Buckley & Gordon (2011); Gillman et al. (2016); Jankouskas et al. (2007) DeVita, Schaefer, Wang, & Dongilli (2005); Przybyl, Androwich, & Evans (2015) Lasater (2005) Kesten, Brown, & Meeker (2015)

Educational interventions used. As noted above, all of the studies reviewed included simulation-based learning using a high-fidelity simulator. Thirteen studies compared pre-test and post-test results following an HFS learning program (Buckley & Gordon, 2011; Dadiz et al., 2013; DeVita et al., 2005; Gilfoyle et al., 2007; Huseman, 2012; Jankouskas et al., 2007; Liaw et al., 2011; Przybyl et al., 2015; Schubert, 2012; Shinnick & Woo, 2013; Sittner et al., 2009; Straka et al., 2012; Wolf, 2008). Standard education was compared to standard education plus HFS learning in four studies (Hall, 2015; Jankouskas et al., 2011; Maneval et al., 2012; Singer et al., 2013). In nine of the studies reviewed (Brannan et al., 2008; Brown & Chronister, 2009; Bultas et al., 2014; Goodstone et al., 2013; Johnson et al., 2014; Lasater, 2005; Shapiro et al., 2004; TenEyck et al., 2010; Wunder, 2016), the outcomes of HFS learning versus an alternate form of education were compared. The remaining six studies examined outcomes with: multiple simulation interventions over time (Gillman et al., 2016 ; Kesten et al., 2015; Lavigne Fadale et al., 2014 ; Meurling et al., 2013); simulation alone versus simulation with a guided debrief (Morgan et al., 2011); and three versus five simulation sessions (Sullivan-Mann et al., 2009).

Assessment measures. The goal of this review was to explore literature related to the translation of behaviors learned in high-fidelity simulation-based learning programs on performance of CRM skills. Thus, the assessment measures highlighted below include only ones that targeted evaluation of the above-mentioned CRM skills. There were studies that evaluated other outcomes in addition to these skills (e.g., confidence in CRM skills or the value of the learning sessions), and while evaluation of learning outcomes through participation in active roles (such as the first responder) were common, reports of learning through participation in other roles (such as the observer) were less common (Hober & Bonnel, 2014). Within the 32 studies included in this review, none studied the degree of learning achieved through

participation in the different roles (i.e., none described a difference in performance of CRM skills [if any] achieved through participation as an observer versus active participation in the simulation scenario).

Confidence in CRM skills and perceived value of the learning session will not be discussed within this review. The reason for not including these reports is because the focus is on the effect of an educational intervention on skill performance or translation of learned behaviors, and not a comparison of the reports of participants on their perceived value of the learning sessions. Confidence is not a proxy for performance. Moreover, according to Thompson, Yang, and Crouch (2012), “it is important to recognize that confidence can act as a biasing heuristic in clinical judgment and mask underlying performance” (p. 2478). It is hoped that by providing objective reports of skill performance, that future research will yield objective comparisons to patient outcomes.

Fourteen of the 32 studies used a validated tool (see Table 3). In the remaining studies, assessment measures varied. The “time to task”, or the time that elapsed before performance of key behaviours, was used in four studies (DeVita et al., 2005; Lavigne Fadale et al., 2014; Meurling, 2015; TenEyck et al., 2010). According to Ten Eyck et al. (2010), tasks were selected based on the criteria that they were “clear and measurable” (p. 141). It was suggested that task completion is an objective measure (DeVita et al., 2005) and “less susceptible to inter-rater differences” (p. 330). Lavigne Fadale et al. (2014) reported 100% interrater reliability. Two studies used chart reviews to assess problem-solving. Huseman (2012) looked at response times during codes, while Wolf (2008) looked at rates of under-triage in an emergency department. Both collected benchmark data prior to the intervention and again afterwards and compared results. The remainder of the studies used tools created by the researchers (see Table 4).

Table 3

Validated Tools Used in Studies Reviewed

Validated Tool	Brief Description of Tool
<p>Anesthetists' Non-Technical Skills (ANTS) (4 studies: Jankouskas et al., 2007; 2011; Morgan et al., 2011; Wunder, 2016)</p>	<p>Involves assessment of task management, team working, situational awareness, and decision-making (Note: Two studies used this tool on physicians and nurses demonstrating generalizability to disciplines other than anesthesia) Fletcher et al. (2004) established content validity through a panel of expert anesthesiologists and calculated internal consistency with a Cronbach's alpha value of 0.70-0.86</p>
<p>Health Sciences Reasoning Test (4 studies: Goodstone et al., 2013; Maneval et al., 2012; Shinnick & Woo, 2013; Sullivan-Mann et al., 2009)</p>	<p>Multiple-choice test designed to assess critical thinking of healthcare profession students (Maneval et al., 2012) A Kuder-Richardson 20 formula calculated reliability to be .77-.84, which is considered to be adequate. The HSRT is considered to be a valid measure of critical thinking with correlations to the Student Aptitude Test (SAT) and the American College Test (ACT) are .40 and .55 respectively (Goodstone et al., 2013) 7-point Likert scale designed to assess performance in all five CRM skills as well as provide an overall performance score Content and construct validity established through expert panel and demonstrated acceptable interrater reliability through intraclass correlation coefficient by Kim et al. (2006)</p>
<p>Ottawa GRS (1 study: Gillman et al., 2016)</p>	<p>Uses five 7-point behaviorally anchored rating scales High internal consistency reliabilities previously calculated with a Cronbach's alpha value of .94 (Morey, et al., (2002).</p>
<p>Team Dimensions Rating Form (1 study: Shapiro et al., 2004)</p>	<p>Multiple-choice exam on rhythm strip interpretation As a measure of reliability, the Kuder-Richardson formula 20 was calculated (0.72),</p>

<p>Electrocardiogram (ECG) SimTest (1 study: Brown & Chronister, 2009)</p>	<p>the point biserial correlation coefficient (PBCC) for each item was determined, and the mean PBCC for the ECG SimTest was 0.22, established by the test publisher on the basis of national scores on 21 of the 30 items (Brown and Chronister, 2009)</p>
<p>Assessment Technologies Institute (ATI) Content Mastery Series (1 study: Hall, 2015)</p>	<p>60 Multiple-choice question exam testing critical thinking skills ATI proficiency levels compared to NCLEX scores and based on custom reports</p>
<p>Rescuing a Patient in Deteriorating Situations (RAPIDS) (1 study: Liaw et al., 2011)</p>	<p>42-item measure evaluating clinical performance Interrater reliability tested across 3 raters with 30 videos of simulation performances. High intraclass correlation coefficient of 0.99 was yielded. Construct validity reported in a previous study (Liaw et al., 2011)</p>
<p>Pediatric Emergency Assessment, Recognitions and Stabilization Course (PEARS) Examination and the Mayo High Performance Teamwork Scale (MHPTS) (1 study: Bultas et al., 2014)</p>	<p>The PEARS test is a written exam of 24 Multiple-choice questions to test knowledge retention The MHPTS evaluates team performance and has shown satisfactory internal consistency as well as satisfactory construct validity through RASCH analysis (Bultas et al., 2014)</p>

Table 4

Tools Created by Researchers in the Studies Reviewed

Tool Type	Brief Description of Tool
Surveys Buckley and Gordon (2011) Dadiz et al. (2013) Lasater (2005)	Likert-scale survey to self-identify practice changes Survey to measure communication Lasater Clinical Judgment in Practice Survey
Checklists Dadiz et al. (2013) Gilfoyle et al. (2007) Johnson et al. (2014) Bultas et al. (2014) Gillman et al. (2016)	Checklist to measure communication (validity established through expert review, feedback, and pilot testing) Score-based, non-validated checklist to evaluate performance Weighted checklist to evaluate performance (inter-rater reliability established in a pilot study) PEARS Behavioural Measures Check-off Tool to score team behaviours, skills, and tasks performed Based on Advanced Trauma Life Support (ATLS) standards
Knowledge Questionnaires Gilfoyle et al. (2007) Straka et al. (2012) Przybyl et al. (2015) Sittner et al. (2009) Schubert (2012) Brannan et al. (2008)	5-item questionnaire testing knowledge pre- and post-intervention An online pretest and posttest assessing knowledge (validity not reported) A pretest and posttest questionnaire assessing knowledge and critical thinking (content validity established by expert reviewers) Multiple-choice test (content validity by expert panel) Multiple-choice test Learning Transfer Tool assessing nurses' problem-solving skills Acute Myocardial Infarction Questionnaire: Cognitive Skills Test (content validity established by experts)
Clinical Judgment Assessment Lasater (2005)	Lasater Clinical Judgment in Simulation Rubric
Competency Assessment Kesten et al. (2015)	Advanced Practice Registered Nurse Evaluation Tool

Results of Studies Reviewed

The learning outcomes of interest for this review are the CRM concepts of problem solving, situational awareness, resource utilization, communication, and leadership (as defined above). CRM training is a method of teaching and practicing team processes. It is meant to use simulation to improve processes during patient crises by removing team errors and improving

patient safety (Jankouskas et al., 2007; Morgan et al., 2011). Because these skills are interrelated, most of the studies measured performance of more than one CRM skill. Results for each study will be reported separately.

Pre-test/post-test comparisons. Thirteen studies compared results of a pre-test and post-test after a high-fidelity simulation learning program. The results of these studies are presented below.

DeVita et al. (2005). In this quality improvement project, roles were pre-assigned to different disciplines (i.e., 69 registered nurses, 48 physicians, and 21 respiratory therapists) prior to simulation events. Problem-solving measures included the time to task completion rates associated with those roles and the rate of “simulator survival” (meaning that participants achieved target goals within a pre-set time frame, preventing the simulator from further deterioration and death). Simulators survived from 0% of the time to 89% of the time in a preliminary report of their study. Pre-assigning the roles also ensured that resources were utilized appropriately, pairing professional designations to skills during the crisis events. Thus, tasks were allocated before ICU nurses, physicians, respiratory therapists and ward nurses even responded to a code (i.e., human resources were pre-assigned). Time-to-task measures improved with this novel approach to the curriculum. The team leadership role was assigned to the ICU physician, which involved directing team efforts and decision making. Performance of leadership items improved after simulation training. The authors indicated that there was no inter-rater reliability of performance ratings and the scenarios were different between groups which made comparisons difficult.

Jankouskas et al. (2007). In this non-experimental pre-test/post-test study, groups of practicing nurses and physicians (N = 40) participated in two simulation scenarios. Groups were

evaluated using the ANTS tool. While the team working domain of the ANTS scale showed a statistically significant improvement, the task management, situation awareness, and critical thinking domains did not. There was also a statistically significant improvement in team working skills, which included communication and leadership. In this first of two Jankouskas studies, it was noted that the element of situation awareness was difficult to assess and visualize on video-taped simulations, making it also difficult to evaluate.

Gilfoyle et al. (2007). In this workshop series, the impact of communication and the components of communication in the development of leadership skills in 15 pediatric residents was measured using a score-based unvalidated checklist and a retrospective five-item knowledge questionnaire. Results related to communication skills from immediate pre- to post-test significantly increased but did not improve six months later in a second workshop meant to test skill retention in returning participants. This study offers the conclusion that no further independent learning of communication in clinical practice occurred in the six months leading to the second intervention, but also no decay occurred over time. Checklist scores related to the leadership domain showed an increase of 63% to 82%. This increase in scores indicates leadership skills were acquired through participation in the intervention. This study listed limitations as use of unvalidated scenarios, an unvalidated evaluative checklist tool, and a possible “training effect” related to use of the same scenario at the six-month session.

Wolf (2008). In this chart review study involving 6 practicing nurses, an improvement from 40% accurate triage to 70-100% accurate triage post participation in three simulation scenarios was noted. Limitations were not addressed with this study.

Sittner et al. (2009). Using a multiple-choice test with content validity established by an expert panel, this study showed there was no significant statistical difference over time in 11

nurses' knowledge and clinical judgment following a team simulation training activity. This study involved a small sample with lack of a control group. Participants also received a recent orientation on relevant material, which may have affected pre-test scores.

Buckley and Gordon (2011). This study reported participants' perceptions (N = 38 practicing nurses), through a reflective Likert-scale survey asking participants to self-identify practice changes post-intervention, regarding critical abilities with airway management in crisis events. The authors studied CRM aspects of problem solving, resource utilization, and handover communication during emergencies, and showed improvement in all areas. Simulation activities in this study were blended with other activities, making it difficult for the researchers to differentiate which aspect resulted in the improvement.

Liaw et al. (2011). In this randomized controlled study, the authors used the Rescuing a Patient in Deteriorating Situations (RAPIDS) tool, a 42-item measure evaluating clinical performance. They showed a statistically significant improvement in clinical performance (N = 31 student nurses) related to complex problem solving and communication after a training program in the intervention versus control group. The authors indicated that competencies can be enhanced through a simulation-based education program. Limitations included a lack of generalizability, small sample size, unknown effects on long-term retention of learning, and single scenario exposure.

Huseman (2012). In this quasi-experimental study involving 112 registered nurses, 66 nurses' aides/nursing assistants, and an unknown number of respiratory therapists, student nurses, and pharmacists (total sample = 178), the author reported that there were statistically significant improvements with time to key behaviors in crisis scenarios (i.e., initiating CPR and first dose of epinephrine), but not in other items (e.g., time to defibrillation), with a

multidisciplinary pre-/post-test HFS education program. These results were not sustained over time during a three-month maintenance period post intervention. Limitations to this study were not addressed.

Schubert (2012). In this quasi-experimental study of practicing nurses, and using an author-created multiple-choice test, the author reported statistically significant improvement in problem-solving skills in a sample of practicing nurses (N = 58). This author listed limitations related to a small sample, a high rate of attrition, and the effect of some participants working a night shift prior to the education session potentially affecting their performance in the study.

Straka et al. (2012). This quasi-experimental, single sample, pre-/post-test study used an unvalidated knowledge questionnaire to test for problem solving in 26 novice nurses. There was a statistically significant improvement in these skills, though the time frame, a small sample, and choice of evaluative tool were listed as limitations.

Dadiz et al. (2013). In this multidisciplinary quasi-experimental study (N = 228 physicians and nurses in total throughout a three-year time frame), the authors created a survey and checklist to measure communication. They reported that validity was established through expert review, feedback, and pilot testing. They also reported the checklist showed “excellent inter-rater reliability when the reviewers used it to assess team communication” (Dadiz et al., 2013, p. 284). Checklist scores improved in communication and leadership from pre-test to post-test high-fidelity simulation education intervention, targeting crisis labor and delivery events. Limitations in this study included reviewers not being blinded to time and order of simulations during the evaluation process, participants were not randomized to group, use of a potentially inappropriate evaluation tool, and potential of contamination of the sample from other education initiatives that may have affected results.

Shinnick and Woo (2013). This study showed statistically significant gains in student nurses' (N = 154) knowledge post-simulation education activity, but not in critical thinking as measured by the Health Sciences Reasoning Test. While these results are consistent with published literature, the authors state that their study population scored among the highest on the pre-test which indicates strong baseline critical thinking skills. These high pre-test scores may not allow for significant increases with their intervention. Limitations were listed as variability with teaching and clinical experiences related to the simulation scenario prior to the education session and prior to follow-up the simulation session. This was described as a "dosing effect" and also included exposure to simulation education prior to participation in the study.

Przybyl et al. (2015). This quality improvement project showed improvement in problem solving in a sample of 93 practicing nurses through a knowledge test. There was no comment on significance of the improvement, only that there was an increase in understanding of targeted principles and critical thinking skills related to operation of continuous renal replacement therapy machines (a type of slow dialysis for critically ill patients). The only limitation discussed was difficulty with recruitment of participants for this study.

These thirteen pre- and post-test studies involving a high-fidelity simulation-based learning program showed statistically and non-statistically significant improvements in CRM skills. Out of the thirteen studies, three commented that learning was not retained over time (Gilfoyle et al., 2007; Huseman, 2012; Liaw et al., 2010). This suggests that with CRM skills in a high-fidelity learning environment improved at least in the period following the education initiative. Long-term benefits, however, are not as clear.

Comparison of HFS intervention with alternate activities. Thirteen studies compared an HFS intervention with some type of alternate activity. These studies are described and

discussed below.

Shapiro et al. (2004). As part of a single-crossover, prospective, blinded, and controlled observational study, the effects of an HFS curriculum on teamwork, which included elements of the behavior of assigning roles and responsibilities, maintaining team structure, team communication, leadership skills, and executing plans, were evaluated in a sample of physicians ($n = 8$) and nurses ($n = 12$). Teams were randomized to experimental and control groups. The experimental groups received a simulation intervention after one of two data collection periods in an actual clinical environment. The control groups did not receive the HFS intervention. The tool used to evaluate team performance was one validated in aviation studies called the Team Dimensions Rating Form, consisting of five seven-point behaviorally anchored rating scales. There was a non-statistically significant increase in scores between pre-training and post-training measures in both the experimental and comparison groups. These results do suggest a positive impact on performance of these skills, though small sample size may have affected results.

Brannan et al. (2008). In this quasi-experimental study involving 107 nursing students, two instructional methods were compared to test their effects on cognitive skills related to nursing education content. Instructional methods were a traditional classroom lecture compared with teaching using a high-fidelity simulator. The authors developed two versions of the Acute Myocardial Infarction Questionnaire: Cognitive Skills Test, with content validity established by experts and reliability tested on nursing students prior to the study. Higher post-test scores with an intervention group were reported compared to a control group using the knowledge test. There was a lack of randomization to groups with this study.

Lasater (2005). A statistically significant improvement was shown in this mixed methods thesis study on the critical thinking skill outcomes of nursing students ($N = 48$). Participants

recruited from a theory course were tested using two unvalidated and one validated critical thinking assessment measures and were compared to another group of participants that took part in the same theory course with the addition of complementary simulation-based learning interventions. Limitations listed included involvement of only a single center, lack of comparable baseline data, and a lack of variation in the sample that participated in the qualitative portion of this mixed-methods study.

Brown and Chronister (2009). With a sample of nursing students (N = 140), this experimental study compared a control group (n = 70) that received only didactic instruction on electrocardiogram (ECG) concepts to an experimental group (n = 70) that received weekly simulations in an HFS environment over a one-year period. They reported no significant differences in critical thinking between pre- and post-simulation measures. The authors admit to several limitations with this study, mainly a lack of control for differences in exposure to outcomes measured (e.g., nursing students' clinical experience with ECG rhythms) that may have affected baseline critical thinking skills. Sample size was also cited as being too small and the amount of time participants spent in learning activities was not equal between groups. The authors felt that this difference may have affected the treatment group negatively.

TenEyck et al. (2010). This was a randomized, controlled, blinded study that used time-to-task measures to test for problem solving and leadership skills with 68 medical students. In the experimental group, there was statistically significant improvement in four of eight critical tasks, indicating improvement in problem solving skills. Within the leadership domain, Ten Eyck et al. (2010) measured time to ordered task, meaning the team leader was evaluated on how long it took him/her to initiate a particular action. The experimental group in this study received more simulation cases than the control group and showed more significant improvement as the

program progressed. The authors concluded that participants in this group learned to mobilize their team earlier and initiate essential tasks concurrently rather than sequentially. Limitations were listed as lack of generalizability of results, lack of a validated instrument, and using a single evaluator for the cases.

Jankouskas et al. (2011). This experimental study by this research team, involving multidisciplinary students (N = 96), reported statistically significant improvements in situational awareness in the experimental group. The hypothesis that CRM team training during a simulated patient crisis event will demonstrate an increase in team process, as measured by four domains, including situation awareness, resource utilization, communication, and leadership compared with teams training only in basic life support skills, was partially supported. There was a significant increase in task management and team-working measures using the ANTS tool in both the experimental and control groups. The authors attribute the lack of difference between groups to unrealized potential for ongoing development of the experimental group, meaning more simulation episodes may serve to further develop team process skills, thus amplifying the effects of the program over time. Limitations included lack of generalizability to more experienced providers, diffusion of treatment that may have occurred over a ten-month period, the potential for bias as the principle investigator was unblinded and was also the instructor for the simulation sessions, and the use of the ANTS tool as a measure. It may not be an adequate tool for the highly complex domains involved with team processes.

