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The Relationship Of Fidelity On Simulation Performance

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THE RELATIONSHIP OF FIDELITY ON SIMULATION PERFORMANCE

by

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This dissertation, submitted by Gail Libby Johnson, in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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Gail Libby Johnson
December 15, 2017

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ABSTRACT

Introduction: The literature is limited and conflicting regarding the effect of simulation fidelity on nurse performance during simulation. Limited publications were found that addressed all aspects of simulation in health care: mannequin, environment, equipment, scenario, and psychological.

Purpose: The purpose of this study was to examine the relationship between fidelity and nurse experience on performance in simulation. The NLN/Jeffries Simulation Framework provided the theoretical foundation for this study

Design and Sample: For this descriptive study, 35 registered nurses were randomly assigned to participate in a high fidelity or low fidelity simulation scenario. A 12-minute scenario was administered and identical for both groups. Fidelity level differences included mannequin type, equipment/environment, and psychological factors.

Methods: Nurse performance was measured by the Clinical Simulation Evaluation Tool (CSET). CSET scores were analyzed using independent t-tests for differences and two-way ANOVA to detect main effects and interaction between fidelity and experience. Pearson's Correlation was used to determine correlation between demographic variables as well as between SDS score and fidelity level; T-tests were conducted to determine difference in SDS means between fidelity levels.

Results: There was no statistically significant difference in performance based on nurse experience alone (t = -1.50, p = .143). There was a statistically significant difference in performance based on fidelity level (t=5.02, p = .001) and a significant interaction effect between fidelity and experience (F(1,31) = 10.231, p = 0.003*).* SDS score correlated with fidelity level.

Implications: Results of this study have implications for undergraduate, graduate and continuing nursing education. Simulation is used frequently in nursing education and can be resource intensive. This study may provide information that will allow educators to choose the best level of fidelity for participants. Results will also contribute to the body of knowledge regarding the NLN/Jeffries Simulation Framework.

CHAPTER I

INTRODUCTION

Background

Simulation is an educational method, or technique (Gaba, 2004) that has gained popularity in all levels of healthcare education since its rebirth in the 1960's. Simulation imitates, replicates, or represents a situation, process, behavior, or action from real-life and recreates it for education/training, assessment/testing, research, and improving processes/systems (Littlewood, 2011; Society for Simulation in Healthcare, 2014). Simulators are the technologies used during simulation, and include task trainers, full body mannequins and virtual reality-computer-based programs. Although there are clear differences between simulation (technique) and simulators (technology) (Gaba, 2004), they are often used interchangeably and incorrectly in the literature.

Simulation is now commonplace in medical and nursing education. In a 2011 report from the Association of American Medical Colleges (AAMC), 92% of responding medical schools included simulation in the curriculum as did 86% of teaching hospitals (Passiment, Sacks, & Huang, 2011). Similarly, in 2010 the National Council of State Boards of Nursing (NCSBN) surveyed 1,729 U.S. nursing programs to better understand the prevalence and use of simulation in nursing education. Of the 1060 respondents, 87% indicated that their students participated in simulation (Hayden, 2010). Medical and nursing schools have incorporated simulation into curricula as a replacement for standard

lecture-based content, clinical rotations, and the use of actual patients for procedures skills training (Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014; Passiment et al., 2011). Simulation's popularity is multifactorial and programs have turned to simulation as clinical rotation sites become increasingly competitive and difficult to locate in some communities. In addition, scenarios can be structured to provide consistent clinical experiences for students. It also offers an environment where students and health care professionals can practice technical and procedural skills at no risk to the patients. Simulation also provides an opportunity for medical and nursing students to demonstrate proficiencies during objective clinical structured exams or other evaluation practices rather than simply verbalizing or writing an explanation. Because medical students, residents and newly licensed nurses have experienced simulation in their education programs, they expect to have it available by their employers in clinical practice (Johnson, personal experience, 2015).

Health care systems also utilize simulation for ongoing staff development, competency assessment, and identification of systems issues (HealthPartners Clinical Simulation, 2016). Therefore failure to recognize signs and symptoms of clinical deterioration contribute to adverse events in healthcare organizations (Garvey, 2015, Levett-Jones, Lapkin, Hoffman, Arthur, Roche, 2011). As a result, the Institute of Medicine and Joint Commission published recommendations for incorporating simulation into education and competency assessment to promote patient safety (Kohn, Corrigan, & Donaldson, 2000). Simulation has been successfully utilized to increase staff's ability to recognize and respond to deteriorating patient conditions (S. Cooper et al., 2012; Johnson & Kipper, 2011; Levett-Jones, Lapkin, Hoffman, Arthur, Roche, 2011).

Since 2006, the Association for Healthcare Quality and Research (AHRQ) has funded research grants that address using simulation to maximize patient safety. The first AHRQ grant cycle, FY 2006-2007, provided over $10 million for simulation research (AHRQ, 2014). These grants have continued to be issued with 11 multi-year projects funded in 2011 (AHRQ, 2011), and a reissuance of the PAR-11-024 *Advances in Patient Safety through Simulation Research (R18)* grant again in 2013 (AHRQ, 2014). This funding opportunity included research questions regarding methodological issues including simulation design and factors that affect performance. Previous AHRQ funded simulation grants did not address methodological issues and focused only on patient safety related issues. While the previous grants have demonstrated AHRQ's recognition of the importance of simulation in maximizing patient safety, the addition of methodological aspects has further illustrated the need for a greater understanding of how simulation design characteristics, including fidelity, may impact outcomes.

Therefore, the purpose of this study was to examine the relationship of simulation fidelity and years of nursing experience when measuring simulated performance scores of registered nurses.