Maneval et al. (2012). In this randomized and controlled pre-/post-test study, critical thinking and clinical decision-making were compared between new graduate nurses. A control group (n = 13) received standard orientation and an experimental group (n = 13) received the standard orientation with the addition of high-fidelity simulation. Both groups showed an

increase in mean scores from pre-test to post-test with the HFS group showing greater, though non-statistically significant, gains. Limitations with this study are listed as limited sample size, higher than national average pre-test scores, which may have affected the degree of improvement post intervention, and a lack of support from nursing management (i.e., managers may have dissuaded participants from enrolling by sending the message that participation would inconvenience the unit), that may have affected participants' attitudes toward learning.

Goodstone et al. (2013). This two group quasi-experimental study reported statistically significant increases in HSRT critical thinking scores (problem solving) in both experimental (weekly high-fidelity simulation scenarios) and a comparison (weekly case study activity) groups. The sample consisted of 42 first-year associate degree nursing students, with 20 assigned to the HFS group and 22 to the case study group. When scores were compared between both groups, however, the difference was not significant. These mixed results indicated that various types of simulation education can be effective in teaching critical thinking. This study lacked randomization, had a small sample, and lacked a no-treatment control.

Singer et al. (2013). This prospective cohort study found that an experimental group of first-year medical residents (n = 40) who received traditional clinical training and a simulation-based curriculum outperformed a control group of third year residents (n = 27) who received traditional training alone. The experimental group demonstrated higher clinical competency than the control group in a bedside assessment using a 20-item checklist. This was a single-center study with limited numbers. It was also not blinded and there were only a limited number of competencies that were assessed.

Bultas et al. (2014). A pre-test/post-test control group design was conducted to compare effectiveness of HFS with traditional static manikins (low fidelity). Participants were evaluated

through a skills checklist measuring team behavior with either the high fidelity or the low fidelity manikin and also a written test measuring knowledge retention. When testing for knowledge and skill performance (problem solving), the experimental group ($n = 19$) in this study scored higher from initial testing to a six-month follow-up in one scenario (p value 0.012) and non-statistically significant improvement with another (p value 0.856). When compared to the control group ($n = 14$), the difference was significant for both scenarios (p value <0.001). This indicates mixed results in the problem solving skill set. The experimental group was also noted to perform better when recognizing and intervening with a deteriorating patient, a key component of situational awareness. Limitations for this study were use of an unvalidated tool, a small sample with high rate of attrition, lack of blinding, scoring teams instead of scoring individual participants, and use of the same scenario at the follow-up education session which may have increased the chance that participants memorized potential responses.

Johnson et al. (2014). This was a quasi-experimental pre-test/post-test study that used a convenience sample of 32 advanced practice nurses randomized to manikin or web-based training. Results showed a significant improvement in observed performance of clinical management in simulated scenarios (problem solving and resource utilizations skills). Performance was evaluated by independent raters using a checklist. Both groups showed statistically significant improvements in observed performance (p value < 0.001) and the manikin group scored statistically significantly higher than the web-based group in observed performance scores. A small sample and varied levels of previous experience within the sample were reported as limitations.

Hall (2015). In this retrospective comparative quantitative study, the effectiveness of adding HFS education to traditional hospital-based clinical experiences for senior level maternity

nursing students was evaluated. Critical thinking (problem solving) was tested through a 60-question multiple-choice test with a simulation group (n = 147) and a non-simulation control group (n = 132). The simulation group scored statistically significantly higher on a post-test when compared to the control group. This study had limited generalizability and there were differences between groups within the sample.

Wunder (2016). In this quasi-experimental study, nursing anesthetist students (n = 32) were tested with the validated Anesthetists' Non-Technical Skills (ANTS) tool in a repeated measures with repeated evaluations HSF education program compared to the HFS education program with an additional CRM focused lecture. Increases in mean scores were statistically significant in all CRM skills with the lecture group. However, there was no breakdown of the scores given. This author concludes that CRM skills were not acquired through experience in the HFS scenarios, but rather through instruction on CRM skills. Lack of interrater reliability and rater familiarity with students were limitations in this study.

In summary, comparison of high-fidelity simulation-based learning to other methods of education including web-based simulation, low-fidelity simulation, case study activities, and traditional lectures showed that HFS learning is an effective method of learning CRM skills. Overall these studies do not show that HFS is superior to these other methods, or in the studies where there were differences, the results were not always statistically significant.

Multiple simulation interventions over time. Four studies measured the effects of multiple simulation exercises over time. These studies are described and discussed below.

Meurling et al. (2013). Mixed results were shown in this exploratory study, where all five CRM skills were studied. Each of the 54 medical student participants acted either as an active participant or an observer in three scenarios, with the teams' clinical performance

evaluated over time. Here, the frequency of the participants summing up (or communicating) the situation present in the simulation showed statistically significant improvement, while other data collection points, such as the time it took to call for help and frequency of reassessments, did not show significant improvement. This study was designed to measure clinical performance of a team during simulation training. It was assumed that learning occurred either through observation or as an active participant in the scenario. In other words, not every participant was primary responder in a scenario. A lack of generalizability was also listed as a limitation.

Lavigne Fadale et al. (2014). Using total number of vasopressor titrations as a marker for critical thinking in a population of critical care and emergency room nurses with less than three years of experience (N = 16) in these environments, this quality improvement project showed a statistically significant improvement across three time points in a simulation-based learning program. These results were mixed, however, as there was a non-statistically significant difference in the other data points of time to medication rate calculation and time to initiate the first titration. This suggests that participants may be able to achieve hemodynamic stability for their patients more effectively with simulation education. A small sample was again listed as a limitation with this study as well as a potential for performance bias as recruitment had to be broadened to include nurses with varied experience. The authors also listed their choice of tool as a limitation and there were missing data points in the final evaluation as a result of failings related to technology and equipment used in the simulation lab.

Kesten et al. (2015). The effectiveness of using simulation to assess and evaluate the competency of advanced practice registered nurses (APRN) using the APRN EVAL tool (designed to measure leadership skills, prioritization, communication, collaboration, and professionalism) was measured in this repeated-measures pilot study. Groups of four APRN

students (N = unknown) participated in an HFS learning program requiring management of complex patients at four intervals over a six-month period. Results showed a statistically significant improvement in scores from test one to test four in all five CRM skills. Implications for this study include assumptions that increased exposure to HSF improves competence of participants. Limitations included a small sample, lack of standardization of the evaluation tools and scenarios used, previous participant exposure to a simulation environment, and ongoing participant learning during the span of the study potentially affecting later scores and overall performance.

Gillman et al. (2016). This non-experimental study compared the results of participant groups (total sample N = 109) in four Simulated Trauma and Resuscitation Team Training Courses (STARTT). Over the span of the four courses, eleven groups completed four scenarios each. Mean Ottawa GRS scores were compared for the teams as they progressed. Significant improvements were shown between scenarios one and three ($p = .022$), scenarios two and three ($p = .017$), and scenarios two and four ($p = .003$). Mean ATLS checklist scores did not show any differences between the scenarios and results were not reported. Limitations to this study include use of the unvalidated ATLS checklist, which may not have been an appropriate way to measure team performance, lack of blind evaluators, and lack of measurement of a delayed evaluation that would assess learning decay over time.

In these four studies, two used three simulations and two used four. It was noted that learning occurred through observation and also through active participation. Each of the studies showed statistically significant improvements in some outcomes measured and non-statistically significant improvement in others. It is possible that participants needed more exposures or more time to show a difference in other skills.

Other types of comparisons. The final two studies reviewed compared either the number of HFS sessions or HFS alone to HFS with a debrief component and are discussed below.

Sullivan-Mann et al. (2009). This two groups by two times mixed methods experimental study compared three HFS sessions to five HFS sessions using the validated HSRT tool. A group of nursing students (N = 53) showed a statistically significant improvement in problem solving skills. Limitations included a small sample, differences in instruction between groups, a lack of no-intervention control, and limited generalizability.

Morgan et al. (2011). As a randomized, controlled, and blinded study, these researchers reported results on all five CRM skills comparing HFS alone to HFS with a debrief component. Using the ANTS tool, they reported that this HFS learning did not show an appreciable improvement in practicing anesthesiologists' (N = 59) non-technical skill performance, except in the situation awareness category. It is interesting to note that this is the only study that looked at leadership traits that showed no improvement following an HFS learning session. Possible limitations include a high functional ability of the sample prior to the intervention, impeding the ability for the learning activity to affect performance. Also, a lengthy interval between staged simulation interventions (five to nine months) may have limited participants' ability to retain learning over time. The authors raise the question whether the ANTS tool is the best choice to use among this population.

Summary

In total, 32 papers that measured translation of the CRM outcomes, problem solving, situational awareness, resource utilization, communication, and leadership, after high-fidelity simulation interventions were reviewed. A variety of study designs were used by researchers,

including experimental, quasi-experimental, non-experimental, and quality improvement initiatives. Samples were all convenience samples, and variable in size and composition. Subjects included practicing physicians, nurses, and support staff, including healthcare aides or respiratory therapists, as well as students from the various disciplines. Educational interventions also varied with pre- and post-test designs with an HFS education program as well as comparisons of HFS education programs to other educational modalities.

Validated tools measured outcomes in 14 studies and the remainder used tools that were not validated. Tools measured a variety of CRM skills, with problem solving being the most frequently studied outcome (23 of the 32 studies).

Results were mixed, with 23 studies showing improvement in at least one CRM skill. Crossover was evident in some studies, where statistically significant improvement was shown in some areas and no improvement or non-statistically significant improvement was shown in others. The pre-test/post-test study design appeared to show the greatest amount of difference in skills learned. Whether this was related to the effectiveness of the study design or the evaluation methods is unclear. Comparison of HFS to other methods showed that simulation is an effective method of teaching CRM skills. It may be superior to traditional didactic lectures though equally as effective as other methods of simulation such as web-based simulation or low-fidelity simulation. HFS was also shown to be effective in teaching CRM skill when used in combination with other methods of instruction. Repeated measures studies did not show greater degrees of learning over time. With the multiple exposures, it would be expected that the degree of improvement would increase over time. Evidence from these four studies reviewed was not consistent with this conclusion, however, with only four studies included in this review it is difficult to pool results. It is interesting to note that in each of the repeated measures studies,

there were statistically significant improvements in some skills and non-statistically significant improvements in others.

JHNEBP ratings made during the review process showed seven studies with “level one, good quality” ratings, eleven “level two, good quality”, ten “level two, low quality”, and four “level 3, low quality”. These judgments were based on criteria using the Johns Hopkins Nursing Evidence-Based Practice Research Evidence Appraisal Tool for strength and quality of evidence (Johns Hopkins University, 2004). Attention to rigour in study design may yield higher quality results with more definitive conclusions.

Gaps in Literature

This literature review revealed at least four gaps that warrant attention and each of these will be briefly considered. The first gap identified is a lack of studies measuring translation of educational interventions on acquisition of CRM skills. An original search from 2003-2014 yielded 20 papers that met criteria for this review. Two repeats of this search from 2014-2016 and 2016-2017 yielded an additional twelve studies. The combined second and third search yielded more than half the number of studies of the first search, and in only a four-year time frame. This appears to be indicative of a greater interest in observable performance of CRM skills. Continued research may provide insight into the actual effect of HFS on behavior, which may lead to insight into future studies on feasibility of simulation education and effects on patient outcomes.

The second gap identified relates to the absence of meta-analyses. Only one meta-analysis was found that looked at the effects of HFS in nursing education and it presented evidence of the effect of HFS on the cognitive domain of learning, including knowledge acquisition, problem-solving, critical thinking, clinical judgment, and communication outcomes

(Lee & Oh, 2015). There was a “significant treatment effect” (p. 504) for all outcomes except communication. Acknowledging the small number of studies and the limited number of samples used that consisted exclusively of nursing students, the authors concluded HFS “might have beneficial effects on cognitive and psychomotor domains of learning” (Lee & Oh, 2015, p. 505). Combined effects of data sets from all healthcare disciplines and levels of practice (i.e., practicing professionals and students) may reveal more definitive conclusions. Consistency between studies, however, will be needed to make such conclusions and that is not the case to date. This lack of consistency is perhaps because research in simulation education and using CRM as a framework is still new in healthcare. Increased interest in these areas may yield a greater volume and quality of evidence that will add to overall results.

The third gap identified relates to the heterogeneity between study methods, tools, and populations and highlights the need for ongoing research into optimal educational formats and evaluative methods. Many of the authors described one-time only interventions, showing mixed results. Those that did present multiple interventions stated they may have been too few, too widely spaced in time, or subject to outside experience in between sessions to reflect positive results (Kesten et al., 2015; Lavigne Fadale et al., 2014; Meurling et al., 2013; Morgan et al., 2011; Wunder, 2016). Incorporating multiple simulation episodes would increase opportunities to practice skills, and spacing them over shorter time spans would also allow learners to build and reinforce skills. It is noted, however, that controlling for outside influences and experiences may be difficult to achieve.

A fourth gap identified relates to the tools used in studies to date. A number of researchers listed their choice of tool as a limitation, citing applicability to population and lack of validation. This highlights the need to match proven tools to educational outcomes. Further work

is needed in adapting existing tools and testing them on different populations.

Conclusions

It has been suggested that improved patient outcomes will result if health care professionals respond to crisis events using CRM principles. As stated previously, these skills are interrelated and interdependent. It has also been suggested that simulation-based education offers an ideal platform for teaching these skills, as it allows the learner to practice in a realistic environment and receive immediate feedback (Lewis et al., 2012). This literature review explored evidence relating to this suggestion and attempted to find evidence pointing to the effectiveness of simulation education on translated educational outcomes. The studies reviewed, however, did not reinforce my assumptions that HFS is an effective environment for teaching CRM skills. Rather, a comparison of 32 studies which used a variety of methods, samples, educational interventions, and evaluative methods showed mixed results.

Based on these observations, I decided to design a study that used an education program that addressed two main gaps. The first gap was a lack of repeated opportunities to practice skills in the simulation environment. The program created allowed nurses to practice skills over time, thereby solidifying concepts learned from previous sessions. The second gap was a lack of reliable evaluative tools. The measures that I chose were a mixture of those found in the literature as well as a checklist created by me. It was my hope that participants would demonstrate improvement in their performance of CRM skills as they progressed through the education program. In the next chapter, the methods used in this study are described.

Chapter 3: Methods

In this chapter, the study design is identified and the strategies for sample recruitment, data collection, and data analysis are described. Ethical considerations for the study are outlined at the end of the chapter.

Study Design

This study used a repeated-measures observational design. This allowed for the same group of participants to be evaluated over time. Building on the suggestions identified through the review of the literature, a high-fidelity simulation-based education program was created that included multiple exposures for learners (i.e., four per learner), set over two separate sessions and spaced over several weeks, as well as an interdisciplinary component with a physician partner. Skills taught in the program included all five CRM skills, and evaluation of performance of these skills was done using tools designed specifically to measure these skills.

Education Program

The education program was composed of two parts. In the first part, the simulated high-fidelity manikin scenarios, the participants acted either as a primary nurse responding to a deteriorating patient or as an observer watching the response of the primary nurse. Each scenario followed a similar format. The nurse participants were given a brief history of a patient and events leading up to the moment the scenario started. These histories, depending on the physiological problem that led to the events, presented key pieces of data meant to guide the learners through their assessment and subsequent reaction to the patient problem. The scenarios were designed to escalate in patient acuity over 10 minutes.

There were 12 patient problems that were available for use during each education session. These scenarios were pre-selected so that no participant responded as the primary nurse to the same patient scenario more than once. These were: pneumonia, septic shock, allergic reaction,

chest pain, decreased level of consciousness, upper gastrointestinal bleed, occluded tracheostomy, pulmonary embolus, fall with decreased level of consciousness, cerebral vascular accident, massive myocardial infarction, and diabetic ketoacidosis (see Appendix B for example scenario). Scenarios were designed to present the nurse with challenges to overcome (e.g., the appropriate nursing response to a patient with signs of early sepsis), providing them with an opportunity to apply CRM skills. Scenarios mirrored “real-life” situations where a nurse is the first to note a patient problem and then report the issue to the resident or attending physician. These scenarios were developed by me as the PI with input from an expert instructor (Tyler Friesen (T.F.)). As a nurse with critical care and educator background, I have several years of experience developing, conducting, and participating in simulation programs in a variety of settings and T.F. is an internal medicine physician with experience in participating and conducting simulation education programs. These scenarios were then reviewed by independent content experts for authenticity and realism of patient situations. The content experts were two members of the PI’s thesis committee, a nurse and a physician, who have extensive experience developing and evaluating simulation education programs.

Even though each simulated patient scenario was different, there was a standard format and set of objectives for each one. These consisted of the nurse:

- responding to an acute patient deterioration situation;
- initiating interventions as appropriate to his/her scope of practice;
- initiating a call for help;
- communicating concerns to a physician once he arrived on scene.

All simulation scenarios were video-taped with in-house audiovisual equipment. The recordings were used after the final simulation session was completed for scoring participant performance. They were not used for debriefing purposes.

The second part of each situation consisted of facilitator-led debrief sessions, lasting approximately ten minutes directly following the simulated scenario. The methods used were a combination of the Advocacy Inquiry method, which seeks to understand the rationale behind a learner's behaviour and allows the facilitator to provide more effective feedback, and the Directive Feedback method, which provides feedback around a specific action. Using a blended approach to debriefing allowed for flexibility to meet the time limits allotted for each simulation session as well as match the learning needs of the participants while engaging them in discussion about observed performance (Cheng et al., 2016).

These sessions were led by the PI (me) and T.F., a female instructor from nursing and a male instructor from medicine respectively. Both instructors received education and training related to debriefing through the Royal College of Physicians and Surgeons "Practice, Performance, and Innovation (PPI)" simulation courses. The PI completed the Critical Care Response Training Instructor Course (CCRT instructor), which is a peer-reviewed and evidence-based course designed to teach healthcare professionals how to integrate simulation into education programs. This includes content on debriefing techniques (Kim et al., 2009). T.F. received training through Acute Critical Events Simulation (ACES), which is an accredited physician simulation course (Royal College of Physicians and Surgeons of Canada, 2017).

Debrief sessions were non-scripted and were meant to be collaborative among all participants. Using the blended approach described above, the instructors lead group discussions through different phases. The first was an exploration of the participants' reactions to the patient

issues that were encountered during the scenarios. The second was to describe the case and understand issues with CRM skills, and the third was to analyze positive and negative responses and understand the rationale for these choices. The fourth stage was to summarize the essential elements of the case and make comparisons to real-life scenarios that participants may encounter in their clinical environment. The target of the program was to master an approach to the situations presented in each case, which can then be generalized to different patient scenarios.

T.F. was responsible for operating the simulator manikin, and both instructors were responsible for observing simulations, participating in scenarios when appropriate, supporting participants, and leading debrief discussions. Feedback provided during the debrief session ensured that recall of the events was appropriate and that the most important educational points were covered (i.e., positive knowledge transfer). It also provided a strategy that ensured that participants engaged in self-analysis and reflection, creating greater insight into their own performance and expanding their skill set. Feedback was offered in a non-threatening learning environment. While the instructors created situations that were realistic, the participants were assured that it was a psychologically safe learning environment and participants were encouraged to learn from mistakes as crisis resource management skills are founded on learning from errors and their prevention.

In order to prevent a conflict in my role as PI and as an instructor, several measures were undertaken. The first was during my role as a secondary nurse or support person in the simulations. Having a person in the scenario that helped with tasks was important to facilitate participants' experience. I received direction from the participant in their role as primary nurse so that they were able to focus on their response in the scenario. The participants were not

prompted by me unless they asked a direct question related to the patient's condition or they "froze" in their response and needed a cue in order to move the scenario forward.

The second measure was to have T.F. operating the simulator equipment. This removed me from influencing the manikin's response to participant actions. T.F. also acted as the physician responding to the nurse's request for assistance. At the point in the scenario that would naturally require medical expertise, T.F. would enter the scenario, making the experience as realistic as possible. At this point, I stepped back and did not interfere with the actions in the scenario. The addition of medical personnel was beneficial in that it prompted the nurses' teamwork behaviors, an essential part of CRM.

The third measure to prevent interference was to have T.F. lead debrief discussions and provide expertise with medical knowledge where appropriate. While I did provide expertise on nursing specific issues, my role was supportive only. T.F. led the discussions around CRM issues that were addressed during the scenarios. Participants were also not evaluated during the debrief sessions as it was important that they did not feel inhibited during the discussion and contributed freely.

Setting and Sample

The education program was held at Max Rady College of Medicine Clinical Learning and Simulation Facility at the University of Manitoba, Canada. This is an 11,000 square foot facility that is operated in collaboration with the Winnipeg Regional Health Authority. This facility promotes education and training in multiple academic and clinical disciplines (University of Manitoba, 2017). In the current study, a Laerdal SimMan 3G manikin was used as the high-fidelity simulator. Other equipment available to the participants included basic respiratory supplies, a blood pressure cuff, an oxygen saturation monitor, and a basic intravenous set-up

with a pump. Any other equipment had to be requested and was supplied if it was something that would be available on a general medicine or surgery unit.

The nurses in the medicine and surgery programs at the Health Sciences Centre in Winnipeg, Manitoba, Canada were the first programs targeted for recruitment to participate in this project. Following approval from the research ethics board at the University of Manitoba (REB approval number E2015:098 [HS19058] – Appendix C), unit managers and directors of patient care were asked to provide the principal investigator with permission to have a recruitment letter emailed to nurses by an administrative support person from the hospital (Appendix D) and display a poster (Appendix E) which invited nursing staff participation from six medical and five surgical units in the largest tertiary care facility in Manitoba. After six weeks (December 23rd, 2015 to February 3rd, 2016) and with only four volunteers, permission was sought and received from the REB to expand recruitment to individuals with training in reading electro-cardiograms (ECGs) working in the medical and surgical programs and to nurses in the critical care program.

Following verbal permission from the critical care nursing director, nursing staff in the medical, surgical, and intermediate intensive care units at the Health Sciences Centre were provided with information about the study. This was done over the course of approximately two weeks, prior to the first scheduled education session (February 12, 2016).

The posters on the medical and surgical units were on display for one month. The poster listed contact information (i.e., email and phone number) for the primary investigator (PI). All communication originated from the PI's University of Manitoba email address, with additional communication through personal cell phone. The PI was not in a position of power over nursing staff in any of these programs, and, therefore, no conflict of interest existed and adherence to

ethical standards was maintained. No communication originated from unit managers or program directors. Email communication for the medicine and surgery programs originated from their respective administrative personnel.

Interested parties contacted the PI using the information provided on the poster and the email, or in person as was the case in the critical care program. They were then screened and selected based on inclusion/exclusion criteria. Nurse participants eligible for this project were required to have:

- a. employment as a nurse at the Health Sciences Centre for a period of at least six months;
- b. current registration as a registered nurse with the College of Registered Nurses of Manitoba;
- c. willingness to commit to four-hour educational sessions on two separate occasions between the months of January, 2016 and April, 2016;
- d. the ability to communicate in English.

Prior education around CRM principles was an exclusion criterion for this study.

Initial participant screening of the medical and surgical nurses was done over the telephone using a verbal script of questions (Appendix F). If the potential participant met the eligibility criteria, a meeting for a more in-depth discussion about the requirements for participation and the schedule of the simulation sessions was held. This was conducted via telephone or in person, whatever was most convenient for the participant. If the potential participant was still in agreement, consent and confidentiality forms and demographic questions (Appendix G) were sent via email or physically handed directly to the participant. These documents were signed or completed and returned to the PI via mail or in person, and then the participant was given pre-reading material as an introduction to CRM concepts (Appendix H).

Further recruitment and screening was done verbally, in a one-on-one conversation with the PI. If the potential participant was still in agreement, a date and time was arranged to do the consent, sign the confidentiality agreement, and complete demographic forms. The pre-reading material was also given to the participant at this time.

The initial target number for participant recruitment for this study was a convenience sample of up to twelve volunteers. I chose a sample size of twelve based on logistics, as there was a limited amount of physical space and limited time in the simulation lab that could accommodate the participants. For data collection and evaluation purposes, each nurse participant was required to play the role of primary nurse twice each scheduled day of attendance (see below for role descriptions). This meant that over the two scheduled days, each participant was primary nurse at least four times. The purpose of the repetition was to address one of the research questions and to observe if more frequent practice with this type of learning program would yield more conclusive results than reported within the literature.

In order to allot enough time for each participant to act as the primary nurse twice each four-hour session, up to six participants were slotted to attend each half-day. This allowed for twenty minutes per ten minute scenario and corresponding ten minute debrief. We felt that if either the simulations or the corresponding debriefs were any shorter, learning objectives would not be achieved thus we would not be able to accommodate any more than six participants per group. It was possible to conduct a simulation session with a minimum of two participants, however, debrief discussions were richer with more participants.

The number twelve was chosen based on the original study protocol where each participant was to attend four full education days (eight hours) in order to act as primary nurse four times. Since this was not achievable with the challenges related to recruitment, the

education schedule was adjusted to accommodate participants' schedules. This new schedule would have allowed us to recruit up to 24 participants if all six spots were filled each education session.

Procedure

Volunteers were given the option of attending two half days out of four scheduled dates. Group sizes were limited to up to six participants per four-hour day. Because the participants had the ability to choose which days they attended an education session, they were not grouped with the same participants each time (i.e., there were no cohorts in this study). Time between each participant's first and second education session was approximately two to four weeks, depending on which dates were chosen by the participant. Each week, nurses had the opportunity to participate in simulations by filling two roles:

- Primary nurse – This was the first nurse on the scene and the nurse that was evaluated using the Ottawa GRS tool and the checklist.
- Observer – During the simulations, there were up to five nurses that were not directly able to participate in the scenario. These participants observed the scenario within the room but did not actively participate.

Orientation to these roles included a 30 minute pre-brief PowerPoint presentation on CRM concepts and expectations related to responding as the primary nurse and as the observer. In this presentation, participants were led through a series of case studies and as a group discussed the steps that could be taken to respond to a patient. This included using the ABC approach to assessment as well as the SBAR communication method as described in Chapter 1. As the primary nurse, they were instructed to act as a nurse would in an actual clinical scenario. As an

observer, they were instructed to silently observe the scenario occurring. Since they were present in the room, they were asked not to speak so that there were no distractions.

Participants were also given an introduction to the technical capabilities of the simulation manikin in order to familiarize them with the simulation environment. This was done prior to beginning the actual scenarios directly after the half-hour PowerPoint presentation. It was accomplished through a brief hands-on “introduction” to the manikin simulator and a description of the technological capabilities that participants may be faced with in the scenarios. For example, the manikin has the ability to blink, have audible chest sounds, and speak through the simulator operator in the control room. This can be quite disturbing for some participants unless they are forewarned ahead of time. Participants were also assured that while their response was being observed, they were free to make mistakes without judgment and that nothing would be shared outside of the simulation environment. They were also given the opportunity to ask questions at this point.

The roles were pre-assigned and volunteers rotated equally so they experienced the active primary nurse role twice per education session. This allowed for a total of four opportunities to act as the primary nurse during the duration of the education program. In other words, during the first education session each participant acted as the primary nurse two times. They then returned between two and four weeks later for a second education session where they again acted as the primary nurse another two times.

The scenarios were loosely scripted. There was an initial presenting scenario that gave background to the patient’s situation (a stem statement), and then depending on the presenting clinical issue, T.F. set vital signs to follow a progressive pattern of deterioration over ten minutes. If the primary nurse initiated an appropriate nursing action, like giving a saline bolus

for a low blood pressure, T.F. would manipulate the manikin program to raise the blood pressure in response. If the nurse did not initiate an appropriate action, T.F. manipulated the program to deteriorate at a slower rate to allow the participant time to respond.

The first six scenarios were used in each participant's first education session and the second set of scenarios was used in the second education session. The second set of scenarios was slightly more challenging with respect to clinical issue and CRM behavioral response. The reason the second set of scenarios was slightly more challenging was because it was anticipated that once each participant had the opportunity to practice their response in the first education session, the focus of learning shifted to a higher level of CRM behaviors as the program progressed. For example, in scenario one, it was expected that participants might recognize a patient problem, but exhibit multiple fixation errors (i.e., become fixated on one point while ignoring other important details) (Kim et al., 2009). After repeated sessions and debriefs they may have then progressed to anticipating likely events exhibiting a growth in situational awareness skills. The focus in education was not on the patient's primary problem, but with how the learner approached responses to the problem using progressively higher levels of CRM skill.

Data Collection Strategies

At the time of consent, the nurses were asked to complete questions related to demographic information, including age, gender, type of unit, and years of nursing experience (Appendix G). This information has been used to describe the sample. Each simulation was videotaped and stored on a compact disc (CD). Each approximately ten minute video on the CD was logged with reference to date of simulation. These log entries were then coded to blind reviewers to the date of the event and order of sequence. The logbook and code key were kept in a locked drawer in the PI's home. Once the education program was completed, all video entries were analyzed and

evaluated by three independent reviewers. Reviewers consisted of: 1) the PI with experience in creating, instructing, and participating in simulation education activities; 2) a critical care nurse and nurse educator with experience designing, conducting, and participating in simulation education activities; and 3) a member of the PI's thesis committee, who had extensive experience evaluating student performance in the simulation environment.

Nurse participant performance was evaluated using the *Ottawa Crisis Resource Management Global Rating Scale (Ottawa GRS)* and a checklist tool. The Ottawa GRS was developed to measure leadership, problem solving, situation awareness, resource utilization, and communication in medical residents and medical students in generic acute care emergencies. It contains six items and uses a seven-point Likert scale assessing these areas of performance and an overall performance score. Construct validity was evaluated in a pilot study of a high-fidelity simulation course. This was done by establishing content validity through expert panel of physicians experienced in crisis response. Response process, referring to the integrity of the data, was achieved through three raters evaluating a simulation with the Ottawa GRS, and reaching consensus on the scoring system. Reliability was assessed through calculating the intraclass correlation coefficient scores of .590 and .613 for two scenarios, which is considered to be acceptable (Kim et al., 2006). I have found no evidence in the literature that this tool has been tested for use among nursing populations.

Because this tool is not known to have been used on a nursing population, there was a risk that the Ottawa GRS would not be appropriate for use with nursing populations. Therefore, participants were also evaluated using a checklist tool (Appendix A). This tool was created by the PI by combining elements from the Ottawa Global Rating Checklist (Kim et al., 2009), a simulation evaluation instrument found in Todd, Manz, Hawkins, Parsons, and Hercinger (2008),

and another instrument created by Radhakrishnan, Roche, and Cunningham (2007). These instruments were chosen as they had elements of all five CRM skills as well as representative nursing behaviours that could be identified in the videos. The layout of the Ottawa checklist tool was modeled as it was confined to one page and easy for the evaluators to use. The checklist tool contained 14 items in four categories and it was designed to measure observed behaviors and assign a numerical score in order to easily compare performance scores over time. Within each of the equally weighted four categories, behaviours were either marked as being observed or not observed. These behaviours were then assigned a numerical score that was sub-totaled within each category out of eight points. Each category subtotal was then added for a possible total score of 32. Some of the items in the categories could be given partial points if they were seen inconsistently versus consistently. For example, if the participant performed an SBAR communication over the phone but not at handover, they were given partial points. There were also items within the categories that had sub-components that allowed for partial points. For example, if the participant communicated situation, background, and assessment of the SBAR format but did not include a recommendation, they were scored three of four possible points.

This checklist is non-standardized and has not been evaluated for reliability. A panel of three independent CRM experts was contacted to establish content validity prior to using the tool. The first was a respiratory therapist from Alberta with extensive experience creating, participating in, and evaluating simulation education programs. The second was a nurse from Ottawa with experience in curriculum design and nursing education in simulation-based programs. And the third was a nurse researcher from Winnipeg who develops content for and studies nursing students in simulation environments. Based on their feedback, changes were

made to the weight of scoring in the leadership category as well as clarifying specifics related to key behaviours that were observed.

To ensure participants were being scored consistently and to establish interrater reliability, a “pilot evaluation” was done by three independent reviewers. Reviewers scored two sample videos using the Ottawa GRS as well as the checklist tool with instructions and sample evaluations as a guide. Reviewers then met to discuss scores of the sample videos and consensus was achieved where there was a discrepancy.

To answer the second research question regarding perceptions of the contribution of the different roles in simulation scenarios (i.e., primary nurse and observer) to overall learning of CRM skills, semi-structured, individual interviews with nurse participants were carried out by the PI. Semi-structured interviews contain “a preset list of questions that each research subject will be asked” (Streubert & Rinaldi Carpenter, 2011, p. 34), but also allow for some flexibility to pursue areas of interest as they arise in the interviews. An interview guide was developed based on a review of the literature and in part shaped by questions posed by Hober and Bonnel (2014) in their study of the observer role in simulation. Participants were asked questions regarding their experiences and learning opportunities in the various roles, including those occasions where they felt they learned the greatest and least amount about CRM skills (Appendix C). Limited field notes were taken at this time to record non-verbal cues associated with verbal discussion. Interviews were all conducted in person based on participant preference, and were taped and later transcribed verbatim from the recording.

Data Analysis

As noted above, two types of data were collected in this study. Numeric data were obtained with the Ottawa GRS and the checklist and interview data were collected through

individual interviews with the nurse participants. To describe the sample, mean age and years of nursing experience were calculated, and ranges are reported. With the Ottawa GRS tool, a score of one represents the performance of a novice, three represents the performance of a novice with some CRM and resuscitation experience, five represents the performance of an individual managing critical events competently, and seven represents an individual with CRM and resuscitation expertise (Kim et al., 2006). Mean scores were calculated for the sample as a whole at each session and then compared over time (i.e., time 1, 2, 3, and 4). Parametric repeated measures analysis of variance (ANOVA) tests were used to compare means between all four times.

With the checklist tool, each primary nurse was scored on performance of critical elements within each CRM skill. The participants scored points based on performance of these key behaviors, which were then added up at the end of the scenario to yield a total score within each component (CRM skill) and a total overall score. A higher score indicated performance of more critical elements and a higher performance of CRM skills. As with the Ottawa GRS tool, mean scores for the checklist were calculated for each nurse and compared over time (i.e., at times 1, 2, 3, and 4). Parametric repeated measures ANOVA tests were used to compare means between all four times. All results from the numeric data were calculated using SPSS (IBM SPSS statistics, version 23, 2014, Armonk, NY) software.

The data collected through the interviews were analyzed using inductive qualitative content analysis (Elo & Kyngas, 2007; Hsieh & Shannon, 2005). As the first few interview transcripts became available, the PI and her advisor read through the transcripts independently to immerse themselves in the data and get a sense of what was being said by the participants. Phrases or words that stood out were recorded in the margins of the transcripts to begin the

process of identifying codes. Through this process, the initial coding scheme was established. After the first three transcripts were read independently, a meeting between the PI and advisor occurred to discuss general impressions of the transcripts and the codes and words written in the margins of the transcripts. Agreement was reached on a coding scheme, recognizing that new codes could be added as more and more transcripts were read. Once all the transcripts were read, the codes were examined and grouped into categories.

Attention to rigor in this process occurred through: a) ensuring that the transcripts were read through while listening to the recordings to ensure accuracy of transcriptions; b) having both the PI and advisor read the transcripts independently and then compare codes; c) ensuring that the PI and advisor agreed on the coding scheme and categories; d) ensuring that the definitions of the categories were situated in the data and the words of the participants. To promote credibility and to enable readers to assess fittingness or transferability outside of the sample (Sandelowski, 1986), excerpts of the data were used in writing up the findings of the study. An audit trail was also kept to illustrate decisions made about coding and the identification of categories (Sandelowski, 1986).

Ethical Considerations

Attention was paid to the core principles outlined in the Tri-Council Policy Statement regarding the “Ethical Conduct for Research Involving Humans” (Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, & Social Sciences and Humanities Research Council of Canada, 2014). These principles are respect for persons, concern for welfare, and justice. The core principle of respect for persons was applied through obtaining voluntary, informed, and ongoing consent throughout the study. Information about the study was provided to potential participants verbally and on a consent form and opportunities

were provided for them to have their questions answered. All participants were asked to sign a consent form indicating their consent to participate in the study (Appendix I). The PI ensured that participants were aware they had the right to withdraw from the study at any time, or review study requirements at any point.

Participants' right to be respected as an autonomous agent was maintained through open and non-judgmental communication with the researcher and the provision of information necessary to make informed choices. The PI and other study personnel (i.e., the expert instructor) were not in a position of authority or power over volunteer participants, therefore, controlling influences and coercion should not have been factors.

The core principle of concern for welfare was adhered to through protecting privacy of the participants and attending to the duty to ensure confidentiality of information. All volunteers were required to sign a confidentiality pledge (Appendix J) prior to participating in the study. This pledge ensured that participants agreed to not share events and information within the simulation environment outside of the simulation environment.

Consent forms and confidentiality pledges are stored in a locked drawer/cabinet in the home of the PI. Only the PI has access to these forms. Once these forms were signed, each participant was assigned a "letter name" (A, B, C, D, etc...), de-identifying them. The list of these "letter names" and their respective actual identities is kept in a locked drawer in the PI's home. From that point forward, any data reported only referred to participants by their "letter name" (i.e., CDs, Ottawa GRS, checklists, and data collected through interviews).

CDs are stored in a separate locked drawer/cabinet in the PI's home. A log of dates of each scenario and which participant acted in each role was created as videos were recorded. The video was then assigned a random number with the "letter name" of the participant, ensuring the

order of sequence and date were blinded. For example, week one of the education program nurse A played the role of the primary nurse during the first scenario. The log indicated the date and time of the event and the “letter name” of the participant. The video indicated randomized number and nurse A. While each participant was assigned a letter, it is possible that during scenarios their name may have been used by other participants. However, any data obtained from the videos referred to participants by their “letter name” de-identifying participants, thus preserving privacy.

Once the education program was completed, copies of randomized videos were then distributed to the expert reviewers for analysis. Each of the three reviewers required a copy of each simulation episode, which was then returned to the PI once analysis of the scenarios was completed.

Data obtained through analysis of the scenarios included copies of Ottawa GRS tools and checklists. Once expert reviewers assigned participants their scores, hard copies of these two tools were returned to the PI. This information was then entered into a database on the PI’s password-protected computer. Only the PI is in possession of the password to this computer. Results were reported as scores assigned to the group as a whole over time.

One-on-one audio-taped interviews were conducted once the education program was completed. These interviews were done in person, as was the preference of the nurse participants. Original audio files were stored on the PI’s password-protected recording device and only accessible to the PI. Transcription of the interviews took place as soon as possible following interviews and the transcripts were stored on the PI’s password-protected personal computer. Copies of the transcripts were made for the PI’s thesis advisor and were kept on her password-protected computer in her office. Once transcription of the audio files was completed,

they were erased. Results reported from interviews included categories as noted through content analysis. Any direct quotes from participants were de-identified as described above.

It was remotely possible that a participant may have found some aspect of the simulation exercise physically taxing or emotionally distressing. Had this occurred, and to ensure attention to participant welfare, the participant would have been given the opportunity to stop the scenario. The PI and/or the other expert instructor were then prepared to approach the participant in a non-threatening manner and offer a personal or group debriefing. If this was not acceptable to the participant, the PI was prepared to offer the participant the opportunity to meet individually at a later date to debrief, if desired, and would have provided the participant with contact information for the Employee Assistance Program (EAP) should they have wanted to talk to a neutral party. The participant would also have been offered the opportunity to withdraw from the study. This did not occur.

The core principle of justice was maintained through fair and equitable treatment of study participants. This was done by equal distribution of roles during simulation scenarios and through respectful interactions and treatment. It was recognized that participants could have felt intimidated or vulnerable during simulation scenarios or debriefing sessions. During the initial consent process, the PI addressed this possibility and encouraged participants to approach the PI with concerns. There were no concerns brought forward, however, one participant did not return after the first education session. This participant did not disclose reasons for withdrawing from the study.

In summary, this study was a repeated-measures observational design. Participants were evaluated at four different time points to measure the effect of an educational program on their performance of CRM skills. Participants were also questioned about how they felt acting in the

role of the primary nurse and as an observer affected their overall learning of CRM skills.

Quantitative data were collected by evaluating participant videos of their response to deteriorating patients using the Ottawa GRS tool as well as a checklist tool. Qualitative data were collected through semi-structured interviews and analyzed using content analysis. In the next chapter, study results are discussed.