Simulation Outcomes

Simulation outcomes include, but are not limited to, participant satisfaction, increased confidence, knowledge acquisition, skill performance, and critical thinking. (Jeffries, 2005, 2012). There is an abundance of evidence that indicates participants like simulation and that confidence increases following simulation (Elfrink Cordi, Leighton, Ryan-Wenger, Doyle, & Ravert, 2012; Jeffries & Rizzolo, 2006). Many studies also address knowledge acquisition (J. M. O'Donnell, Decker, & Howard, 2012). While there

are a number of studies demonstrating increased skill performance, they are typically related to task trainer use and acquisition of specific skills such as central line insertion, intravenous catheter insertion, cardiopulmonary resuscitation, and surgical procedures. There is less published on using simulation to assess integrated knowledge, or performance including the judgments and skills that nurses utilize when caring for patients in clinical situations (Brydges, 2010). Additionally, some of the studies that did investigate outcomes beyond satisfaction or participant perceptions, compared simulation to traditional educational methods or only focused on mannequin fidelity. Published studies comparing participant performance when encountering different levels of simulation fidelity, not just simulator fidelity, are limited.

Instruments

A number of instruments have been developed to measure simulation-specific outcomes. (Adamson, 2011; Adamson & Kardong-Edgren, 2012; Adamson, Kardong-Edgren, & Willhaus, 2012; Kardong-Edgren, Adamson, & Fitzgerald, 2010). Many instruments have been developed by an individual researcher, used for one study, and may lack documentation of validity and reliability. Studies using existing instruments with new populations and venues are recommended (Adamson et al., 2012). One instrument, the Clinical Simulation Evaluation Tool (CSET) (Adamson et al., 2012; Grant, Moss, Epps, & Watts, 2010; Radhakrishnan, Roche, & Cunningham, 2007) has been used to evaluate clinical performance during simulation.

Fidelity

The term, fidelity, is prevalent in simulation literature. Unfortunately it frequently refers only to a mannequin (Cant & Cooper, 2010). Yet "simulation in nursing is not

synonymous with the human patient simulator any more than multimedia is with video" (Schiavenato, 2009). One challenge with fidelity in healthcare simulation, is that unlike the military or aviation industry, there are no standardized terms or definitions of what makes something high or low fidelity (Rehmann, Mitman, & Reynolds, 1995). Paper-pencil case studies have been used as an example of low fidelity simulation (Tosterud, Hedelin, & Hall-Lord, 2013), while others classify low fidelity by the type of mannequin used, such as Laerdal's Vitasim Kelly (Thompson, Yang, & Crouch, 2012).

Another challenge with categorizing fidelity based only on mannequins is that mannequin fidelity is relative. Because of technological advances, mannequins that were considered high fidelity in 2007, i.e. Laerdal SimMan Classic, is now considered moderate fidelity as it lacks features like blink/eye opening, pupil reactivity, drug recognition, and a cyanosis feature. Mannequin manufacturers build and market increasingly expensive mannequins that have advanced features (Epps, White, & Tofil, 2013). Yet features and characteristics may not be clinically valuable or accurate (De Luca, Sall, Sailley, Capellier, & Khoury, 2015).

Experience

Years of nursing experience is one variable that may impact simulation outcomes (Jeffries 2005, 2012; Adamson, 2015). Studies involving nursing students, medical students, and residents, have used their current academic year to denote experience. For example, junior or senior, fourth year, post graduate year 1.This study, and other studies with practicing nurses, used years of nursing experience. Previous work based on cognitive load theory by van Merrienboer & Sweller (2010), suggest that lower levels of

fidelity be used for novice learners and higher levels of fidelity for experienced learners. However, there are very limited published studies that include experience as a variable.

Cognitive Load

It has been suggested that the highest level of fidelity possible should be used for all simulations (Caro, 1988; Jeffries, 2005; Jeffries & Rizzolo, 2006). However, a situation that is too realistic may be overwhelming for participants with limited experience. High realism, or high fidelity may provide too high of a cognitive load, thus negatively affecting participant learning and performance (Groom, Henderson, & Sittner, 2014; Kalyuga, Ayres, Chandler, & Sweller, 2003; Sweller, 1988; van Merrienboer & Sweller, 2010).

Problem Statement

There has been tremendous growth in the use of simulation as an educational methodology in healthcare undergraduate, graduate, and continuing education, and recognition that incorporating simulation positively impacts patient safety. Despite this, there is little known regarding how the design, or characteristics of the simulation activity, impact participant outcomes. Jeffries (2005) published a simulation framework depicting the relationship among the facilitator, participant, simulation design, and participant outcomes. In 2011, the NLN-Jeffries Simulation Framework study commenced to evaluate "the state-of-the science and existing research" (Ravert, 2013, p. e1). This was a year-long study sponsored by the National League for Nursing and the International Association of Clinical Simulation. The results illuminated gaps in current research and provided recommendations for future work. These recommendations include a dedicated focus on the relationship between fidelity and participant experience and

focusing outcomes research on more than participant satisfaction and knowledge acquisition (Groom et al., 2014; J. M. O'Donnell et al., 2012). While fidelity has been identified as a key simulation design characteristic, little research has been done on fidelity levels beyond the simulator. Simulation fidelity encompasses mannequins, equipment, environment, and psychological aspects (Rehmann, Mitman, & Reynolds, 1995). It is often described under two conditions: low fidelity and high fidelity.

Study Significance

This study will contribute to the body of knowledge supporting the National League for Nursing/Jeffries Simulation Framework (NLN/Jeffries Simulation Framwork). Results of this study may increase the understanding of fidelity as it applies to simulation and a nurse's ability to perform during simulation. These results may directly impact simulation centers and educators working in academic and health system settings by allowing them to incorporate the level of fidelity that will optimize participant performance. In addition, maximizing performance in simulated practice events may ultimately impact and improve patient outcomes as participants do in real life what they practice in simulation.

Purpose Statement

The purpose of this quantitative study was to examine the relationship of simulation fidelity and years of nursing experience when measuring simulated performance scores of registered nurses. It was hypothesized that different levels of fidelity may result in variations in simulation performance scores, and that variations in experienced nurses and novice nurses simulation performance scores may be explained by interactions among the levels of simulator fidelity and the nurses' experience. More

experienced nurses in a high fidelity simulation may have a higher simulation performance score than experienced nurses in a low fidelity simulation, conversely, novice nurses may have a higher simulation performance score when participating in a low fidelity simulation when compared to participation in high fidelity simulation. The purpose of this study was examined by the following study aims:

Study Aims

1. To determine the demographic characteristics of novice and experienced practicing nurses participating in low and high fidelity simulations.
2. To examine differences in simulation performance scores of novice and experienced nurses.
3. To examine differences in simulation performance scores of registered nurses during low and high fidelity simulations.
4. To examine differences in Simulation Design Scale scores between the high and low fidelity groups.
5. To examine the association among nurses' demographics, years of nursing experience, fidelity levels, and simulation performance scores.

Theoretical Framework

This study will be guided by the NLN-Jeffries Simulation Framework (Jeffries, 2005; Jeffries & Rogers, 2012). The framework was developed from educational theories including constructivism, and Bandura's Social Learning Theory as well as simulation literature. Theoretical underpinnings of this model include the assumption that the outcomes from a simulation activity (knowledge, skill performance, critical thinking,

self-confidence and participant satisfaction) are determined by the design of the simulation, the participant, the facilitator, and general educational practices. This is illustrated with one-way arrows. While the facilitator, participant, or educational practices influence the scenario design, the reverse is not true (Jeffries, 2005). The experience level of a simulation educator will impact the type of scenario that is designed, but the design characteristics do not impact the participant or facilitator (Figure 1).

The NLN/Jeffries Simulation Framework was designed to provide a guide for the design, implementation and evaluation of simulation in nursing education. The framework consists of five constructs: 1) Facilitator, 2) Participant, 3) Education Practices, 4) Simulation Design Characteristics and 5) Outcomes.

Figure 1. NLN/Jeffries Simulation Framework. (From Jeffries, P. (Ed.). (2012) *Simulation in Nursing Education: From Conceptualization to Evaluation*. (2nd ed.). New York, NY: National League for Nursing.

Participant

Jeffries originally designed the framework using *Student* (Jeffries, 2005). The construct was changed to *Participant* in 2012. This change was based on the findings of the National League for Nursing's Jeffries Simulation Framework Study, and feedback from participants who attended the 2012 INACSL conference (Jones, Reese, & Shelton, 2014). This change acknowledged that not all individuals involved in simulation are students, and expanded the applicability to non-academic settings. Within the *Participant* construct, there are a number of variables that could impact the design of the simulation as well as outcomes. In addition to demographics (experience level, gender, type of program, age, culture/ethnicity), other variables include roles and the values that a participant has regarding their simulation experience. Examples of values include active learning, timely feedback, patient–centered care, application of professional behaviors, skills, knowledge and attitudes, and collaborative learning (Durham, Cato, & Lasater, 2014). According to Jeffries (2006), how the participants are oriented to the simulation experience can affect the outcome and their achievement of goals (external). Wilson & Hagler (2012) found that simply reviewing objectives did not provide sufficient support for the learners. Orientation to the environment and expected roles were also key to success.

Facilitator

Similar to participant, Jeffries originally used the term *Teacher* to indicate the individual facilitating the simulation experience. The construct was changed to *Facilitator* in 2012. Jeffries & Rogers (2012) suggest that the effectiveness of the facilitator impacts simulation outcomes. Instructor effectiveness may be affected by

demographics, like their age, experience, and area of clinical expertise as well as their familiarity and comfort with simulation, and level of preparation for facilitating the simulation experience. Reese, as cited in Jeffries & Rogers (2012, p. 28), identified several measures pertaining to facilitator effectiveness in her 2010 dissertation *Effective Teaching in Clinical Simulation: Development of the Student Perception of Effective Teaching in Clinical Simulation Scale*. The measures identified by students, include: usefulness of facilitator feedback, perception that the debriefing session supported clinical reasoning, and fidelity of the simulation. Variables within the Facilitator construct directly impacts the Simulation Design Characteristics as well as Outcomes.

Education Practices in Simulation

The construct, Educational Practices, has less to do with simulation-specific design, than ensuring that features of effective instruction are in place. Elements within Educational Practices include active learning, providing feedback to participants, ensuring there is a process for participants to provide feedback to the facilitator, having high expectations, and consideration of diverse learning styles.

Simulation Design Characteristics

Jeffries identified five features that should be considered when designing simulation activities. These include objectives, problem solving, participant support, debriefing and fidelity. All should be included; the extent is dependent on the purpose and intended outcomes (Jeffries, 2005; Jeffries & Rogers, 2012).

1. Objectives. Objectives guide the simulation much as they guide any instructional design process. Simulation allows the facilitator to create a scenario that includes anything. Objectives are utilized to ensure that there is a clear purpose for the

scenario and that the elements included are important and not extraneous. Opinions differ regarding whether to share objectives with participants prior to the scenario (Jeffries, 2007), or wait and review objectives after the scenario, during the debriefing session (Alinier, 2010; Cioffi, 2001).

2. Problem solving. Problem solving refers to the level of complexity of the simulation. Jeffries and Rogers suggest that the scenario should be challenging but manageable to provide an effective learning experience.

3. Participant support. Participant support includes the cues and assistance that are provided to the participant during the simulation. For some simulations, the facilitator may choose to not provide any additional assistance, in other situations, the facilitator may stop the scenario to provide instruction, yet a third option may be that assistance is provided by someone that would normally be in the situation at hand. For example, a charge nurse or more senior physician may join the scenario and provide guidance. Cues are different than assistance. Cues are designed to elicit an action or response. Cues may be something the participant is expected to recognize such as a blood pressure change, diaphoresis, or dressing. Cues can also be provided by embedded actors in the simulation, or may be a combination of both, especially if the participant hasn't recognized a particular cue. Cues can be subtle or dramatic depending on the objectives and ability of the participant to recognize the cue. If a subtle cue is not recognized, the facilitator may choose to make the next cue more obvious. Cue recognition would then be one of the topics for discussion during debriefing.

4. Debriefing. Debriefing offers participants the opportunity to reflect on their performance and/or observations in the simulation and should occur immediately after

the simulation (Jeffries & Rogers, 2012). There are a number of debriefing style recommendations in the literature (Decker et al., 2013; Grant et al., 2010; Hayden, Smiley, et al., 2014; Jeffries & Rizzolo, 2006; Jeffries & Rogers, 2012; Rudolph, Simon, Rivard, Dufresne, & Raemer, 2007), with generally accepted assumptions that the for effective debriefings the facilitator should create a safe and supportive environment, create specific topics for discussion that relate to scenario objectives and participant actions in the simulation, and ensure that they are guiding the discussion, with participants talking most of the time.