Chapter 4: Results

The purpose of this thesis was to study the effects of a high-fidelity simulation-based education program on nurses' performance of crisis resource management (CRM) skills. The goal of this research was to investigate whether teaching CRM cognitive skills to nurses is translated into changed behavior in a simulated setting. In this chapter, the results of the study are presented.

Description of the Sample

Approximately 400 nurses from the medicine and surgery programs received an email invitation (Appendix D) to participate in this thesis project. A poster was also posted in each medical and surgical unit in the facility where recruitment took place (Appendix E). Recruiting 12 nurses proved to be quite difficult and some changes to recruitment were made. The initial intent for the project was to only recruit nurses from general medicine and surgery units who had not had additional specialty nursing training beyond their undergraduate programs (example.g., a critical care education course or advanced monitoring course). I was only able to recruit four individuals prior to the first scheduled education day and two of these individuals did not come to this session, making the sample two nurses. As described above, it was decided to open recruitment to individuals with ECG training. Following this change, no additional participants were recruited; therefore, it was decided to open recruitment to include nurses with critical care training. Approximately 50 critical care nurses were invited to participate.

Another change that was made to facilitate recruitment and retention of the sample was to decrease the number of required education sessions for participants from four days to two days, keeping the group sizes small (i.e., less than or equal to four participants), so that each participant could play the role of the primary nurse twice per education session. The original plan

was to have each participant attend four education days, participating as the primary nurse once per session. The change was made in consultation with the participants that had already been recruited, who agreed that the time commitment of four education days was difficult to fit into their schedules. They felt it would be more convenient to attend two of the four days but act the role of primary nurse the same number of times (i.e., four times over two days versus four times over four days).

There were no cohorts and the convenience sample was comprised of a total of fifteen participants who volunteered to take part in the study. Three participants were eliminated due to conflicts with schedules and/or non-attendance. One participant withdrew from the study and did not provide any information as to why. This resulted in a final sample size of 11. The age range for participants was 26 to 53 years of age, with a mean of 38 years of age. The number of females that participated in the study was nine (81.8%), while the number of males that participated in the study was two (18.2%). The range of nursing experience was 3 to 35 years, with a mean of 14.31 years.

Three programs were represented in this sample. Of the eleven participants, four were from the surgery program and two from the medicine program. This represented 36.4% of the sample. Seven of the nurses worked in the critical care program in a mixture of medical, surgical, and intermediate intensive care units. This represented 63.6% of the sample.

Scores on Instruments

The total number of simulation days was four, with a total of 44 simulation scenarios completed. The number of nurses present at each session ranged from two to four individuals and each participant acted as the primary nurse four times. In total, there were 42 videos available for review. Two videos did not record, thus two participants had three videos instead of four. In

order to mitigate the possibility of bias, all three evaluators separately scored two sample videos prior to evaluating the participant videos and then met to reach a consensus where there was disagreement between scores. Videos were also blinded to date and order of sequence.

Reliability analysis was fair with a Chronbach's alpha value of .565.

Ottawa Global Rating Scale. The maximum possible score achievable using this scale is 42. The scores for individual participants in this study ranged from 17 to 37, with higher scores representing higher-level performance of CRM skills. Table 5 summarizes the mean results for the sample of the Ottawa GRS scores by time.

Table 5

Ottawa GRS Mean Scores for Sample

Estimates				
Measure: Test				
time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	26.078	1.139	23.451	28.704
2	28.589	1.233	25.745	31.433
3	26.567	1.454	23.215	29.919
4	29.733	1.099	27.200	32.267

These means were then plotted graphically with mean scores displayed on the Y axis and time or test number (testnum) along the X axis.

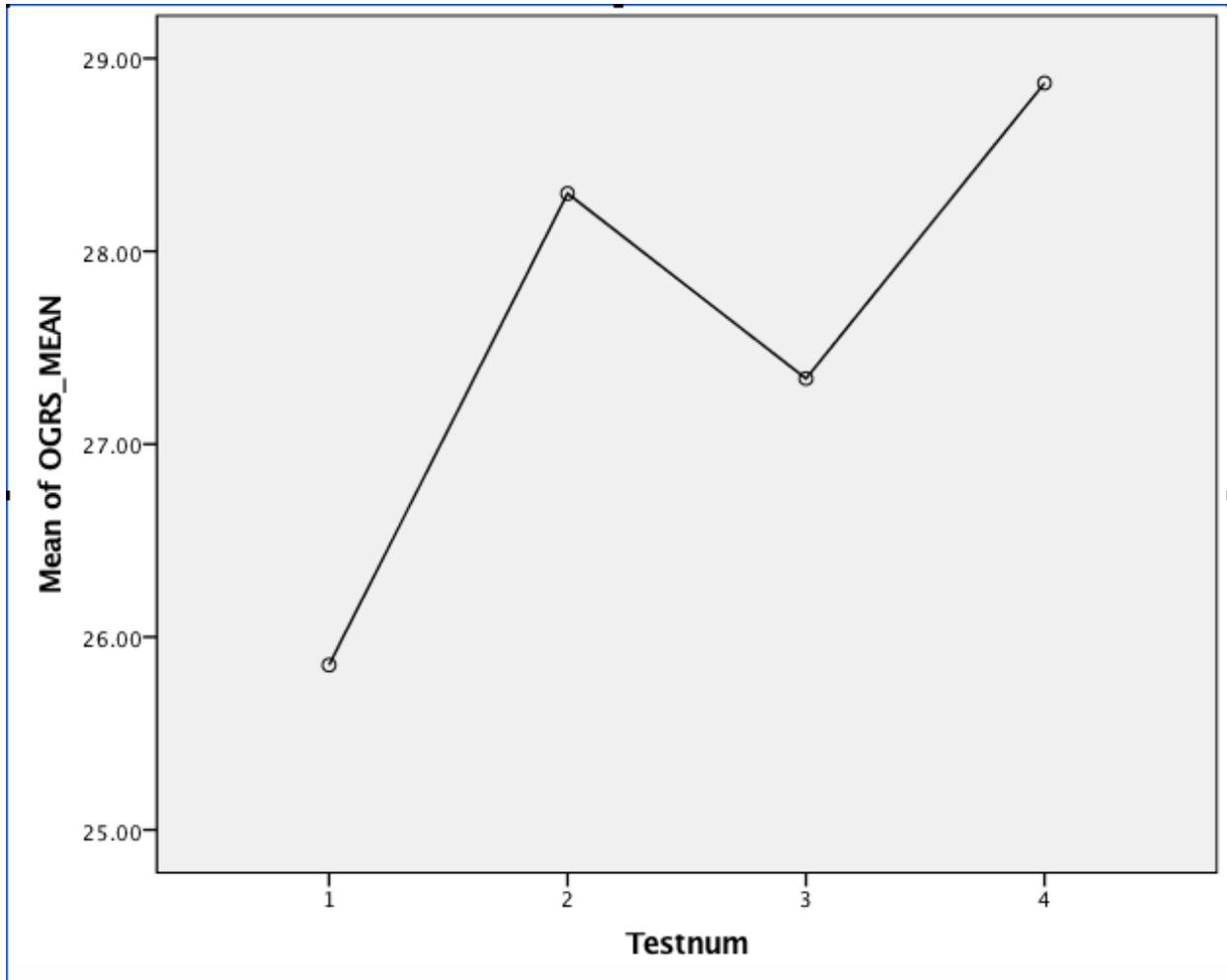


Figure 1. Graph representing change in mean scores of the Ottawa GRS over time

Outliers. Boxplots were generated to assess for outliers at all four data collection points. There were outliers present at the third time point, however, because of the small sample size and after consultation with a statistician, it was decided to include these values in the analysis. It was felt that to remove outliers would further decrease the sample size and would further contribute to the possibility of a type I error.

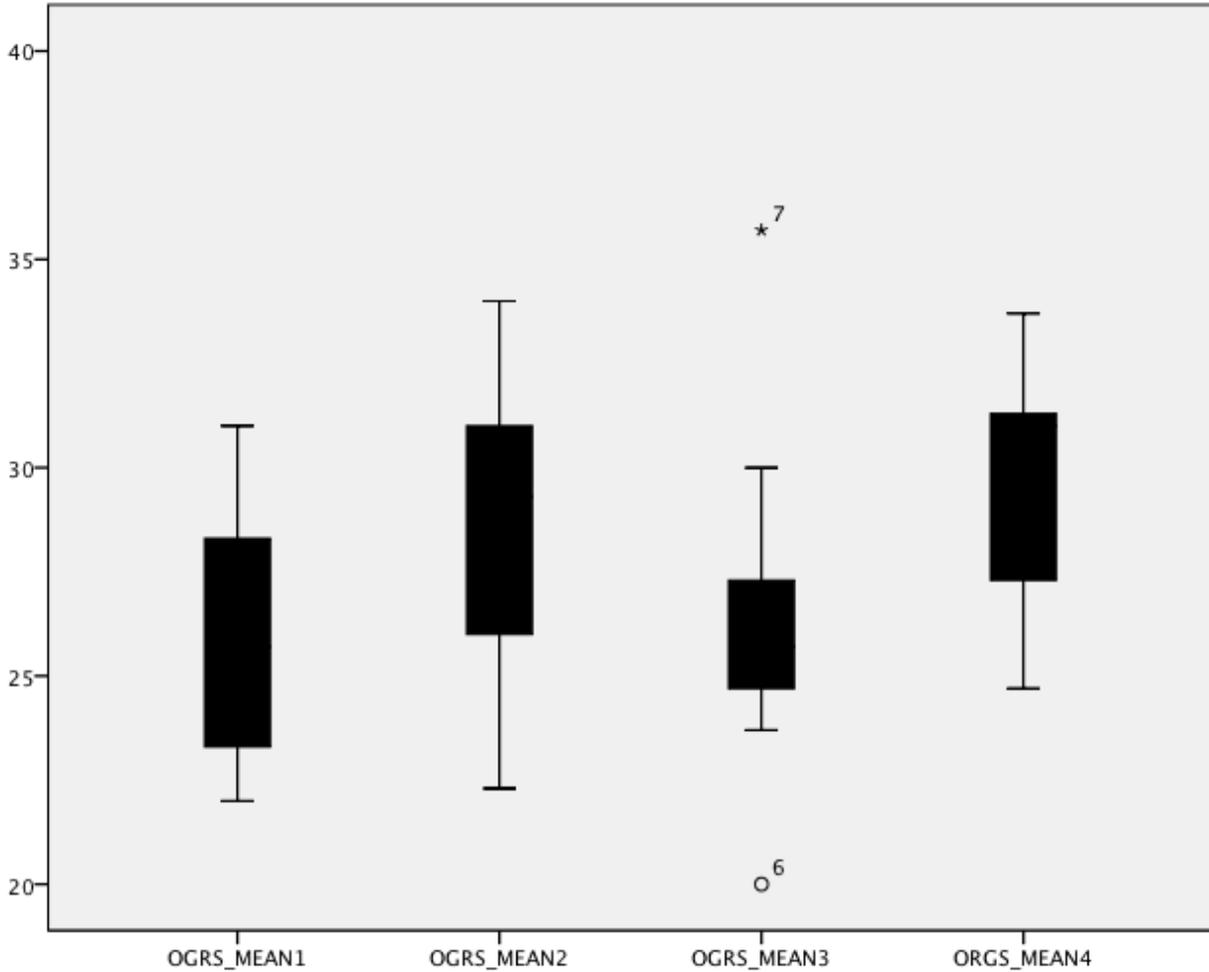


Figure 2. Ottawa GRS boxplot representing presence of outliers

Ottawa GRS analysis of normality. The Ottawa GRS was analyzed for normality and found to be normally distributed at each of the four time points. This was assessed by the Shapiro-Wilk test ($p > .05$), with p-values of .252, .932, .427, and .186 respectively. This indicates that participants scored similarly to the expected normal distribution, even with the presence of outliers at the third time point (Laerd Statistics, 2015).

Table 6

Ottawa GRS Tests of Normality

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
OGRS_MEAN1	.201	9	.200 [*]	.900	9	.252
OGRS_MEAN2	.140	9	.200 [*]	.975	9	.932
OGRS_MEAN3	.211	9	.200 [*]	.924	9	.427
ORGS_MEAN4	.235	9	.164	.887	9	.186

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Ottawa GRS assumption of sphericity. The Mauchly's test of Sphericity tests the null hypothesis that the variances of the differences within the four time points are equal. The Ottawa GRS Mauchly test of Sphericity was not significant ($p > .05$), indicating that the null hypothesis is not rejected, as there is not enough evidence to suggest that the variances in the differences in scores are not equal (i.e., the assumption of sphericity has not been violated with a p-value of .250). This means that the one-way repeated measures analysis of variance (ANOVA) described below will not be biased toward statistical significance (Laerd Statistics, 2015).

Table 7

Ottawa GRS Mauchly's Test of Sphericity

Mauchly's Test of Sphericity ^a							
Measure: Test							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Epsilon ^b Huynh-Feldt	Lower-bound
time	.370	6.681	5	.250	.619	.798	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Ottawa GRS analysis of variance. Based on the assumed sphericity and a p-value of .016 (see Table 8), it can be concluded that there is a statistically significant different mean at least at one unknown time point compared to another time point (Laerd Statistics, 2015).

Table 8

Ottawa GRS Tests Within-Subjects Effects

Tests of Within-Subjects Effects							
Measure: Test							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
time	Sphericity Assumed	79.503	3	26.501	4.226	.016	.346
	Greenhouse-Geisser	79.503	1.857	42.815	4.226	.038	.346
	Huynh-Feldt	79.503	2.395	33.197	4.226	.025	.346
	Lower-bound	79.503	1.000	79.503	4.226	.074	.346
Error(time)	Sphericity Assumed	150.504	24	6.271			
	Greenhouse-Geisser	150.504	14.855	10.131			
	Huynh-Feldt	150.504	19.159	7.855			
	Lower-bound	150.504	8.000	18.813			

The Bonferroni post-hoc test was conducted to test all possible pairwise combinations between means at all four time points. This revealed a statistically significant difference in means scores from time one to time two ($p = .041$), but not between any other time points (see Table 9).

Table 9

Pairwise Comparisons for Ottawa GRS

Pairwise Comparisons

Measure: Test

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	-2.511 [*]	.695	.041	-4.929	-.093
	3	-.489	.932	1.000	-3.731	2.754
	4	-3.656	1.277	.127	-8.100	.789
2	1	2.511 [*]	.695	.041	.093	4.929
	3	2.022	.841	.257	-.902	4.947
	4	-1.144	1.518	1.000	-6.427	4.138
3	1	.489	.932	1.000	-2.754	3.731
	2	-2.022	.841	.257	-4.947	.902
	4	-3.167	1.538	.441	-8.517	2.184
4	1	3.656	1.277	.127	-.789	8.100
	2	1.144	1.518	1.000	-4.138	6.427
	3	3.167	1.538	.441	-2.184	8.517

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Checklist tool. The maximum possible score on the checklist tool was 32, with individual participants’ scores ranging from 10 to 32. Higher scores represented higher-level performance of CRM skills. **Table** 10 summarizes the sample mean results for the checklist tool over time.

Table 10

Checklist Tool Means

Estimates				
Measure: Test				
time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	22.156	1.226	19.329	24.982
2	25.456	1.144	22.817	28.094
3	22.889	1.132	20.279	25.499
4	25.333	.972	23.092	27.575

As with the Ottawa GRS tool, means for the checklist tool were then plotted graphically with mean scores displayed on the Y axis and time or test number (testnum) along the X axis.

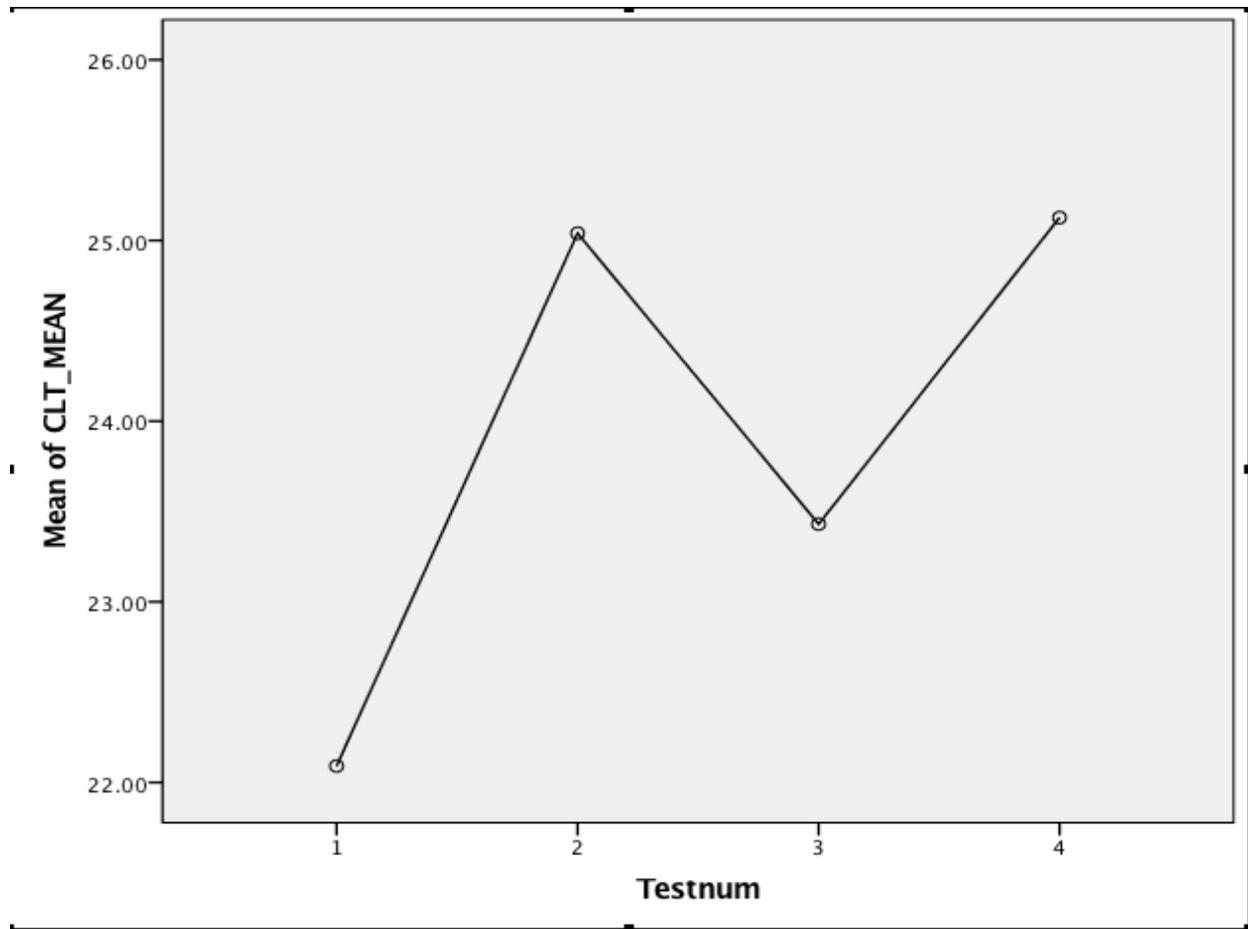


Figure 3. Graph representing change in mean scores of the checklist tool over time

Checklist tool presence of outliers. Boxplots were generated to assess for outliers at all four data collection points. There were outliers present at the second and third time point, however, because of the small sample size and based on discussion with a statistician, it was decided to include these values in the analysis. It was felt that to remove outliers would decrease the sample size and would further contribute to the possibility of a type I error.