5. Fidelity. Fidelity "is the extent to which a simulation mimics reality" (Jeffries & Rogers, 2012, p. 33) and will be described in detail in Chapter Two. The direct relationship between fidelity, as an aspect of simulation design characteristics, and outcomes influences this study.

Outcomes

The final construct of the framework is Outcomes. According to this model, the construct, *Outcomes,* can be influenced by a number of factors including participant experience and the design characteristics, including the fidelity. Jeffries & Rogers (2012) list several examples including learning/knowledge gained, skills performed, participant satisfaction, self-confidence, and critical thinking. They recognize that this is only some of the outcomes and the list isn't intended to be all-inclusive. Increased patient safety and identification/mitigation of systems issues are outcome of simulation, yet are not included in this list. Participant performance is also omitted. One significant limitation of this framework is that the measurement tools to substantiate the constructs are often based on

participant perception rather than objective documentation of a change in performance or transfer of learning to the patient care environment.

Although initially published in 2005, few simulation studies cite this framework as their theory (Groom et al., 2014; Hallmark, Thomas, & Gantt, 2013; Sanford, 2010; Young & Shellenbarger, 2012). However, lack of a theoretical framework is a recognized weakness in simulation-related research (Dieckmann, Phero, et al., 2011; Issenberg, McGaghie, Petrusa, Lee Gordon, & Scalese, 2005; Kardong-Edgren & Roche, 2013; McGaghie, Issenberg, Petrusa, & Scalese, 2010).

NLN/Jeffries Simulation Framework Study

In 2011, the National League for Nursing (NLN) sponsored an in-depth study of the National League for Nursing-Jeffries Simulation Framework (NLN/Jeffries Simulation Framework). This multi-year project included an in-depth analysis of each of the constructs. The preliminary findings were presented at the 2011 International Nursing Association for Clinical Simulation & Learning (INACSL) conference. Research needs were identified regarding fidelity and the relationship between fidelity and learner experience (Groom et al., 2014). Gaps in knowledge were also identified in the Outcomes construct. There are many examples of participant satisfaction and knowledge in the literature, but a paucity of studies that explored participant performance and clinical judgment, especially with adequate rigor (J. O'Donnell, S. Decker, V. Howard, T. Levett-Jones, & C. W. Miller, 2014b). Recommendations from the NLN/Jeffries Simulation Framework *Outcomes Construct* work, include ensuring the use of reliable and valid tools (J. O'Donnell et al., 2014b). The outcome measures chosen for this study will be

participant performance based on the Clinical Simulation Evaluation Tool score and satisfaction specifically regarding the design characteristic, fidelity.

Assumptions

For this study, several assumptions are acknowledged as follows. First, participants will engage in the simulation scenario and put forth their best effort. Second, all participants will receive a pre-brief before the simulation, which is consistent with best practice. Finally, the study sample is representative of the general population of nurses in the geographic area.

Delimitations

This study only addresses simulation involving full-body mannequins and immersive environments. Other simulation technologies include task trainers and computer-based simulation. Fidelity and performance related to the use of these other simulation technologies are not addressed in this study and any results from this study cannot be generalized to these other technologies.

Definitions of Terms

Operational Definitions

Experienced Nurse. A registered nurse with more than three years of acute care experience.

Fidelity. The level of realism of the simulation or aspects of the simulation; how realistically something replicates the real world.

Novice Nurse: A registered nurse with 0 to three years of nursing experience.

Simulation Performance Score. An outcome measurement of participant actions and behaviors during simulation. Performance reflects the ability to correctly assess a

situation, synthesize clinical knowledge, and prioritize and perform interventions (including psychomotor skills) according to what is encountered during the simulation. For this study, performance will be indicated by the score on the CSET.

Study Definitions

Environmental fidelity. The degree that the physical environment, including any related equipment, replicates what it is representing.

Functional Fidelity: The level of feedback or response provided to the participant in response to action/nonaction. Obtaining a flash of blood in the catheter during intravenous catheter placement is one example.

High fidelity mannequin: A wireless mannequin, programmed by computer with advanced features including eye opening & pupillary response, chest rise, cyanosis, dynamic vital signs. Laerdal SimMan 3G will be used for this study.

Low fidelity mannequin: A mannequin with limited physical and functional realism; this includes lack of eye opening/blink function and no chest expansion with spontaneous respiration. Laerdal Megacode Kelly will be used for this study.

Mannequin fidelity. The degree that a mannequin looks and responds like a patient.

Physical fidelity. The extent that the simulation looks, feels, sounds like what it is representing.

Psychological fidelity: How real the experience feels to the participant; the level to which the participant believes that they are engaged in the actual event rather than a simulation.

Scenario fidelity: How closely the flow of the simulation scenario follows what would occur in an actual clinical situation. This may include realistic changes in vital signs or realistic timing of events.

Simulation fidelity: For the purpose of this study, simulation fidelity refers to the functional and physical fidelity of the mannequin, environment, and equipment, as well as the psychological fidelity.

Summary

Although simulation is widely used in academic settings and continuing nursing education, there are significant gaps in current knowledge. Both the NLN/Jeffries Simulation Framework Study and the Association for Healthcare Quality and Research (AHRQ) have recommended further research related to identifying best practices in simulation. Because this study focused on the NLN/Jeffries Simulation Framework design characteristics, fidelity, it met one recommendation identified by the *NLN/Jeffries Simulation Framework* Study team. This recommendation was to investigate "how design characteristics, including fidelity, influences outcomes" (O'Donnell, 2014, p. 379). As simulation becomes increasingly prevalent in undergraduate, graduate and continuing nursing education, it is imperative that there is research-based recommendations for simulation design to maximize outcomes.

Organization of the Dissertation

This research study will be presented in five chapters. Chapter One consists of the background, definition of terms, problem statement, research questions, purpose, significance, theoretical framework, and limitations/assumptions. Chapter Two is comprised of the literature review including the areas of simulation, fidelity, outcomes,

cognitive load, and instruments. Chapter Three presents the methodology that will be used in this research study including information on the participants, instruments, data collection and analysis. Chapter Four presents and summarizes the findings of the research. This includes the participant demographics and statistics used to analyze the data. Finally, Chapter Five summarizes the study and includes a discussion of the findings and recommendations for further research in this area.