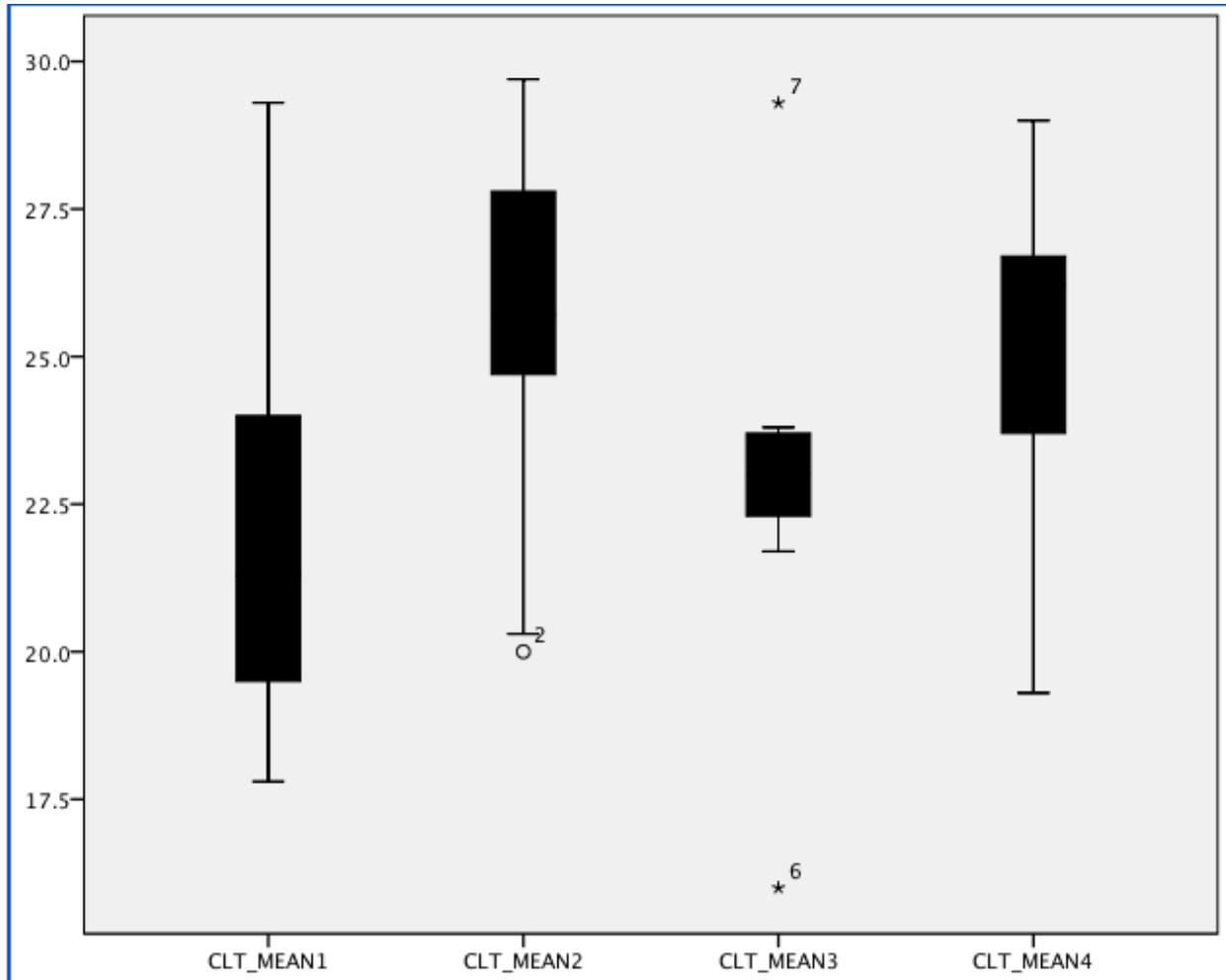


Figure 4. Checklist tool boxplot representing presence of outliers

Checklist tool analysis of normality. The checklist tool was analyzed for normality and found to be normally distributed at each of the four time points. This was assessed by the Shapiro-Wilk test ($p > .05$), with p-values of .491, .310, .078, and .351 respectively. This indicates that participants scored similarly to the expected normal distribution, even with the presence of outliers at the second and third time points (Laerd Statistics, 2015).

Table 11

Checklist Tool Tests of Normality

Tests of Normality						
	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CLT_MEAN1	.205	9	.200*	.931	9	.491
CLT_MEAN2	.191	9	.200*	.909	9	.310
CLT_MEAN3	.283	9	.036	.852	9	.078
CLT_MEAN4	.257	9	.088	.915	9	.351

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Checklist tool assumption of sphericity. The Mauchly's test of Sphericity tests the null hypothesis that the variances of the differences within the four time points are equal. The checklist tool Mauchly's test of Sphericity was not significant ($p > .05$), indicating that the null hypothesis is not rejected, as there is not enough evidence to suggest that the variances in the differences in scores are not equal (i.e., assumption of sphericity has not been violated with a p-value of .319). This means that the one-way repeated measures analysis of variance (ANOVA) described below will not be biased toward statistical significance (Laerd Statistics, 2015).

Table 12

Checklist Tool Mauchly's Test of Sphericity

Mauchly's Test of Sphericity ^a							
Measure: Test							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Epsilon ^b Huynh-Feldt	Lower-bound
time	.415	5.912	5	.319	.668	.892	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Checklist tool analysis of variance. Based on the assumed sphericity and a significance p-value of .007 (see Table 13), it can be concluded that there is a statistically significant different mean at least at one time point compared to another time point (Laerd Statistics, 2015).

Table 13

Checklist Tool Within-Subjects Effects

Tests of Within-Subjects Effects							
Measure: Test							
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
time	Sphericity Assumed	76.734	3	25.578	5.089	.007	.389
	Greenhouse-Geisser	76.734	2.005	38.265	5.089	.019	.389
	Huynh-Feldt	76.734	2.677	28.663	5.089	.010	.389
	Lower-bound	76.734	1.000	76.734	5.089	.054	.389
Error(time)	Sphericity Assumed	120.638	24	5.027			
	Greenhouse-Geisser	120.638	16.043	7.520			
	Huynh-Feldt	120.638	21.417	5.633			
	Lower-bound	120.638	8.000	15.080			

The Bonferroni post-hoc test was conducted to test all possible pairwise combinations between means at all four time points. This revealed a statistically significant difference in means scores from time one to time two ($p = .045$), but not between any other time points (see Table 14).

Table 14

Pairwise Comparisons for the Checklist Tool

Pairwise Comparisons						
Measure: Test						
(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
1	2	-3.300 [*]	.928	.045	-6.527	-.073
	3	-.733	.794	1.000	-3.497	2.030
	4	-3.178	1.422	.335	-8.123	1.768
2	1	3.300 [*]	.928	.045	.073	6.527
	3	2.567	.842	.095	-.363	5.496
	4	.122	1.272	1.000	-4.304	4.549
3	1	.733	.794	1.000	-2.030	3.497
	2	-2.567	.842	.095	-5.496	.363
	4	-2.444	.928	.180	-5.673	.784
4	1	3.178	1.422	.335	-1.768	8.123
	2	-.122	1.272	1.000	-4.549	4.304
	3	2.444	.928	.180	-.784	5.673

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Summary of Quantitative Results

Results from both tools showed similar patterns where mean scores increased from time one to time two, decreased from time two to time three, and then increased above the time two mean at time four. This showed a similar graphical pattern as well. Analysis of means showed there is a statistically significant difference in participant performance between times one and two using both tools. There are no other statistically significant differences between other time points despite evidence of increased calculated mean scores over time. Findings are discussed in the next chapter.

Semi-Structured Interviews

All eleven participants agreed to be interviewed to discuss their participation in the roles of primary nurse and observer. Interviews were conducted in a private place so that distractions could be minimized and to encourage participants to answer questions openly. All participants opted to be interviewed at the site of recruitment, either in the PI's office, or in a quiet area in their patient care unit. The interviews ranged from approximately 5 to 11 minutes in length. As outlined in the methods chapter, transcripts were reviewed, codes identified by me and my adviser, and then codes were collapsed into categories and sub-categories through discussion and consensus. Table 15 provides an example of category identification from codes.

Table 15

Example of Category Identification

Codes	Sub-categories	Category
Anxious Overwhelmed Intimidated	Negative feelings	Feelings evoked by the simulation experience
Challenged Confident	Positive feelings	

Through the analysis process, four categories were identified: learning from the primary nurse role; learning from the observer role; feelings evoked by the simulation experience; and strengths and limitations of the simulation experience. Each of the categories will be discussed and a summary of the findings are presented in Table 16.

Learning from the Primary Nurse Role. Many of the participants described feeling anxious or feeling like they were under pressure as the primary nurse. As one nurse stated, “I think you’re sort of under more pressure when you are primary...” (Participant B). But they also

viewed this role as important for their learning in terms of: 1) learning by “doing”; and 2) learning from feedback. One nurse described it as follows:

I think you always learn better doing... you doing it, in that situation. It may not feel like you are learning, but you're learning better by doing it. And the more you do it, the more you learn, and the more comfortable you get. (Participant E)

In the “doing”, participants indicated that they were required to think and problem solve in real time, as described by this nurse:

It [the primary nurse role] helped because I had to think, analyze, look at the situation, classify what was going on, what would be the appropriate response to the situation at the time, and then delegate. So, I had to do and think at the same time and to allocate resources, delegate, and pretty much problem solve. It was just a process of problem solving as the problem was unfolding. (Participant N)

The fact that they were participating in multiple scenarios per session and over time was also recognized as an important contributor to their learning, as their confidence grew with each scenario. One nurse described her first experience as feeling like “a big gong show”, but by the fifth experience she “felt a lot more confident in going through the process” (Participant J).

The other aspect of the primary nurse role that participants felt was important for their learning was the feedback they received, both from the physician and other participants. One nurse commented:

I think [the physician] gave excellent feedback and, you know, sort of helped you to maybe just think about things that – different ways of doing it, or things you could have tried differently in terms of how you went through things. I thought it was helpful. I think it was more helpful to get that feedback and be like, okay, you know, because in real life,

nobody comes after and says, 'Oh, you know, you were really great that you did this, this, and this. But what about this?' So you always tend to sort of, when you're rethinking situations in real life, and reflecting on them, you know, sometimes you kind of wish you had that feedback. (Participant J)

Another nurse talked about the importance of feedback from the group:

I thought a lot of people did a really good job. And, so, then just going over it again and reinforcing it and just getting a little bit more input from everybody as a group was good. (Participant L)

When asked about the aspect of the simulation experience that caused them to learn the most, the one common response was receiving feedback during debrief sessions from the physician. Participants appreciated not only positive feedback, but constructive criticism and understanding what they did wrong, with suggestions on what to do better in scenarios that followed. They commented on the lack of feedback in “real-life” and how it contributed to poor communication between different professionals. They felt that the opportunity to learn in the simulation environment facilitated their ability to learn better teamwork.

Overall, the participants indicated that fulfilling the role of the primary nurse was effective in allowing them to practice CRM skills reviewed prior to the education program. There was an interesting sense that participants identified being physically present in the scenario as the primary nurse, which contrasted to comments about the observer role discussed below.

Learning from the Observer Role. Participants were visibly relaxed when commenting on the observer role in the interviews, some even physically sitting back in their chair when providing responses. Three sub-categories in relation to this role were identified: 1) learning without pressure; 2) learning from others' mistakes; and 3) learning from different approaches.

Learning without pressure. Participants tended to compare and contrast their experiences as primary nurse and observer. One notable comparison was the element of being present in the scenario. One nurse described the observer role as making her feel “somehow detached from the situation, because it’s not me dealing with the problem” (Participant N). While describing another participant getting off track while playing the role of primary nurse, participant C stated “it was nice to sit back and to sit to the side and watch what happened and realize it’s very easy to get off track and how you have to bring yourself back”. Another nurse commented on how the lack of pressure in the observer role contributed to her learning, stating:

So, you’re not under pressure, the element of pressure is lifted, so you’re able to look from above and see the complete picture and I think in a more objective way. Like, you’re thinking objectively because you’re not in that situation, but you’re looking, it’s like something unfolding in front of you and you’re able to pick and see what could be done better basically. (Participant N).

Learning from different approaches. The sense of detachment or passive participation through observation was coupled with expressions of feeling they had learned from other participants. Many participants reflected on how they were also passively participating in the observed scenarios, essentially performing their own response internally while comparing themselves to the participant playing the primary nurse role. Participant O stated: “I was thinking about what I should do, too, at the same time when they’re doing it”. Another nurse commented:

So, you’re sitting there and you think, okay, this what I’m going to do. But then to see how someone else processes the situation and then what they think to do is really helpful. Because sometimes people said things that I would not think of, I just would not have thought of them. And they do things in a systematic way that I wouldn’t have necessarily

done, and it's not right or wrong, it's just like, oh, yeah, could do that too. (Participant G)

Learning from others' mistakes. Participants described how the observer role also enabled them to learn from others' mistakes. As Participant C identified, "it's easy to see some things that they had missed just because of stress". Participant M stated: "you learn from their mistakes, as they also learn from yours." This participant was hesitant to use the word "mistake", indicating "maybe mistakes isn't the right word", but clearly the opportunity to see others assume the primary nurse role provided participants with the opportunity to reflect on "what could be done better" (Participant N).

Feelings Evoked by the Simulation Experience. Participation in the simulation experience, both as primary nurse and observer, evoked a variety of feelings for the nurses involved. Some of these feelings could be described as positive, including feeling challenged in a positive way to perform and learn and feeling confident as their knowledge and abilities improved over time. Some of the feelings could be considered negative, including feeling nervous, anxious, overwhelmed, or intimidated. As one nurse stated:

Going up in front of people and having to perform – and it's the anxiety. Like what if I don't know what to do?... I have been a nurse for [a number] of years.... And so you are in front of nurses who expect you to know, and you are like, if I don't know anything, I am going to look like... (Participant E)

Most participants described feeling more comfortable with the experience over time.

Strengths and Limitations of the Simulation Experience. After the first few interviews were conducted, it was evident that participants wanted an opportunity to talk about their experiences and impressions about the program. As a result, a question was added to enable

participants to give feedback on how valuable they felt the program was. Overall the feedback was positive. They appreciated the opportunity to practice in the simulation environment prior to being in real-life crisis situations. There was also satisfaction with the mixture of nurses from different work areas and learning from people that they would not ordinarily have interacted with in a work setting. Participants enjoyed learning from the physician who provided feedback (T.F.), and felt his input enriched their experience. Nurses felt it would be a beneficial exercise for any level of nurse, in any setting, particularly for nurses who respond to codes. Participant C, who very honestly admitted to not enjoying the primary nurse role, stated she would “definitely do it again”, as she recognized the importance and effectiveness of playing that role.

The limitations identified by participants included having to sit around and wait to set up between scenarios and issues related to fidelity or having to act artificially compared to a normal environment. One participant indicated that a limitation could be scenarios that were familiar to nurses, where they believed they understood the pathophysiology of the “patient’s” presenting problem. This same participant then identified that the purpose of the learning was to build on the CRM skills stating, “I knew what to do. But, I guess that was not the point of the scenario. I was sort of to build on crisis resource management and thinking in an organized way to resolve an issue”.

Table 16

Summary of Findings from the Interviews

Category	Sub-categories and Participants' Responses
Learning in the Primary Nurse Role	<p>Learning by Doing So very different to be doing, being on the spot, explaining it, delegating tasks, problem-solving Have the sense of urgency ... <i>I need to fix this</i></p> <p>Learning from Feedback Identification of strengths and weaknesses Ask for opinions</p>
Learning in the Observer Role	<p>Learning without Pressure Detached, objective, pressure is lifted</p> <p>Learning from Others' Mistakes See and learn from mistakes, what person missed Think about what you would do differently</p> <p>Learning from Different Approaches Helpful to see how others think, do things</p>
Feelings Evoked by the Simulation Experience	<p>Positive Feelings Challenged, confident</p> <p>Negative feelings Nervous, anxious, overwhelmed, intimidated</p>
Strengths and Limitations of the Simulation Experience	<p>Strengths Practice prior to real-life experience Learning from nurses from other units Learning from the physician</p> <p>Limitations Waiting for set up of scenarios Fidelity – having to act artificially</p>

Summary of Qualitative Results

Based on the analysis of eleven one-on-one semi-structured interviews, participants appreciated the active learning by playing the role of the primary nurse and also learning passively through observation of others playing the role of primary nurse. Participants found being the primary nurse to be stressful, but essential to learning crisis response. Overall it was

felt that learning through observation was more relaxing and detached but not as effective as active responses to the scenarios.

The feedback that was given during the debrief sessions was most often mentioned as the opportunity for the greatest amount of learning. Other activities that were mentioned as contributing to learning included repetition and the chance to practice skills, as well as the opportunity to learn from other people in the group. Participants were not able to offer specific occasions where they felt they learned the least amount, but did mention the fidelity of the environment may have been a barrier to learning at times. Overall impressions of the program were positive and participants enjoyed the opportunity to offer feedback about their experiences.

Chapter 5: Discussion

In this chapter, the results of the study are discussed in the context of the existing literature in this area. The implications for practice, education, and research are identified, limitations of the study outlined, and conclusions to the study provided.

Comparison of Results to Existing Literature

The purpose of this study was to evaluate the effects of a high-fidelity simulation education program on nurses' performance of crisis resource management skills over time. Because there were no standard formats for the delivery of CRM principles, development of the education program was required. The education program was designed to give participants a brief introduction to the CRM concepts of problem solving, situation awareness, resource utilization, communication, and leadership. While these concepts are not unfamiliar to nurses at all levels of experience, explaining them using the CRM framework was new. Performance of the CRM skills was evaluated through quantitative measures using the Ottawa GRS and a checklist tool. Qualitative interviews were designed to yield information on degree of learning in the active responder role as well as in the passive observer role.

This was a very small study with only eleven participants. It could be argued that the statistically significant result between time one and time two is not meaningful because of the small sample. Therefore the discussion of quantitative findings that follows relates to raw mean scores only. While these score were not statistically significant, they did show improvements overall, meaning that calculated mean scores increased from time one to time four. It can be argued that while there was a lack of statistically significant improvements over time, there was an observed clinical significance where participants' mean scores improved overall.

The raw mean scores of both tools at the four time points showed an interesting pattern. The scores for the entire sample increased from time one to time two, declined from time two to time three, and increased from time three to time four. The mean score at time four was the highest of the four time points (see Figure 5 below).

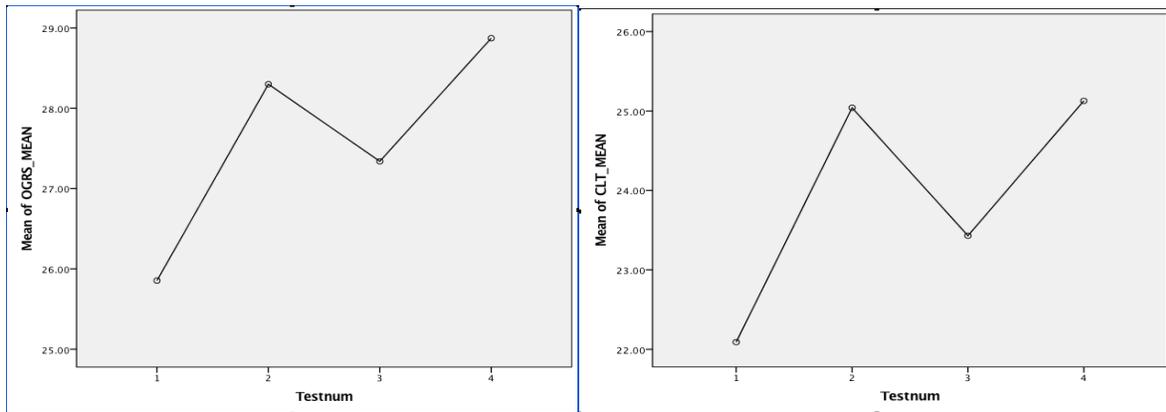


Figure 5. Ottawa GRS and checklist tool graphical displays of mean scores

These scores are interesting because not only do they demonstrate a trend that indicates improvement over time, but they also demonstrate a decline at the time two to time three points. As described in the methods chapter above, participants attended two education sessions where they acted as the primary nurse a total of four times. During the first education session, they acted as the primary nurse twice in one day. These are the scores at time one and time two that showed statistically significant increases. The second education session took place between two and four weeks later, when the participants returned and acted as primary nurse another two times in the same day.

The decline in scores between time two and three with subsequent improvement at time four could be explained by a number of reasons. The first reason relates to the two- to four-week gap between the first and second education session. It is possible that this extended period away from the simulation environment and reinforcement of CRM skills allowed for a deterioration in

knowledge. This conclusion is in contrast to the Gilfoyle et al. (2007) study where pediatric residents showed mixed results where there was no learning that occurred during a maintenance period, but no deterioration of learning occurred. This study used the same scenario at both education sessions. Yee et al. (2005) showed improvement in Ottawa GRS scores from the first to second scenarios and a decline in the third and lowest scored scenario. Yee et al. posit that there is no added benefit to participating in more than two scenarios. This statement difficult to accept since anecdotally there are observed benefits to participating in regular continuing education focused on crisis response. It is also possible that using the same scenario as in the Gilfoyle et al. (2007) study, participants memorized the scenario and thus the response. This use of the same scenario was also listed as a limitation in Bultas et al. (2014) and Liaw et al. (2011). Therefore, it is possible that using the same scenario versus a different scenario may contribute to overall results.

In the current study, the scenarios were designed so that each simulated patient had a different clinical presentation, but the approach to the assessment and the response was consistent. This was meant as a strategy to prevent memorizing the same patient scenario while also allowing for familiarity with response behaviours. In a qualitative study comparing observers and active participants in an HFS program, participants identified the importance of training several times to build confidence (Reime et al., 2017). In the current study there was continued improvement in mean scores beyond the second scenario (i.e., at time four). It can be argued that repetition beyond the second scenario contributed to overall improvement in scores. Gillman et al. (2016) showed no improvement as groups progressed through their first and second scenarios, but then showed statistically significant improvements between their first and third, second and third, and second and fourth scenarios. They argue that based on their results,

the first two scenarios are needed to develop rapport among participants, which then allows them to integrate CRM skills by the third and fourth scenarios.

In the current study, participants had different group members in both education sessions they attended. A second reason for the pattern exhibited in mean scores in this study could be that, as with Gillman et al. study (2016), participants regressed at time three because they needed to build this rapport with a new group before they were able to focus on applying CRM skills in the fourth, and highest scored, scenario. During one-on-one interviews, participants were asked how they felt about the other nurses in their group. Most participants were very positive about the mixture of clinical expertise that was present within the group members. However, some general ward nurses also expressed having initial reservations about the mix, especially when informed that some participants were from higher acuity areas like critical care. Conversely, some critical care nurses felt pressure to perform at a higher level because of their perceptions of the expectations from their acute care colleagues. Participants reported these initial reservations were unfounded, as the level of support for whomever was acting as primary nurse amongst all participants was evident in debriefing sessions. As with the Bonnel and Hober (2016) study, participants identified the value of peer debriefing, and emphasized the importance of encouragement and guidance in this process.

A third reason for the decline may be related to a lack of relevance to the clinical environments that participants worked in. As mentioned previously, crisis events are rare enough that nurses are not able to practice their responses in clinical environments. It is possible that these participants did not have the opportunity to use skills learned in the simulation environment because they did not have a patient deteriorate between their first and second education sessions. In other words, they were not able to apply CRM skills learned in the simulation environment to

real-life situations, thus knowledge was not reinforced during this time. As with the Morgan et al. study (2011), education sessions may have been too widely spaced in time to affect long-term retention of CRM concepts. The length of time between the sessions in the Morgan et al. (2011) study was much longer than the current study at five to nine months, versus only two to four weeks.

If participants did have the opportunity to respond to a crisis scenario in their work environments, it is possible that other team members did not use CRM principles in their management approach. This is problematic because, as was demonstrated with the aviation industry adoption of crew resource management, using consistent and common or familiar interactions is essential to the success of day-to-day functions within an effective team (Gordon et al., 2013). While CRM theory is beginning to emerge as a guiding philosophy in some disciplines, it is not pervasive in all areas where this study's recruitment occurred. Again, they may not have been able to apply in their work environments new skills learned and new knowledge may not have been reinforced.

A fourth reason to explain the overall improvement of scores over the four scenarios could be as a result of the cumulative effects of learning through observation and active participation. In one-on-one interviews, participants were asked how much they felt that participating in the primary nurse role and the observer role contributed to their overall learning of CRM skills. Most participants reported learning through both roles. They reported the more stressful primary nurse role was important because it allowed them to practice first hand, and "hands on", their approach to a deteriorating patient. They also reported that observing others' approach was valuable as it allowed them to mentally practice their own approach while not under the same pressure as performing in front of the group. Participants acted as the primary

nurse a total of four times. They were, however, able to observe up to eight other responses (depending on the group size) per session. This allowed for greater exposure and reinforcement of skills over time. In other words, learning through observation may have contributed to the overall improvement in scores over the length of the program.

These results are in line with emerging evidence that suggests that learning obtained while in the role of the observer is also valuable in simulation education (Bloch & Bloch, 2015). In a study carried out by Reime et al. (2017), one major theme that emerged was that “participating in different roles is important” (p. 55). Participants in this study also reported valuable learning outcomes occurred while watching others but that greater learning occurred from participation in scenarios. One theme identified by Bonnel and Hober (2016), “using the reflective observer role for self-assessment” (p. 354), mirrors the current study qualitative sub-categories of “learning from others’ mistakes and learning from different approaches” described in the results chapter. It appears that the practice of reflection is also a form of active learning that allows students to identify personal strengths and weaknesses in relation to other participants. This identification in turn allows them to set goals for improvement as they progress through the education program.

Zulkosky, White, Price, and Pretz (2016) measured the accuracy of clinical decision making among various active and passive roles in a pre-licensure nursing student simulation education program. They found that observers had the opportunity to discuss and share knowledge as they watched the scenario and this may have contributed to greater accuracy in measured outcomes. Acting as the observer was not as stressful as acting as a primary responder, “which may increase available cognitive resources and enhance the ability to perform analytical processes” (p. 99). As was noted by the participants in the current study, observers were removed

from the direct experience, which was not reflective of real life. As observers in the same room as the primary nurse responding to the scenario, they did not have the opportunity to discuss what unfolding in front of them. While they were engaged in the debrief discussions that followed, the lack of opportunity for “in the moment” discussion may have lessened the impact of the cumulative learning through observation. As with Zulosky et al. (2016), it can be concluded that there is benefit to rotating participants through active and passive roles but maximizing engagement as an observer may have added to the significance of the results.

The feelings that were evoked as the primary nurse versus the observer nurse may also explain the lack of statistically significant results. In the current study, participants reported higher degrees of stress or anxiety when acting as the primary nurse versus when they were observing. This anxiety has been reported as a barrier to learning in the literature (Harder, Ross, & Paul, 2013; Nielson & Harder, 2013; Zulosky et al., 2016) and measures have been introduced to mitigate the effects. Many simulation programs, including the current one, promote the use of a pre-brief in order to decrease anxiety associated with the simulation environment and the evaluative process. A pre-brief is essentially the introduction to the simulation lab that was described above.

While the optimal level of stress in crisis events has not been established, there must be a balance in creating a realistic experience (which is often stressful) and one that is nurturing and supportive. According to the Yerkes-Dodson law, there is an optimal level of arousal where performance is at its peak. Once the arousal becomes too high, performance decreases (Wikipedia, 2017). Arousal or stress levels may not have been at the appropriate level to allow participants to apply knowledge in the simulation environment.

Research Tools Used

The approach we used when selecting evaluative instruments was influenced by evidence provided in the literature. As described in chapter two, there was much heterogeneity in the published literature related to scoring instruments and tools. While some studies presented evidence using validated tools, others presented results from unvalidated tools. There was no single tool that pointed to a standard method of measurement in our population and outcomes studied. A decision was made to use the Ottawa GRS because it included all five CRM skills on one page, it was validated in a health profession (i.e., medicine), and it was reported as being easy to use. We then decided to create the checklist tool in the event that our assumptions about the Ottawa GRS and its appropriateness with a nursing population were incorrect and we needed another data source to demonstrate performance of CRM skills.

The three evaluators agreed that the Ottawa GRS was easy to use and appreciated the descriptions presented with the scoring system. It also allowed the evaluator the opportunity to give credit where an action was performed sometimes but not all the time. For example, if a participant reassessed vital signs only once during the scenario, they still got some credit for this action even though they should be reassessing vital signs multiple times throughout the scenario. The disadvantage to this instrument is that there were limited opportunities for this population to exhibit the higher level CRM skills like leadership. The description for the high scores in this category related more to the medical profession and not to a nursing role. This limited the usefulness of the Ottawa GRS on a nursing population.

The checklist tool was not as easy to use as it relied on direct observation of key behaviours. If the participant did not perform that behaviour, they did not achieve that element on the score. This was an issue because in the simulation environment, so much depends on one's ability to observe through visual and audio sources. As an evaluator, I could see that a

participant turned up the rate on an intravenous (IV) bolus. I assumed that this is in response to the display showing a low blood pressure. While this is the correct response, if the participant did not verbalize that they noted the low blood pressure and thus turned up the IV in response to it, I could not give them credit for that action.

Other Insights Gained

As noted in the description of the methods, as a result of recruitment and scheduling issues, some changes had to be made to the procedures used in this study. We structured the education program so that only one participant responded to the patient at a time while the other participants watched. Initially, we also thought to include one of the participants as a secondary nurse, but with the difficulties that arose in the recruitment process, this was not possible. Therefore, it was decided that I would act as the secondary nurse or helper in this setting. We now believe it actually worked to our advantage to have one consistent person in each scenario. It allowed for more control over how much information was being fed to the participant and allowed for the flow of the scenario to be maintained. For example, if the participant got “stuck” on what to do next, I was able to pose a question that prompted them to continue forward.

The small groups also created an interesting situation where we ended up changing our initial plans with the observers. At the time of project proposal, we thought the groups would be larger. We reserved space in the simulation lab so that the primary and secondary nurses were in the room responding to the patient and the observers were in a separate room watching the scenario through a video link on a television screen. We were concerned that we would not be able to control observers separated in the viewing room. How would we know they were observing the scenario unfold if we were not monitoring them? This was important because we wanted to understand their degree of learning from the observer perspective and answer the

second research question. As a way to focus their attention on the response, we thought we would have observers use the checklist tool to evaluate their peers. The scores would not have been used in the analysis, but rather used as a strategy to maintain their attention on the participant performance without being monitored directly. Given the small group sizes, however, we ended up including them in the simulation room, and the checklist tool was not used in this way.

One of the challenges to teaching and learning using a simulation environment is that not all participants can act as the primary responder in each scenario. Most of the literature on simulation education emphasizes that active participation is key to adult learning (Reime et al., 2017). However, as an instructor, I am challenged with what to do with the other participants that are observing. Recently there has been research looking at learning outcomes of active participants and of observers learning CRM skills (Bonnell & Hober, 2016; Lai et al., 2016; Reime et al., 2017). In a recent systematic review looking at observer roles that optimize learning in the simulation environment (O'Regan, Molloy, Watterson, & Nestel, 2016), the concept of "directed observer" is defined. This is "whereby learners are actively directed to observe without hands-on participation" (p. 2). They provide evidence that this role as an education method leads to positive educational outcomes. They conclude that the use of observer tools may turn the passive process of watching into an active one. In the current study, it may have been a mistake to change our original plan of having the participants use the checklist to focus their attention to having them watch the scenarios only. At the time it seemed that it had the potential to be a source of distraction for the nurse playing the role of the primary nurse, however using the tool may have contributed to overall results.

There appears to be an opportunity to increase the efficiency of HFS learning if observers can learn vicariously through the active participants. This was certainly reinforced with the findings from the one-on-one interviews carried out as part of this study, as nurses described learning without pressure, learning from different approaches, and learning from others' mistakes. An interesting question that arises is whether the vicarious learning is different depending on the location of the observer (e.g., in the room versus in a viewing room). As with the Hawthorne effect, individuals may alter their behavior when they know they are being observed (Wikipedia, 2017). It is possible that the presence of the observers in the simulation environment has the ability to influence the primary nurse's response.

Implications for Practice, Research, and Education

Crisis resource management as a guiding framework offers healthcare professionals a common platform in their approach to deteriorating patients. For it to be truly effective and successful, a focus on a global application of this practice is required. This means that all healthcare disciplines need to follow the example set by the aviation industry where concepts are introduced as early as possible into pre-licensure training. This framework then needs to be reinforced as the standard approach to crises throughout healthcare environments so that all members of a healthcare team are essentially "on the same page". This should be coupled with increased efforts to include team training early on, with education outcomes applicable to each discipline.

These types of changes have implications across a broad spectrum of clinical environments. Institutions such as hospitals would require changes in infrastructure to promote team training and continuing education, the purpose of which would be to teach teams to

function as more cohesive units through a shared cultural mind set. Similar to the aviation industry, professionals that work together are expected to approach a problem in a common way. Their responses become more streamlined and predictable where behavioral responses are familiar between team members, even when the actual team members may be strangers to each other. This implies that teams can function better and can potentially improve patient outcomes through application of the CRM framework. It suggests that clinical care can be positively affected by how individuals interact together. This also implies there may be a unique perspective on inter-professional relationships and how they affect clinical environments as well as those individuals directly associated with them.

The findings from this study offer unique opportunities for additional research. The implication that time away from the simulation environment can contribute to a decline in observed behaviors suggests that a valid area of more intensive research focus is on retention of skills. Research in this area may involve a focus on strategies to improve retention over time as well as ways to eliminate the need to build rapport among participants that return for additional training at a later date. It would be interesting to see if similar results to the current study would occur if group members were consistent between education sessions or if participants were well known to each other prior to education sessions.

The contribution of overall learning of skills through observation is also an area requiring further study. Participants reported learning through the observer role as well as through acting as the primary nurse. A study comparing the learning effects of both this active and passive process may yield important insight into ways to improve overall learning, especially when considering the limitations of simulation education programs. The difficulties involved with hosting a simulation education program, such as the need for small group sizes, high demand

from multiple parties on simulation lab space, and the time commitment required to devote to education days, may be balanced through optimizing all types of learning in this environment.

Other opportunities for research lie in designing studies that use larger sample sizes. Many of the studies included in the literature review had small samples which limited their statistical significance. A large study, or several studies with homogenous methods where results could be pooled, have the potential to yield more definitive results. Comparing the effects of simulation education programs within different areas of nursing or different disciplines (e.g., critical care nurses to general ward nurses or nurses to physicians) is an area that also requires further study. There is the potential that this type of education may have more of an impact in one area compared to another.

The effect of this type of education on patient outcomes is also an area of study that requires attention. In order to justify the resources required to train multiple disciplines and change to a CRM culture, translation of concepts learned in a simulated environment into the clinical environment must be a focus of future work. How this work benefits (or does not benefit) patients is the crux of healthcare research.

Limitations

First and foremost, this research was limited by sample size. Several changes had to be made to the original recruitment strategies in order to recruit eleven participants. Within the sample there was a variety of nursing areas represented, however, there were almost twice as many nurses from a critical care environment compared to a general medical or surgical unit (i.e., four ward nurses versus seven critical care nurses). The critical care nurses in the facility where recruitment occurred are required to undergo a formal education program focused on intensive care nursing prior to working in critical care. This program takes place over several

months and consists of a theory and practical component. The ward nurses in this study did not have this education and experience and may have shown a greater degree of improvement over time since their exposure to deteriorating patients may not have been as diverse or as acute as that of a critical care nurse. Therefore, another limitation would be a high baseline level of knowledge and experience with high acuity patients of the sample limiting the sensitivity of the evaluative tools.

Another limitation would be in the scoring process itself. There is a possibility that the unblinded primary investigator as one of three evaluators may have influenced results. As described in the methods chapter, efforts were made to prevent any bias from occurring in the evaluation process.

There is a relative lack of reliable and valid evaluation instruments measuring the learning outcomes outlined in this study and / or the effectiveness of HFS as a teaching modality (Kardong-Edgren, Adamson, & Fitzgerald, 2010). The Ottawa GRS measures all five CRM skills listed within this proposal. There are other tools in the literature that measure separate CRM skills but rather than obtaining performance measures using several different tools, I felt it was feasible to use one tool that measured all five. Since the tool uses a Likert scale to quantify performance scores, it also allows for easier comparison between evaluations (i.e., the score on scenario one versus the score on scenario four).

There was no evidence in the literature that the Ottawa GRS had been validated with a nursing population. The checklist tool was new and had also not been used previously. Both tools were meant to evaluate all five CRM skills and were contained to one page each.

Evaluators appreciated this as it made the tools easy to use when watching the videos. It is

possible, however, that either or both of these tools were inappropriate for the population being studied.

There were also some treatment differences between participants. Some participants had a two-week time gap between their first and second education session and some participants had a four-week gap. It is possible that participants that were away for shorter time periods had a greater degree of retention than those that had a longer time gap.

Conclusions

In this study, a high-fidelity simulation education program was created to teach crisis resource management skills to practicing nurses in acute care areas. Performance of these skills was evaluated through quantitative measures using the Ottawa GRS and a checklist tool. Qualitative interviews were designed to yield information on degree of learning in the active responder role as well as in the passive observer role.

A nurse's response to a patient crisis can be overwhelming, particularly if they are inexperienced or have not had opportunities to practice response skills in their clinical environments. Reason's Swiss Cheese Model (1990) cautions us that if enough "holes" in our practices and processes line up, significant errors can occur with potentially drastic consequences. Crisis resource management principles can be used to guide responses in a basic and systematic way that can be applied in a broad range of circumstances. Practice in a high-fidelity simulation environment allows nurses the opportunity to practice these skills in a realistic way without jeopardizing patient safety. It is possible that these skills can then be applied in clinical environments when life-threatening problems arise.

The overall conclusions of this research show a clinical improvement of performance of crisis resource management skills in a simulation environment over time. The Ottawa GRS and

the checklist tool offer a quantitative measure of how behaviors change over time and show an interesting pattern of overall mean scores. Statistically significant improvement in scores was shown with both tools between time points one and two. Both tools also showed a similar, though non-statistically significant pattern, with a decline from time two to time three and overall improvement at time four. These mixed results are supported by evidence in the literature.

Mixed results can be attributed to multiple reasons such as lack of familiarity with the simulation experience and other participants, lack of opportunity to practice and reinforce skills between education sessions, and the effects of learning through observation versus through active participation in scenarios. Qualitative results from one-on-one interviews reflect participant insight into how learning occurred throughout the program. Given that CRM in healthcare is relatively nascent, there are exciting implications for research and changes to practice. A global movement toward using CRM as a guiding framework is needed, however, in order for the potential impact to be truly seen.