CHAPTER II

LITERATURE REVIEW

This literature review is organized into five sections. The first section provides an overview of the history of simulation in healthcare applications and the National League for Nursing-Jeffries Simulation Framework *(NLN/Jeffries Simulation Framework)* and provides a foundation for the remaining sections. The second section describes the literature within the context of Aim 1 and participants in simulation. The third section addresses Aim 2 and simulation fidelity, while the fourth section addresses Aim 3, including outcomes and cognitive load. The final section, summarizes some of the limitations in health care simulation.

The purpose of this quantitative study was to examine the effect of simulation fidelity and nursing experience on performance of registered nurses in a simulation. Simulation fidelity encompasses mannequins, equipment, environment, and psychological aspects under two conditions: low fidelity and high fidelity. It was hypothesized that different levels of fidelity may result in variations in simulation performance scores, and that variations in experienced nurses and novice nurses simulation performance scores may be explained by interactions among the levels of simulator fidelity and the nurses' experience. More experienced nurses in a high fidelity simulation may have better simulation performance than experienced nurses in a low fidelity simulation, conversely, novice nurses may perform better when participating in a

low fidelity simulation when compared to high fidelity simulation. The purpose of this study will be examined by the following research study aims:

Study Aims

1. To determine the demographic characteristics of novice and experienced practicing nurses participating in low and high fidelity simulations.
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4. To examine differences in Simulation Design Scale scores between the high and low fidelity groups.
5. To examine the association among nurses' demographics, years of nursing experience, fidelity levels, and simulation performance scores.

History

Early Simulation

The start of simulation in healthcare is typically credited to the aviation industry and early flight simulators (Rizollo, 2014; Rosen, 2013), but actually dates back over 250 years earlier to 18th century France (Byrne, 2013; Gelbart, 1998; Owen, 2012). In 1756, Madame du Coudray, a French midwife, sought to improve the performance of rural midwives and maternal and fetal safety with simulation. She created a life size anatomical model of a woman's pelvis and baby out of cloth, leather, wicker, stuffing, and sponges. This model emulated a high level of realism, or fidelity in her "machine"

which included organs and a womb out of colored fabric and leather, bones from wood and wicker, membranes, a cervix with a ribbon to allow for dilation, and saturated sponges to provide clear or red fluid. She valued the opportunity for hands-on practice "The model is meant mostly for maneuvers that, as others confirm, allow her students to gain confidence, be encouraged and succeed perfectly" (Gelbart, 1998). This experience resulted in an "impression that can never be erased" (p. 63). Although a number of simulators were created and used for training and assessment during the 18th and 19th centuries with good outcomes, they fell out of favor with medical educators for the first half of the 20th century as the focus was cadaveric exploration, and learning on patients (Byrne, 2013; Owen, 2012).

Aviation & Military Influence

Modern healthcare simulation is often attributed to the technological advances of the computer age and successful utilization of flight simulators (Koonce & Debons, 2010; Owen, 2012; Rosen, 2008, 2013). In the early 1900s, rudimentary training devices were available to help new pilots learn to control an aircraft (Hays & Singer, 1989). During World War I, more pilot and plane losses were attributed to accidents than combat. In fact, the British found that only 10 percent of aviation deaths were due to enemy action or defective planes. The remainder were as a result of improper training and individual (pilot) physical defects (Koonce & Debons, 2010; Rosen, 2013). Between 1929-1931, Edwin Link developed the predecessor to modern flight simulators, the Link Trainer. In 1934, because of the number of pilot fatalities, the United States Army Air Corp purchased six *Link* trainers. However, these early training devices were so unlike actual

airplanes because of low functional fidelity that “many techniques had to be unlearned” (Hays & Singer, 1989; p. 79).

In the 1940’s, flight simulators became more advanced, featuring a replicated cockpit with instruments. The increased fidelity, and the need to train large numbers of personnel during World War II, resulted in greater acceptance of the use of flight simulators (Hays & Singer, 1989; Koonce & Debons, 2010). The military provided funding for additional development and purchased 10,000 trainers (Rosen, 2013). In the 1960s and 1970s, technological advances allowed for more advanced simulators. These provided a realistic cockpit appearance and switch function as well as accurate flight characteristics (Caro, 1988). According to Caro, by the late 1970s, “training in realistic simulators with elaborate and realistic visual, motion, and sound systems began to be accepted as a partial substitute for training in aircraft” (1988, p. 236). The FAA has acknowledged that simulators can provide more in-depth, efficient, safe, and cost effective training and testing than what is possible to achieve in airplanes. NASA developed such realistic space flight simulators for astronaut training that “it was almost impossible to distinguish simulation from real flight” (Hays & Singer, 1989; p. 93). This level of fidelity continues today in commercial and military aviation use. In addition to pilot technique, simulation was also used to increase flight safety through training in cockpit communication techniques during emergency situations, called crew resource management (CRM). The success of this aviation program has led to implementation of concepts in medical emergency team performance and emergency management in healthcare.

Early Healthcare Simulators

Computer and related technologies of advanced flight simulators also impacted healthcare simulation. The 1960s is generally considered the start of modern healthcare simulation. Few early pioneers developed mannequins and task trainers with varying features and levels of physical response. Laerdal created Resusci-Annie (Rizollo, 2014; Rosen, 2013) and a team from the Department of Anesthesiology at the University of Southern California created the first computerized patient simulator, SimOne. While the Resusci-Annie was a static doll designed for practicing cardiopulmonary resuscitation, the SimOne simulator could breathe, had palpable pulses, heart sounds, eye opening, reactive pupils, vomiting, fasciculation, cyanosis, and drug recognition. However, it was not a full body mannequin as it ended at the hips (Rosen, 2013). Shortly after SimOne, others created similar simulators. These early simulators were expensive and required a roomful of equipment to run them. They were only available at select programs.

There were few mannequin advances over the next 30 years and limited mannequins available for purchase. This changed in the 21st century. Since 2000, there has been an explosion in the area of mannequin development. The three main mannequin manufacturers, CAE Healthcare, Gaumard, and Laerdal, have multiple mannequin product lines including pediatric, obstetrical, and adult with varying features and costs. As popularity has increased, additional companies are developing and/or distributing simulators as well. Over the same time period, task trainers have been developed. One task trainer, the PROMPT Birthing Simulator (Limbs & Things, 2002-2014), bears a striking resemblance to the "machine" developed by Madame du Coudray (Gelbart,

1998). Simulator use has expanded from its roots in anesthesiology to all aspects of academic preparation and continuing professional development.

Simulation in Nursing

Even though simulation was no longer routinely used in medical education in the 20th century, Mrs. Chase, a 5'4" cloth doll, became part of nursing education in 1911 (Rizollo, 2014). This commercially available doll lacked the realism and technological advances of modern simulators; she did have jointed limbs and later models included fluid reservoirs for catheterization. Nursing students at many schools throughout the United States learned and practiced clinical skills using Mrs. Chase as their patient.

High fidelity simulators have been used increasingly in nursing education for the past 10 years (Nehring, 2010) as nursing faculty and students realized the value-added benefits of simulation. Including simulation in nursing education allows students to practice technical skills, communication, critical thinking and clinical decision making without putting patients at risk (Hayden, Smiley, et al., 2014). By 2010, 917 nursing programs in the United States had incorporated the use of medium or high fidelity mannequins in their curriculum (Hayden, 2010). As the use of simulation has increased, Boards of Nursing in several states have allowed schools to replace clinical time with simulation. This practice was not universally supported as there was a lack of evidence regarding the effect of simulation as a replacement strategy (Hayden, Smiley, et al., 2014), but may be changing because of recent study findings.

In 2011, the National Council of State Boards of Nursing (NCSBN) implemented a large-scale, longitudinal, randomized, control study to investigate the effect of replacing up to 50% of clinical hours with simulation. This two-year study involved 666 nursing

students at ten prelicensure programs across the United States, (effect size d = .35, p = .05, power = .92). This study was different than many previous simulation studies in that it identified a theoretical framework, established a control group, randomization process, and adequate sample size/power, and utilized validated instruments involving multiple outcomes. Participants were randomized into 3 groups: traditional clinical experiences (may include <10% simulation time), 25% clinical time replaced with simulation, and 50% clinical time replaced with simulation. There was no statistically significant difference between groups for knowledge (p = .48), NCLEX pass rate (p = .74), or manager's assessment of readiness for practice; the 50% simulation group reported higher levels of feeling prepared for practice (p = .03). Clinical competence was evaluated by clinical topic/rotation and results varied based on topic. Creighton Competency Evaluation Instrument (C-CEI) scores were higher in the control group for maternal child (p = .02) and mental health (p = .05); the control group and 25% group for nursing fundamentals (p = <.001) and pediatrics (p = .001); in the 25% and 50% groups for advanced medical-surgical nursing (p = .03); and in the 25% group for community health nursing (p < .01). Although there were statistically significant differences, all scores were well over 90%, meeting the criteria for clinical competence as determined by clinical preceptors and instructors (Hayden, et al. 2014, p. S15).

It is important to note that simulation time in this study included both active participant and active observer. A nursing student may have only participated as a nurse or family member at the bedside for 15 minutes in an eight-hour simulation day. The remaining time was spent observing and discussing simulations during the debriefing sessions; thus the simulation groups had fewer hours of direct patient (simulated or real)

contact per student than the traditional clinical/control group. Another important factor is that there was significant variability in what schools could constitute as simulation. Simulation for this study included "medium- or high-fidelity manikins, standardized patients, role-playing, skills stations, and computer-based critical thinking simulations" (Hayden, Smiley, et al., 2014, p. S8).

Over the past 60 years, the technological advances and accomplishments in health care simulation have been significant. Simulation has progressed from simple mannequins and trainers for cardiopulmonary resuscitation (CPR) and nursing skills, to complex, computer-driven mannequins that respond to participant actions. While simulation technology has advanced, research-based evidence regarding the design and implementation of simulation-based education has not progressed as rapidly.

Theoretical Underpinnings in Simulation Research

Identification of a conceptual or theoretical framework has been limited in simulation research (Kardong-Edgren & Roche, 2013; Ravert, 2013), yet it is important to base research on a framework in order to provide common assumptions, definitions, and understand underlying processes (Dieckmann, Phero, et al., 2011). In a systematic review of the literature on simulation in nursing education, Jamil Norman (2012) found that only 41% of research articles identified a theoretical framework. Of the 17 articles reviewed, seven had a theoretical framework identified and only two of these used a simulation-specific theory. The other five articles identified one of several educational theories.

Theoretical frameworks used in simulation research focus predominantly on general education theories including Adult Learning Theory (Knowles), Experiential

Learning (Kolb), Novice to Expert (Benner), Self-efficacy (Bandura), Deliberate Practice (Ericsson), Reflective Practice (Schön), and to a lesser extent, Sweller's Cognitive Load Theory (V. J. Hallenbeck, 2012; Kaakinen & Arwood, 2009; Kardong-Edgren & Roche, 2013; J. Norman, 2012).

In 2007, Jeffries published the first simulation-specific framework, the Jeffries Simulation Framework, and in 2012 it was officially renamed the NLN/Jeffries Simulation Framework (National League for Nursing-Jeffries Simulation Framework). Although developed specifically for use in simulation-based education, its use is limited in simulation literature, and exclusively within nursing. The NLN NLN/Jeffries Simulation Framework has been identified as the theoretical framework for an increasing number of studies (Basak, Unver, Moss, Watts, & Gaioso, 2016; Beebe, 2012; Bussard, 2015 ; Grant et al., 2010; Guhde, 2011; Stefaniak & Turkelson, 2013; Wilson & Hagler, 2012; Young & Shellenbarger, 2012), most notably the NCSBN Simulation Study (Hayden, Smiley, et al., 2014). In 2010, the National League for Nursing, in conjunction with the International Nursing Association for Clinical and Simulation Learning (INACSL), initiated a multi-year project to investigate the state of the science regarding the NLN NLN/Jeffries Simulation Framework. Aspects of the Participant, Simulation Design and Outcomes constructs formed the basis for this literature review.