References

- Allan, C., Thiagarajan, R., Beke, D., Imprescia, A., Kappus, L., Garden, A.,... Weinstock, P. (2010). Simulation-based training delivered to the pediatric cardiac intensive care unit engenders preparedness, comfort, and decreased anxiety among multidisciplinary resuscitation teams. *The Journal of Thoracic and Cardiovascular Surgery*, *140*(3), 646-652. <https://doi.org/10.1016/j.jtcvs.2010.04.027>
- Andersen, P., Jensen, M., Lippert, A., & Ostergaard, D. (2010). Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. *Resuscitation*, *81*, 695-702. <https://doi.org/10.1016/j.resuscitation2010.01.024>
- Bearman, M., O'Brien, R., Anthony, A., Civil, I., Flanagan, B., Jolly, B.,... Nestel, D. (2012). Learning surgical communication, leadership and teamwork through simulation. *Journal of Surgical Education*, *69*(2), 201-207. <https://doi.org/10.1016/j.surg.2011.07.014>
- Bloch, S.A., & Bloch, A.J. (2015). Simulation training and observation with minimal participation improves paediatric emergency medicine knowledge, skills, and confidence. *Journal of Emergency Medicine*, *32*, 195-202.
- Bonnel, W., & Hober, C. (2016). Optimizing the reflective observer role in high-fidelity patient simulation. *Journal of Nursing Education*, *55*(6), 353-356.
- Brannan, J., White, A., & Bezanson, J. (2008). Simulator effects on cognitive skills and confidence levels. *Journal of Nursing Education*, *47*(11), 495-500. <https://doi.org/10.3928/01484834-20081101-01>

- Brown, D., & Chronister, C. (2009). The effect of simulation learning on critical thinking and self-confidence when incorporated into an electrocardiogram nursing course. *Clinical Simulation in Nursing*, 5(1), e45-e52. <https://doi.org/10.1016/j.ecns.2008.11.001>
- Buckley, T., & Gordon, C. (2011). The effectiveness of high fidelity simulation on medical-surgical registered nurses' ability to recognize and respond to clinical emergencies. *Nurse Education Today*, 31, 716-721. <https://doi.org/10.1016/j.nedt.2010.04.004>
- Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council of Canada, and Social Sciences and Humanities Research Council of Canada. (2014). *Tri-Council policy statement: Ethical conduct for research involving humans*. Retrieved from http://www.pre.ethics.gc.ca/pdf/eng/tcps2-2014/TCPS_2_FINAL_Web.pdf
- Canadian Nurses Association. (2004). *Promoting continuing competence for registered nurses*. Retrieved from http://www2.cna-aiic.ca/CNA/documents/pdf/publications/PS77_promoting_competence_e.pdf
- Cato, D., & Murray, M. (2010). Use of simulation training in the intensive care unit. *Critical Care Nursing Quarterly*, 33(1), 44-51. <https://doi.org/10.1097/CNQ.0b013e3181c8dfd4>
- Cheng, A., Grant, V.J., & Sandhu, N.K., (2016). Constructive debriefing for trauma team education. In L. M. Gillman, S. Widder, M. Blaiwas, & D. Karakitsos (Eds.), *Trauma team dynamics* (pp. 285-290). New York: Springer. <https://doi.org/10.1007/978-3-319-16586-8>
- College of Registered Nurses of Manitoba. (2013). *Standards of practice for registered nurses: Nursing practice expectations*. Retrieved from http://cms.tng-secure.com/file_download.php?ffile_id=140

- Cooper, S., Cant, R., Porter, J., Missen, K., Sparkes, L., McConnell-Henry, T., & Endacott, R. (2013). Managing patient deterioration: Assessing teamwork and individual performance. *Journal of Emergency Medicine, 30*(5), 377-381. doi: 10.1136/emered-2012-201312
- Cooper, S., Kinsman, L., Buykx, P., McConnell-Henry, T., Endacott, R., & Scholes, J. (2010). Managing the deteriorating patient in a simulated environment: Nursing students' knowledge skill and situation awareness. *Journal of Clinical Nursing, 19*(15-16), 2309-2318. <https://doi.org/10.1111/j.1365-2702.2009.03164.x>
- Cooper, S., McConnell-Henry, T., Cant, R., Porter, J., Missen, K., Kinsman, L.,...Scholes, J. (2011). Managing deteriorating patients: Registered nurses' performance in a simulated setting. *The Open Nursing Journal, 5*, 120-126. <https://doi.org/10.2174/18744346011050100120>
- Cooper, S., & Wakeham, A. (1999). Leadership of resuscitation teams: Lighthouse leadership. *Resuscitation, 42*, 27-45. [https://doi.org/10.1016/S0300-9572\(99\)00080-5](https://doi.org/10.1016/S0300-9572(99)00080-5)
- Dadiz, R., Weinschreider, J., Schriefer, J., Arnold, C., Greves, C., Crosby, E.,...Guillet, R. (2013). Interdisciplinary simulation-based training to improve delivery room communication. *The Society for Simulation in Healthcare, 8*, 279-291. <https://doi.org/10.1097/SIH.0b013e31829543a3>
- Decker, S., Sportsman, S., Puetz, L., & Billings, L. (2008). The evolution of simulation and its contribution to competency. *The Journal of Continuing Education in Nursing, 39*(2) 74-80. <https://doi.org/10.3928/00220124-2008201-06>

- DeVita, M., Schaefer, J., Wang, H., & Dongilli, T. (2005). Improving medical emergency team (MET) performance using a novel curriculum and a computerized human patient simulator. *Quality and Safety in Healthcare, 14*, 326-331. <https://doi.org/10.1136/qshc.2004.011148>
- Elo, S., & Kyngas, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing, 62*(1), 107-115. <https://doi.org/10.1111/j.1365-2648.2007.04569.x>
- Fero, L., O'Donnell, J., Zullo, T., Dabbs, A., Kitutu, J., Somosky, J., & Hoffman, L. (2010). Critical thinking skills in nursing students: Comparison of simulation-based performance with metrics. *Journal of Advanced Nursing, 66*(10), 2182-2193. <https://doi.org/10.1111/j.1365-2648.2010.05385.x>
- Flanagan, B., Nestel, D., & Joseph, M. (2004). Making patient safety the focus: Crisis resource management in the undergraduate curriculum. *Medical Education, 38*, 56-66. <https://doi.org/10.1046/j.1365-2923.2004.01701.x>
- Fletcher, G, Flin, R., McGeorge P., Glavin, R., Maran, N., & Patey, R. (2004). Rating non-technical skills: developing a behavioural marker system for use in anaesthesia. *Cognition, Technology, and Work, 6*(3), 165-171
- Gaba, D. (2007). The future vision of simulation in healthcare. *Journal of the Society for Simulation in Healthcare, 2*(2), 126-163. <https://doi.org/10.1136/qshc.2004.009878>
- Gaba, D., Fish, K., & Howard, S. (1994). *Crisis management in anesthesia*. New York: Churchill Livingstone.
- Gilfoyle, E., Gottesman, R., & Razack, S. (2007). Development of a leadership skills workshop in paediatric advanced resuscitation. *Medical Teacher, 29*(9-10), e276-e283. <https://doi.org/10.1080/01421590701663287>

Gillman, L.M., Brindley, P., Paton-Gay, J.D., Engels, P.T., Park, J., Vergis, A., & Widder, S. (2016). Simulated trauma and resuscitation team training course - evolution of a multidisciplinary trauma crisis resource management simulation course. *The American Journal of Surgery*, 212(1), 188-193. <https://doi.org/10.1016/j.amjsurg.2015.07.024>

Gordon, S, Mendenhall, P, & Blair O'Connor, B. (2013). *Beyond the checklist. What else health care can learn from aviation teamwork and safety?* Ithaca, New York: ILR Press.

Harder, N., Ross, C. J.M., & Paul, P. (2013). Student perspective of roles assignment in high-fidelity simulation: an ethnographic study. *Clinical Simulation in Nursing* 9, e329-e334. Doi <http://dx.doi.org/10.1016/j.ecns.2012.09.003>

Hall, S. (2015). High-fidelity simulation for senior maternity nursing students. *Nursing Education Perspectives*, 36(2), 124-126

Helmreich, R.L., Merritt, A.C., & Wilhelm, J.A. (1999). The evolution of crew resource management training in commercial aviation. *International Journal of Aviation Psychology*, 9(1), 19-32.

Hirshon, J.M., Risko, N., Calvello, E. J.B., Stewart de Ramirez, S., Narayan, M., Theodosis, C., O'Neill, J., (2013). Health systems and services: the role of acute care. *Bulletin of the World Health Organization*, 91, 383-388. <https://doi.org/10.2471/BLT.12.112664>

Hober, C. & Bonnel, W. (2014). Student perceptions of the observer role in high-fidelity simulation. *Clinical Simulation in Nursing*, 10(10), 507-514. <https://doi.org/10.1016/j.ecns.2014.07.008>

- Hsieh, H.-F., & Shannon, S. (2005). Three approaches to content analysis. *Qualitative Health Research, 15*(9), 1277-1288. <https://doi.org/10.1177/104973230527/6687>
- Huseman, K. (2012). Improving code blue response through the use of simulation. *Journal for Nurses in Staff Development, 28*(3), 120-124. <https://doi.org/10.1097/NND.0b013e3182551506>
- Jankouskas, T., Chaska Bush, M., Murray, B., Rudy, S., & Henry, J. (2007). Crisis resource management: Evaluating outcomes of a multidisciplinary team. *Society for Simulation in Healthcare, 2*(2), 96-101. <https://doi.org/10.1097/SIH.0b013e31805d8b0d>
- Jankouskas, T. S., Haidet, K., Hupcey, J., Kolanowski, A., & Murray, M. (2011). Targeted crisis resource management improves performance among randomized nursing and medical students. *Journal of the Society for Simulation in Healthcare, 6*(6), 316-326. <https://doi.org/10.1097/SIH.0b013e31822bc676>
- Johns Hopkins Hospital / Johns Hopkins University (2004). *JHNEBP research evidence appraisal*. Retrieved from <http://nursingworld.org/DocumentVault/NursingPractice/Research-Toolkit/JHNEBP-Research-Evidence-Appraisal.pdf>
- Kaddoura, M. (2010). New graduate nurses' perceptions of the effects of clinical simulation on their critical thinking, learning, and confidence. *Journal of Continuing Education in Nursing, 31*(11), 506-516. <https://doi.org/10.3928/00220124-20100701-02>
- Kardong- Edgren, S., Adamson, K.A., & Fitzgerald, C. (2010). A review of currently published evaluation instruments for human patient simulation. *Clinical Simulation in Nursing, 6*(1), e25-e35. <https://doi.org/10.1016/j.ecns.2009.08.004>

- Kim, J., Fox-Robichaud, A., & Wax, R. (2009). Crisis resource management- CCRT instructors. CCRT instructor training. In Kim, J., Wax, R., Chiu, M., Bell, D., Fox-Robichaud, A., Landriault, A. *CCRT high-fidelity simulation instructor course training manual* (pp. 3-25). Ottawa, Ontario: CRI Critical Care Education Network.
- Kim, J., Neilipovitz, D., Cardinal, P., Chiu, M., & Clinch, J. (2006). A pilot study using high-fidelity simulation to formally evaluate performance in the resuscitation of critically ill patients: The University of Ottawa critical care medicine, high-fidelity simulation and crisis resource management I study. *Critical Care Medicine*, *34*(8), 2167-2174.
<https://doi.org/10.1097.01.CCM.0000229877.45125.CC>
- Kim J, Neilipovitz D, Cardinal P, Chiu M. (2009). A comparison of global rating scale and checklist scores in the validation of an evaluation tool to assess performance in the resuscitation of critically ill patients during simulated emergencies (abbreviated as “CRM simulator study 1B”). *Simulation in Healthcare*, *4*(1), 6-16.
- Kim, J., & Wax, R. (2006). Crisis resource management. In R. Hodder (Ed.), *Critical care response team provider manual* (pp. 13-19). Ottawa, Ontario: Canadian Resuscitation Institute.
- Kohn, L.T., Corrigan, J., & Donaldson, M. S. (2000). *To err is human: Building a safer health system*. Washington, D.C.: National Academy Press.
- Lai, A., Haligua, A., Bould, M.D., Everett, T., Gale, M., Pigford, A., & Boet, S. (2016). Learning crisis resource management: Practicing versus an observational role in simulation training-a randomized controlled trial. *Anesthesia Critical Care and Pain Management*, *35*, 275-281. <https://doi.org/10.1016/j.accpm.2015.10.010>

- Lapkin, S., Levett-Jones, T., Bellchambers, H., & Fernandez, R. (2010). Effectiveness of patient simulation manikins in teaching clinical reasoning skills to undergraduate nursing students: A systematic review. *Clinical Simulation in Nursing*, 6(6), e207-e222. <https://doi.org/10.1016/j.ecns.2010.05.005>
- Lasater, K. (2005). The impact of high fidelity simulation on the development of clinical judgment in nursing students: An exploratory study. *Portland State University*.
- Lewis, R., Strachan, A., & McKenzie-Smith, M. (2012). Is high fidelity simulation the most effective method for the development of non-technical skills in nursing? A review of the current evidence. *The Open Nursing Journal*, 6, 82-89.
- Liaw, S.Y., Rethans, J., Scherpier, A., & Piyanee, K. (2011). Rescuing a patient in deteriorating situations (RAPDIS): a simulation-based educational program on recognizing responding and reporting of physiological signs of deterioration. *Resuscitation*, 82, 1224-1230.
- Lucas, A., & Edwards, M. (2017). Development of crisis resource management skills: A literature review. *Clinical Simulation in Nursing*, 13(8), 347-358. <https://doi.org/10.1016/j.ecns.2017.04.006>
- Maneval, R., Fowler, K., Kays, J., Boyd, T., Shuey, J., Harne-Britner, S., & Mastrine, C. (2012). The effect of high-fidelity patient simulation on the critical thinking and clinical decision making skills of new graduate nurses. *The Journal of Continuing Education in Nursing*, 43(3), 125-134. <https://doi.org/10.3928/00220124-20111101-02>
- Maxson, P., Dozois, E., Holubar, S., Wroblewski, D., Overman, J., Klipfel, J., & Arnold, J. (2011). Enhancing nurse and physician collaboration in clinical decision making through high-fidelity interdisciplinary simulation training. *Mayo Clinic Proceedings*, 86(1), 31-36.

- Messmer P. R. (2008). Enhancing nurse-physician collaboration using pediatric simulation. *The Journal of Continuing Education in Nursing, 39*(7), 319-327.
- Morey, J.C., Simon, R., Jay, G.D., Wears, R.L., Salisbury, M., Dukes, K.A., & Berns, S.D. (2002). Error reduction and performance improvement in the emergency department through formal teamwork training: evaluation results of the MedTeam project. *Health Services Research, 37*(6), 1553-1581
- Morgan, P., Kurrek, M., Bertram, S., LeBlanc, V., & Przybyszewski, T. (2011). Nontechnical skills assessment after simulation-based continuing medical education. *Society for Simulation in Healthcare, 6*(5), 255-259. <https://doi.org/10.1097/SIH.0b013e31821dfd05>
- Nagle, G., McHale, J., Alexander, G., & French, B. (2009). Incorporating scenario-based simulation into a hospital nursing education program. *The Journal of Continuing Education in Nursing, 40*(1), 18-25. <https://doi.org/10.3928/00220124-20090101-02>
- Nickerson, N., Morrison, B., & Pollard, M. (2011). Simulation in nursing staff development: A concept analysis. *Journal for Nurses in Staff Development, 27*(2), 81-89. <https://doi.org/10.1097/NND.0b013e3181a681bd>
- Nielson, B. & Harder, N. (2013). Causes of student anxiety during simulation: what the literature says. *Clinical Simulation in Nursing, 9*, e507-e512. Doi: <http://dx.doi.org/10.1016/j.jecns.2013.03.003>
- Pearson, E., & McLafferty, I. (2011). The use of simulation as a learning approach to non-technical skills awareness in final year student nurses. *Nurse Education in Practice, 11*, 399-405. <https://doi.org/10.1016/j.nepr.2011.03.023>

- Radhakrishnan, K., Roche, J.P., & Cunningham, H. (2007). Measuring clinical parameters with human patient simulation: A pilot study. *International Journal of Nursing Education Scholarship*, 4(1), 1-11.
- Reason, J.T. (1990). *Human error*. New York: Cambridge University Press.
- Reime, M., Johnsgaard, T., Kvam, F. Aarflot, M., Engeberg, J., Breivik, M., & Brattebo, G. (2017). Learning by viewing versus learning by doing: A comparative study of observer and participant experiences during an interprofessional simulation training. *Journal of Interprofessional Care*, 31(1), 51-58. <https://doi.org/10.1080/13561820.2016.1233390>
- Royal College of Physicians and Surgeons of Canada. (2017). Acute Critical Events Simulation (ACES) course. Retrieved from <http://www.royalcollege.ca/rcsite/ppi/courses/acute-critical-events-simulation-aces-course-e>
- Rudy, S., Polomano, R., Murray, W., Henry, J., & Marine, R. (2007). Team management training using crisis resource management results in perceived benefits by healthcare workers. *The Journal of Continuing Education in Nursing*, 38(5), 219-226.
- Salas, E., Burke, C. S., Bowers, C.A., & Wilson, K. A. (2001). Team training in the skies: Does crew resource management (CRM) training work? *Human Factors*, 43, 641-674.
- Sandelowski, M. (1986). The problem of rigor in qualitative research. *Advances in Nursing Science*, 8(3), 27-37.
- Schubert, C. (2012). Effect of simulation on nursing knowledge and critical thinking in failure to rescue events. *The Journal of Continuing Education in Nursing*, 43(10), 467-471. <https://doi.org/10.3928/00220124-20120904-27>
- Shapiro, M., Morey, J., Small, S., Langford, V., Kaylor, C., Jagminas, L.,... Jay, G. (2004). Simulation based teamwork training for emergency department staff: Does it improve

- clinical team performance when added to an existing didactic teamwork curriculum?
Quality and Safety in Healthcare, 13, 417-421. <https://doi.org/10.1136/qshc.2003.005447>
- Singer, B., Corbridge, T., Schroedl, C., Wilcox, J., Cohen, E., McGaghie, W., & Wayne, D. (2013). First year residents outperform third-year residents after simulation-based education in critical care medicine. *The Society for Simulation in Healthcare*, 8(2), 67-71. <https://doi.org/10.1097/SIH.0b013e31827744f2>
- Sittner, B.J., Schmaderer, M, Zimmerman, L., Hertzog, M., & George, B. (2009). Rapid response team simulated training for enhancing patient safety (STEPS). *Clinical Simulation in Nursing*, 5(3), 119-127. <https://doi.org/10.1016/j.ecns.2009.02.007>
- Straka, K., Burkett, M., Capan, M., & Eswein, J. (2012). The impact of education and simulation on pediatric novice nurses' response and recognition to deteriorating. *Journal for Nurses in Staff Development*, 28(6), e5-e8. <https://doi.org/10.1097/NND.0b013e3182732db5>
- Streubert, H., & J., Rinaldi Carpenter, D. (2011). *Qualitative research in nursing: Advancing the humanistic imperative (5th ed.)*.edition. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins.
- Strouse, A. C. (2010). Multidisciplinary simulation centers: Promoting safe practice. *Clinical Simulation in Nursing*, 6(4), 139-142. <https://doi.org/10.1016/j.ecns.2009.08.007>
- Sullivan-Mann, J., Perron, C., & Fellner, A. (2009). The effects of simulation on nursing students' critical thinking scores: A quantitative study. *Newborn and Infant Nursing Reviews*, 9(2), 111-116. <https://doi.org/10.1053/j.nainr.2009.03.006>
- TenEyck, R., Tews, M., Ballester, J., & Hamilton, G. (2010). Improved fourth-year medical student clinical decision-making performance as a resuscitation team leader after a

simulation-based curriculum. *Society for Simulation in Healthcare*, 5(3), 139-145.

<https://doi.org/10.1097/SIH.0b013e3181cca544>

Thompson, C., Yang, H., & Crouch, S. (2012). Clinical simulation fidelity and nurses' identification of critical event risk: A signal detection analysis. *Journal of Advanced Nursing*, 68(11), 2477-2485. <https://doi.org/10.1111/j.1365-2648.2012.05945.x>

Todd, M., Manz, J.A., Hawkins, K.S., Parsons, M.E., & Hercinger, M. (2008). The development of a quantitative evaluation tool for simulations in nursing education. *International Journal of Nursing Education Scholarship*, 5(1), 1-17.

University of Manitoba (2017). *Max Rady College of Medicine Clinical Learning and Simulation Facility, Rady Faculty of Health Sciences*. Retrieved from http://umanitoba.ca/faculties/health_sciences/medicine/education/ed_dev/clsf/6206.html

Van de Ven, J., Houterman, S., Steinweg, R., Scherpbier, A., Wijers, W., Mol, B., & Oei, S. (2010). Reducing errors in health care: Cost-effectiveness of multidisciplinary team training in obstetric emergencies (TOSTI study): A randomized controlled trial. *BMC Pregnancy and Childbirth*, 10(59), 1-6. <https://doi.org/10.1186/1471-2393-10-59>

White, N. (2012). Understanding the role of non-technical skills in patient safety. *Nursing Standard*, 26(26), 43-48.