This Literature review will be organized as follows: Participant, Simulation Scenario Design, Fidelity, Outcomes.

Participant Characteristics

As part of the International Nursing Association for Clinical Simulation and Learning's (INACSL) international project to examine the NLN NLN/Jeffries Simulation

Framework and its constructs, a project team examined the nature of the individuals who participate in simulation. The comprehensive review included all types of simulation from mannequins and task trainers to standardized patients and actors (Durham et al., 2014). The *NLN/* NLN/Jeffries Simulation Framework *Participant Construct* team found that the participants involved in simulation research were very diverse and included professionals, graduate, and undergraduate students from nursing, medicine and other healthcare disciplines as well as non-health care areas like aviation and military. Jeffries' original simulation framework (Jeffries, 2007) used the term *student*; this was changed to *participant* in 2012 (Jeffries, 2012) to be more inclusive and accurately represent individuals involved in simulation activities. The NLN/Jeffries Simulation Framework includes three variables regarding participants: age, level, and program (Jeffries, 2005; Jeffries & Rizzolo, 2006; Jeffries & Rogers, 2012). Other participant variables identified in the literature include gender, culture/ethnicity, self-confidence, readiness to learn, learning style, and level of anxiety (Beischel, 2013; Durham et al., 2014; Fenske, Harris, Aebersold, & Hartman, 2013; Fraser et al., 2012; Shinnick & Woo, 2015).

Age, Student Program Level and Fidelity Level

Zapko, Ferranto, Blasiman & Shelestack (2017) used age and program level in the development of hypotheses for their study on the effect of serial simulations in nursing students. In this study of 199 nursing students, the researchers compared sophomore, junior and senior students' perceptions on their simulation experience. Basak, Unver Moss, Watts, & Gaioso (2016), also studied nursing students at different program levels. Basak, et al., compared the satisfaction of first year (beginning) and fourth year students (advanced) using low and high fidelity mannequins. They found that while all groups

rated the high-fidelity mannequin higher than the low-fidelity mannequin, advanced students rated the low-fidelity simulation higher than beginning students ($Z = -2.01$; $p = .04$). There were no statistically significant differences between the beginning and advanced students on the Simulation Design Scale.

There is a plethora of simulation research studies in the literature using nursing students (Aqel & Ahmad, 2014; Arnold, 2012; Baptista et al., 2016; Basak et al., 2016; Beebe, 2012; Bogossian et al., 2014; Brady, Bogossian, & Gibbons, 2015b; Bussard, 2015; Cardoza & Hood, 2012; Cato, 2012; Diener & Hobbs, 2012; Fero et al., 2010; Foronda, Liu, & Bauman, 2013; Guhde, 2011; Horsley & Wambach, 2015; Kirkman, 2013; Lapkin & Levett-Jones, 2011; Radhakrishnan et al., 2007; Schlairet, Schlairet, Sauls, & Bellflowers, 2015; Stefaniak & Turkelson, 2013; Tosterud et al., 2013; Zapko, Ferranto, Blasiman, & Shelestak, 2017). These studies often consisted of small convenience samples and rarely include effect size. However, this was not the case in a Lapkin and Levett-Jones (2011) study of 352 Australian nursing students, the 2014 multi-site Simulation Study by the National Council of State Boards of Nursing, nor in a study by Agel & Ahmad (2014). Aqel & Ahmad compared CPR knowledge and skill acquisition with nursing students using high-fidelity and low-fidelity mannequins. Ninety nursing students were randomly assigned to participate in either traditional CPR training with a low-fidelity mannequin or CPR training with a high fidelity mannequin. In addition to the random assignment and experimental design with an established control group, the researchers established an effect size, using *G** power. To establish a medium effect size (d=.50), a sample of 102 (51 per group) was needed for 80% power at a.05 significance level. Despite a smaller than planned sample size, (n = 90), the effect size

was larger than initially expected for knowledge and skill acquisition and statistically significant (d = -1.47 and -1.14 respectively; $p \leq .001$).

Registered Nurses and Simulation

Studies with registered nurses are more limited (Bultas, Hassler, Ercole, & Rea, 2014; Calhoun, Boone, Dauer, Campbell, & Montgomery, 2014; Cannon-Diehl, Rugari, & Jones, 2012; S. Cooper et al., 2012; Delaney, Friedman, Dolansky, & Fitzpatrick, 2015; Huseman, 2012). Articles describing implementation of a simulation program or activity are more common than formal research studies. Studies (Bultas et al., 2014; Hoadley, 2009; Thompson et al., 2012) comparing different fidelity levels with professional nurses as the sample are even more limited. Like many of the studies with nursing students, studies with registered nurses also consisted of small sample sizes.

Bultas, et al. (2014) and Calhoun, et al. (2014) both included small numbers of pediatric nurses in their respective studies. Of the 66 nurses recruited for the Bultas study, comparing high fidelity mannequin to static mannequin use for pediatric staff nurse education, only 33 nurses completed the study. Reasons for withdrawal included other employment, inconvenient study data collection times, and lack of interest. Because experienced nurses were sought, nurses with less than six months of experience were excluded. Although the findings included statistically significant differences between the two groups (greater increase in knowledge and retention with high fidelity), the effect size and power were not included.

In contrast, Calhoun, Boone, Dauer, Campbell, & Montgomery (2014), included a detailed description of their sample of registered nurses working in pediatric intensive care. The effect size was included in their study of using simulation to investigate the

impact of hours worked on task performance in a pediatric intensive care unit. Initial calculations indicated that a sample size of 50 would be required to achieve a large effect size. However, only 28 nurses were entered into the study. During the post hoc power calculation using the actual standard deviations, the researchers found that a sample of 11 was required to achieve a power of .80.

Studies with medical students and residents are also prevalent in simulation literature, especially related to procedural, teamwork, and resuscitation simulations.