Wikipedia (2017). *Hawthorne effect*. Retrieved from https://en.wikipedia.org/wiki/Hawthorne_effect

Wikipedia (2017). *Yerkes-Dodson law*. Retrieved from https://en.wikipedia.org/wiki/Yerkes%E2%80%93Dodson_law

- Wolf, L. (2008). The use of human patient simulation in ED triage can improve nursing confidence and patient outcomes. *Journal of Emergency Nursing, 34*(2), 169-171.
<https://doi.org/10.1016/j.jen.2007.11.005>
- Yee, B., Naik, V.N., Joo, H.S., Savoldelli, G.L, Chung, D., Houston, P.L., ... Hamstra, S.J. (2005). Nontechnical skills in anesthesia crisis management with repeated exposure to simulation-based education. *Anesthesiology, 103*(2), 241-248.
- Zulkosky, K., White, K., Price, A., & Pretz, J. (2016). Effect of simulation role on clinical decision-making accuracy. *Clinical Simulation in Nursing, 12*, 98-106.
<https://doi.org/10.1016/j.ecns.2016.01.007>

Appendix A

Checklist Tool

Nurse Evaluated:
Name of Evaluator:

Cohort Number:
Total Score:

Date:

Measurable Objectives		Total Score /31	Comments
Situational Awareness		/10	
Assesses vital signs and identifies normal and/or abnormal	<input type="checkbox"/> BP <input type="checkbox"/> HR <input type="checkbox"/> RR <input type="checkbox"/> SpO2	/4	
forms follow-up assessments	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Anticipates actions (Fluid, IV access, Abx, need for A/W support, need for help)	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Summarizes events	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Communication		/8	
Detects error and interrupts	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Communicates effectively (verbal and non-verbal)	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Communicates effectively with primary service (SBAR)	<input type="checkbox"/> Situation <input type="checkbox"/> Background <input type="checkbox"/> Assessment <input type="checkbox"/> Recommendations	/4	
Problem Solving		/9	
Uses systematic approach (ABC)	<input type="checkbox"/> Airway <input type="checkbox"/> Breathing <input type="checkbox"/> Circulation	/3	
Recognizes primary problem	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Implements interventions	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Reflects on simulation experience	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Resource Utilization and Leadership		/4	
Calls for help	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	
Assigns tasks appropriately	<input type="checkbox"/> Yes <input type="checkbox"/> No	/2	

Appendix B

Scenario Example

LEARNING OBJECTIVES:

By the end of the session the participants will be able to:

- *Demonstrate adequate assessment skills with a focus on systematic ABC approach*
- *Identify primary issue (airway obstruction due to allergic reaction)*
- *Demonstrate appropriate nursing actions taken for a patient with an allergic reaction (stop antibiotic)*
- *Discuss appropriate treatment for a patient with an allergic reaction*
- *Initiate a "code blue" in response to airway obstruction*
- *Communicate effectively with team members, including using SBAR format with primary service.*

SCENARIO ENVIRONMENT

Location (*Scenario scene*): General medicine or surgical unit

Monitors:

- HR
- NIBP
- Spo2

Physical props/equipment:

- IV pole with piggyback set-up for antibiotic
- Simulated patient
- Benedryl
- Supplies to administer IV medication
- MARs

Personnel:

- 1 Confederate Nurse

Potential Distracters (Optional): None

SCENARIO

Patient has just been admitted to the general unit from ER. The primary nurse is receiving report from the ER nurse, when the patient begins to complain of difficulty breathing.

Appendix B

Case Introduction: Report given by Secondary nurse to the Primary nurse. This is Mr. Smith; he is an 80 year old male who was found at home after falling. He has been diagnosed with a urinary tract infection and is admitted to your unit for a course of IV antibiotics. This (gesture to IV set up) is his first dose. He was brought in by his landlord and we don't know his past medical history.

Available Collateral History:

The Script: When the primary nurse enters the room with the secondary nurse, the patient is confused. He starts complaining of having difficulty breathing and is gasping for air. The secondary nurse states "he wasn't doing this in the ER".

- A – stridor, airway constricted with swollen tongue
- B – SpO2 initially 90 but trends down, lung sounds wheezy
- C – hypertensive, tachycardic trending up until last 3 minutes and then drop dramatically
- D – confused, wide eyed, panic
- E – T 38.2

Scenario Transitions / patient parameters	Effective Management	Consequences of Ineffective Management	Notes
1. Initially stable but then verbalizes difficulty breathing. Patient becomes stridorous until loses consciousness.	<ul style="list-style-type: none"> ▪ Primary nurse obtains report from secondary nurse ▪ Secondary nurse stays to help once patient verbalizes difficulty breathing ▪ Primary nurse conducts ABC assessment and notes airway obstruction ▪ Primary nurse tries to troubleshoot causes of obstructed airway ▪ Primary nurse stops IV antibiotic, noting the patient may be having an allergic reaction to new antibiotic ▪ BP 110/60, HR 90 sats 90% on 3LNP 	<ul style="list-style-type: none"> ▪ 	
2. Once the primary nurse has identified an airway issue, they should initiate a	<ul style="list-style-type: none"> ▪ Code team delayed for several minutes ▪ Primary nurse anticipates actions and prepares fluid bolus and calls for additional IV 	<ul style="list-style-type: none"> ▪ 	

Appendix B

"code blue" call. The remaining team members enter the room and handover occurs	▪ Code "team" arrives and Primary nurse delivers handover in SBAR format		
3. BP drops to 80/30, HR drops to 60	▪ administer fluid, benedryl ▪	▪ NO change in BP.	

De Briefing Points

- Systematic ABC assessment
- Use of resources
- Anticipating actions
- SBAR handover
- Discuss the causes of obstructed airway and common actions

Appendix D



Research Ethics and Compliance
Office of the Vice-President (Research and International)

Human Ethics
208-194 Dafoe Road
Winnipeg, MB
Canada R3T 2N2
Phone +204-474-7122
Fax +204-269-7173

APPROVAL CERTIFICATE

November 9, 2015

TO: **Amanda Lucas** (Advisor M. Edwards)
Principal Investigator

FROM: **Zana Lutfiyya, Chair**
Education/Nursing Research Ethics Board (ENREB)

Re: **Protocol #E2015:098**
"Development of Crisis Resource Management Skills using High-Fidelity Simulation Education"

Please be advised that your above-referenced protocol has received human ethics approval by the **Education/Nursing Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement (2). **This approval is valid for one year only.**

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- **If you have funds pending human ethics approval, please mail/e-mail/fax (261-0325) a copy of this Approval (identifying the related UM Project Number) to the Research Grants Officer in ORS in order to initiate fund setup. (How to find your UM Project Number: <http://umanitoba.ca/research/ors/mrt-faq.html#pr0>)**
- **if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.**

The Research Quality Management Office may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans*.

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/orec/ethics/human_ethics_REB_forms_guidelines.html) in order to be in compliance with Tri-Council Guidelines.

Appendix D



“Development of Crisis Resource Management Skills Using High-Fidelity Simulation Education”

Identifying the impact of simulation-based education on non-technical nursing skills

To nurses in the Medicine and Surgery Programs:

As part of my Master of Nursing Program I am carrying out a **study** designed to investigate the effect of a high-fidelity simulation (HFS) based educational program on nursing performance of Crisis Resource Management Skills (CRM). These skills include problem solving, situational awareness, resource utilization, communication, and leadership and have been shown to have the greatest amount of impact in crisis scenarios, like code blues. I want to know if this type of education is effective in teaching these skills and am inviting you to be part of this study. If you agree to take part, you will be required to:

- 1) Participate in an interdisciplinary simulation education program over x number of weeks.
- 2) Participate in a short one-on-one interview reflecting on your experiences in the education program.

Interested parties are requested to contact the Primary Investigator (PI) as soon as possible, as there are only 12 spots available.

Your participation is voluntary and confidential.

You can refuse to participate in this study and/or withdraw at any time. The data collected here will be used to guide future educational interventions, supports and strategies that would improve nursing crisis response and improve patient outcomes. There will be no repercussions to your work at your place of employment should you choose not to participate or to withdraw from the study.

Thank-you for your interest in my study.

For additional information please contact:
Amanda Lucas XXX-XXXX or XXX@xx

This project has been approved by the Education/Nursing Ethics Board at the University of Manitoba. If you have concerns or complaints about this project, you may contact any of the investigators or the Human Ethics Secretariat at 204-747-7122 or email humanethics@umanitoba.ca



Development of Crisis Resource Management Skills Using High-Fidelity Simulation-Based Education

Check your email for an exciting chance to participate in a nursing study.

Your participation is greatly valued!

Participate in an education program designed to teach non-technical nursing skills, used in high acuity situations.

For more information contact:

**Amanda Lucas Master of Nursing Program student
XXX@myumanitoba.ca**

This research has been approved by the Education/Nursing Ethics Board at the University of Manitoba and the Health Sciences Centre. If you have concerns or complaints about this project, you may contact any of the investigators or the Human Ethics Secretariat at 747-7122 or email humanethics@umanitoba.ca

Appendix F

Hello, my name is: _____. May I speak with: _____

I am calling to follow up with you regarding your recent email expressing an interest in participating in a nursing study called *Development of Crisis Resource Management Skills Using High-Fidelity Simulation Education*.

Do you have a few moments to answer some questions to ensure you are eligible to take part in this study?

Did you have any question for me about the letter you received?

These questions are to confirm that you meet the eligibility criteria for the study.

1. Have you been employed as a nurse at the Health Sciences Centre for a period of at least six months?
2. Are you currently registered as a registered nurse with the College of Registered Nurses of Manitoba?
3. Have you had any prior education around CRM principles?
5. Are you willing to commit to two 4- hour education days February through April, 2016?

Appendix G

1. What is your gender?
2. How old are you?
3. What is your highest level of education?
4. How many years have you been employed as a nurse?
5. Do you work in the surgery program, the medicine program, or the critical care program at HSC?

Appendix H

Most medical errors are not caused by problems with knowledge. Rather, other problems such as poor equipment or inadequate staffing can combine with communication failures and team malfunction, to create hazardous situations. A set of “non-medical” or “non-technical” skills have been identified that comprise those skills necessary to manage any crisis situation in a manner that will minimize the chance for error. These skills have been referred to as “crisis resource management”, or CRM.

PROBLEM SOLVING

Daily practice requires nurses to be organized and to prioritize care based on fluctuating patient needs. Often, they are met with barriers, like demands related to patients / family and staffing shortages. Finding solutions to these barriers requires creativity. Furthermore, it is an expectation that nurses are able to react quickly and appropriately if a crisis arises. Thus your problem-solving strategy used in these situations must not only take into account the need to act quickly and deal with the most life-threatening problems first, but you must also remain aware of the “big picture”. In CRM, this concept is referred to as “concurrent management” (Kim, Fox-Robichaud, & Wax, 2009, p.2).

In nursing, problem solving is referred to as “critical inquiry” which is “the process of purposive thinking and reflective reasoning” (College of Registered Nurses of Manitoba (CRNM), 2013, p. 4). If applied to a crisis situation, practicing critical inquiry includes use of nursing skills that encompass concurrent management principles like initiating a primary assessment, airway, breathing, and circulation (ABC) survey and rapid life-saving treatments while continually re-evaluating changing priorities. This ensures the basics are covered while the life-saving treatment is implemented at the earliest possible time (Kim, Fox-Robichaud, & Wax, 2009, p. 5). This concept seems intuitive, however, it is well documented that nurses often lack the ability to recognize clinical urgency and / or fail to react when they note signs of deterioration (Cooper et al., 2011).

Situational Awareness

Situational awareness describes the extent to which a person appreciates the seriousness of the crisis at hand. It also refers to the ability to remain aware of important events that are occurring and the surrounding environment (Flanagan, Nestel, & Joseph, 2004), or the “perception of the environmental elements” (Cooper et al., 2013, p. 377). According to Lewis, Strachan, and McKenzie-Smith, it is “what is going on in any given situation and involves the individual’s perception and understanding of what is happening, and their prediction of what may happen in the future” (2012, p. 86). In order for nurses to be good clinicians, they must be able to use situational awareness and perceive information from the environment, appreciate this information and apply meaning to it (Kim, Fox-Robichaud, & Wax, 2009). Thus, situational awareness requires knowledge of events and being aware of the “big picture” in order to problem solve effectively.

There are three steps to effective situational awareness: physiologic perception, comprehension, and projection. Perception involves receiving information from the senses. Healthcare professionals must rely on assessment data, history taking, and monitoring equipment in order to be fully situationally aware. Comprehension is the

Appendix H

ability to appreciate what the information gathered from the senses means. It involves being aware of the significance of sensory inputs from the environment (e.g., changes in noises from monitors and accompanying changes in patient condition). Projection entails making the greatest use of information that is both perceived and comprehended. In CRM, the clinician must use these skills and predict the next step (Kim, Fox-Robichaud, & Wax, 2009).

Resource Utilization

An important aspect of CRM is knowledge and understanding of resources available. This includes being efficient and effective in using equipment, medications, monitors and, most importantly, using people. In other words, resource utilization means to “allocate attention wisely and use all available information” (Flanagan et al., 2004, p. 5). There are at least three keys to success in resource utilization. The first is calling for help early. Often additional help is delayed; therefore in order to ensure that appropriate tasks are initiated at the earliest possible time, evaluating the need for assistance should be considered even when by all appearances the situation is under control. The second key is distributing workload and delegating appropriately. Resource utilization is essentially workload management, “the implementation of a strategy to balance the amount of work with appropriate time and resources available” (Gordon, Mendenhall, & O’Connor, 2013, p. 119). CRM is meant to take full advantage of all the resources available, this involves ensuring that workload is distributed and delegated appropriately. The third key is understanding the gifts and talents of those at hand. As with distributing workload to match individual skills, tasks in crisis events should also match personality styles. For example, a person who is generally shy or withdrawn may not be comfortable acting as a leader in a high stress event (Kim, Fox-Robichaud, & Wax, 2009).

Communication

One of the major system problems that lead to crisis events in hospitals is the failure to communicate effectively (Sittner et al., 2009). Communication problems have been identified as the root cause in “65% of sentinel events, with 74% resulting in death” (Maxson et al., 2011, p 34). There are five CRM strategies used to prevent communication errors. The first, directed communication ensures the intended recipient of the message is listening. Using names or eye contact to direct others’ behaviors are examples of directed communication. The second strategy is to be specific, as general instructions can lead to misunderstanding and other undesirable outcomes. Third, use read back, “having the recipient of the message relaying that they have understood the direction by repeating back what they heard” (Kim, Fox-Robichaud, & Wax, 2009, p. 18). The fourth strategy is closing the loop. This process involves the person assigned a task to follow up once the task has been completed. The final strategy is to flatten the hierarchy and encourage open communication. Healthcare teams are composed of members with differing levels of education and expertise. Some members may not feel comfortable speaking up in this environment and may need to be invited to share important information or observations. Flattening the hierarchy by inviting suggestions (as a leader) or offering ideas (as a follower) are important to ensuring the welfare of the patient (Kim, Fox-Robichaud, & Wax, 2009).

Leadership

Effective leadership is essential to working as a member of a large team. Teams are “social entities that use shared knowledge, skills, attitudes, goals, and monitoring of

Appendix H

own and others' performance to achieve high quality teamwork" (Lewis et al., 2012, p. 84). The leadership role includes explanation of the goals of the situation while still inspiring others to perform at a higher level. According to Cooper and Wakeham (1999), there are two factors used to describe leadership behavior. These are consideration, "the extent to which leaders show consideration towards the members of the team" (p. 28), and initiating structure, which is the "the extent to which a leader defines, initiates, and organizes the activities within the team" (p. 28). In CRM, there are three essential qualities for effective leadership. These are the ability to remain calm in a crisis, the ability to be decisive even with uncertainty, and the ability to maintain a global perspective (view of the "big picture") (Kim, Fox-Robichaud, & Wax, 2009).

Incorporating teamwork and leadership exercises in simulation-based training curriculum allows nurses to define their role as members of a collaborative team. It also allows them to understand the role of others so that the combination of competent professionals creates a more cohesive group.

Appendix I

Project Title: Development of Crisis Resource Management Skills Using High-Fidelity Simulation-Based Education

Principle Investigator: Amanda Lucas Master of Nursing Program student

XXX@myumanitoba.ca

Thesis Advisor: Dr. Marie Edwards, Associate Professor, College of Nursing, Faculty of Health Sciences

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Dear Participant,

Purpose:

This thesis study is designed to investigate the following research questions:

- What are the differences in acute care medical-surgical unit nurses' crisis resource management (CRM) skills performance scores (i.e., problem solving, situational awareness, resource utilization, communication, and leadership) over time, measured using the Ottawa GRS and a checklist tool, in a high-fidelity simulation (HFS) -based learning program?
- What are participants' impressions/ perceptions of the contribution to overall learning of CRM skills through participation in each of the respective roles of primary nurse, secondary nurse / support person, and observer?

I am asking you to participate in HFS- based learning program that was developed to teach skills needed in crisis situations like "code blues". The commitment for this project will be two 4-hour education sessions every 2 to 4 weeks. During these sessions, you will rotate through different roles in a deteriorating patient scenario. You will also participate in debrief sessions post simulations, where you will receive teaching relevant to the "patient's" condition as well as CRM skills. Each simulation session will be videotaped as part of the data collection. This data will only be accessible to the primary investigator (PI), Amanda Lucas, Marie Edwards, and two independent evaluators Kelly Hallock and Nicole Harder. Once Evaluations are completed, compact disk (CD) copies of videotaped scenarios will be stored in a locked cabinet in the PIs home. Only the PI will have a key to this cabinet.

You will also be asked to participate in a brief interview exploring your view of the learning you received during the education program. This interview will take place after the education program is completed and will only take approximately 15 minutes. You may participate in this interview in person or by telephone. Interviews will be recorded using an audio device and listened to and transcribed by myself (Amanda Lucas) and my thesis advisor Dr. Marie Edwards. These files will only be accessible to Amanda Lucas and Marie Edwards. Audio files and

Appendix I

transcription files will be stored on a password-protected computer and audio files will be deleted once transcription is complete.

Risk/Benefits:

There is a minimal risk that you will find the education sessions stressful. Many participants in similar programs have felt their performance is being judged and reflects their competence in their nursing practice. This is not the intent of the program, and every effort will be made to ensure that you feel safe and supported during the entire experience. Should the program become overwhelming, an independent crisis worker will be made available to you for counseling and debriefing. This crisis worker can be reached at the Employee Assistance Plan office at: Ph. (204) 786-8880, TTY (204) 775-0586 or T toll free 1-800-590-5553.

The benefit to your nursing practice is that you will learn how to use non-technical skills to guide your response to a patient during a crisis event. This study will also yield the usefulness of such an educational program for future larger projects using multidisciplinary HFS learning.

Confidentiality:

Results of this study will be presented in aggregate form so that no individual participant will be identified. The raw data will only be accessible to the principle investigator Amanda Lucas and her thesis advisor Marie Edwards. In addition, raw hard copy data will be stored in a locked drawer in the PI's office and computer files will be password protected. Only the PI and Marie Edwards will be in possession of the key and password.

Once you have signed this consent form and accompanying confidentiality pledge, you will be assigned a "letter name" which de-identifies you from this point forward. This means your name will not appear with your accompanying data (CDs, evaluations with Ottawa GRS tool, checklist tools, and interview files). The list of participants with their accompanied letter names will be kept in a password-protected file on the PIs personal computer and will be accessible only to the PI and Marie Edwards.

It is possible that you may know or recognize other participants in this study, and/or that other participant may know or recognize you. In order to maintain their privacy and protect your own, all participants will be asked to sign a pledge of confidentiality. This pledge demonstrates that you understand you will have knowledge of the performance of other participants as well as knowledge of curriculum associated with the program. It also demonstrates that you will not communicate this knowledge (in any format) to individuals not associated with this thesis project.

Dissemination of Results:

Information from this study will be submitted as part of a thesis project. It is hoped that these findings and subsequent research will be presented locally, provincially, or nationally through publication or presentations. Should you wish to receive results related to this study, they will be made available to you within 12 months of completing the program and before publication.

Consent to participate

Appendix I

Participation in this survey is completely voluntary and will have no repercussions on your work at your place of employment if you decide not to participate. You are free to withdraw from the study at any time, and/or refrain from participating in the educational program, without prejudice or consequences. Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Education/Nursing Ethics Board at the University of Manitoba and the Health Sciences Centre. If you have concerns or complaints about this project, you may contact any of the investigators or the Human Ethics Secretariat at 747-7122 or email **humanethics@umanitoba.ca**. Or the Human Ethics Coordinator (HEC) at 474-7122.

A copy of this consent form has been given to you to keep for your records and reference.

For further information contact:
Amanda Lucas MN student
XXX@myumanitoba.ca

Participant signature

Date

Primary Investigator signature

Date

Appendix J

Pledge of Confidentiality

I _____, through my involvement with and participation in
“Development of Crisis Resource Management Skills Using High-Fidelity Simulation
Education”

will observe and have knowledge of other participants in this education program. I understand my observations and knowledge will contain confidential information that other participants perceive as personal and private. I also understand that curriculum associated with this program is confidential. To treat information as confidential means to not divulge it or make it accessible to anyone who is not directly involved as part of the study. Such a disclosure would violate the confidentiality promised to other participants and/or affect the success of future participants.

I agree to fulfill my responsibilities on this project in accordance with the following

1. I agree to not discuss events observed in this education program with non-participants, either verbally or through written communication.
2. I agree to not divulge any knowledge of curriculum (simulation cases) to non-participants, either verbally or through written communication.

Name

Signature

Date