Simulation Scenario Design

Recommendations for scenario design are prevalent in the literature. Scenarios should be designed based on the objectives to be achieved. In the NLN/Jeffries Simulation Framework, Jeffries (2007) recommends sharing objectives with participants prior to the simulation as a way to foster learning. According to Alinier (2010), this would only make participants lose the benefit of coming to their own conclusion of what is going on and what actions they should take. Cioffi also recommends that very little information is provided initially (Cioffi, 2001). The clinician should be able to investigate the problem and come to conclusions over time. Scenario length varies, but the average is 15 minutes. Small groups of two to six participants per scenario are recommended (Garrett, MacPhee, & Jackson, 2010), however, the scenario should be designed for the number of people that would actually be involved in an event. Scripted scenarios should be reviewed with clinical experts to ensure they are valid, realistic, authentic and adequately represents the content (Alinier, Hunt, & Gordon, 2004; Cioffi, 2001). Scenarios should be realistic to help participants suspend disbelief (Alinier, 2007; Beaubien & Baker, 2004). This realism, or fidelity, is important so that participants

consider the simulation experience as real, making the same decisions and taking the same actions as they would in an actual clinical situation (Issenberg & Scalese, 2007).

Fidelity

Fidelity refers to the extent that simulation mimics or is authentic to reality (Jeffries, 2005, 2012; Roza, 2004); or in the case of flight simulation, how it matches the characteristics of an aircraft (Rehmann et al., 1995). "The degree to which a simulation model reproduces the state and behavior of a real system in a measurable or perceived manner" (Kim, McGinnis, & Zhou, 2012). Throughout the simulation literature and the heath care simulation community, there are a myriad of opinions on fidelity and a lack of well-defined and consistent terms. Many articles address a one-dimensional view of fidelity where only mannequin or simulator fidelity is addressed. Although articles mention high fidelity simulation, what is actually presented is a high fidelity mannequin and not other aspects of fidelity. Yet "simulation in nursing is not synonymous with the human patient simulator any more than multimedia is with video" (Schiavenato, 2009). The mannequin itself doesn't necessarily mean that the simulation experience was highly realistic. A program may have a high-fidelity mannequin, but if for numerous reasons, they are not using it to its capabilities, it has become a very expensive low-fidelity simulator. According to E. E. Wang (2011, p. 667), "a high-fidelity mannequin can be reduced to a static trainer if not used correctly".

Terms such as low, medium and high fidelity are often used without clear and universally accepted criteria. The literature, as well as mannequin manufacturers, only classify mannequins in terms of fidelity, i.e. a low-fidelity or high-fidelity mannequin. Advances in technology have resulted in an increase in mannequin capabilities. What

might be considered a high fidelity simulator three years ago is now only moderate fidelity (Epps et al., 2013). Unlike standardized design terminology in aviation, the military and manufacturing, there are no industry standards or conventions for quantifying or naming mannequin or other simulator fidelity levels. As a result, authors and organizations have created their own definitions. In 2016, the Minnesota Board of Nursing sponsored changes to the State Statutes regarding replacement of clinical hours with simulation (MN Statute 6301.2340 (2016)). As part of these statute changes, the Minnesota Board of Nursing defined high fidelity simulation. The following definition is included in the State Statutes "High-fidelity simulation means a simulation conducted with computerized patient mannequins, virtual reality, or standardized patients and designed to provide a high level of interactivity and realism" (MN Statute 6301.0100 (2016)).

Physical and Functional Fidelity

Within the construct of fidelity, there are two dimensions: physical and functional (Hays & Singer, 1989). Physical fidelity is the level that the mannequin, equipment or environment appears like that of which it is representing. Functional fidelity is how realistically it responds or acts like the real item. A mannequin may have many high functional fidelity features, including circumoral cyanosis if the oxygen saturation is low, chest rise, or responsive pupils, yet because the arms and legs don't bend, it may be less realistic physically. A life-size picture of a ventilator or a non-functioning ventilator may suffice to create a high physical fidelity from an equipment perspective, but lower functional fidelity. However, appropriate visual and audio alarms and functioning buttons are required (functional fidelity) for a simulation of an intubated

patient with decreased lung compliance and high airway pressures. There is an increasing reliance on simulation for learning, high stakes assessment, systems analysis/improvement, and research academic institutions and health systems. Because of this, it is important to know how aspects of the simulation experience, including the simulator, relates to fidelity "in order to guarantee the validity and credibility of the simulation results" (Roza, 2004, p2).

Types of Simulators and Simulator Fidelity

Simulators are the technology components utilized in simulation. There are different types of simulators: full-body mannequins, task trainers, virtual reality/haptic trainers, and simulated patients/standardized patients. Full-body mannequins, also called patient simulators, are intended to replicate a patient. While they may have aspects of physical and functional fidelity, it would be cost prohibitive for them to include the anatomical specificity to complete many procedures. Task trainers, on the other hand, are realistic anatomical models designed for one type of psychomotor skills, like arms for intravenous access, obstetrical pelvises for practicing deliveries and managing obstetrical complications, or ultrasoundable central line insertion trainers. Task trainers also vary in level of fidelity. A number of task trainer-focused studies have been published that illustrate the effectiveness of realistic task trainer use on participant performance and patient outcomes (Barsuk et al., 2014; Barsuk et al., 2012; Brydges, Carnahan, Rose, Rose, & Dubrowski, 2010; Draycott et al., 2008).

Brydges, et al. (2010), used a combination of simulator modalities, including task trainers, to investigate medical students' ability to insert an intravenous catheter (IVC) after receiving training in IVC insertion with differing fidelity levels. Forty-five students

were randomly assigned to practice IVC insertion using high fidelity (Laerdal SimMan Mannequin), low fidelity (Laerdal IV trainer, which is an interactive computer program that provides touch response or haptic feedback), or progressive fidelity (low fidelity, moderate fidelity using an IV arm, and high fidelity). Students could practice for up to two hours and then after seven days, were tested on technical and communication skills. An actor with an IV arm (task trainer) was used for the testing.

Data analysis indicated that the progressive group spent more practice time overall ($F_{2,28} = 25.64$; $P<.001$), with less time on the high fidelity equipment and scored higher on technical skills and communication than the other groups. However, the high fidelity group had the shortest practice time, 30% less than the progressive group, and scored highest using the Global Rating Scale (GRS). The GRS, is acknowledged by the authors as the gold standard in performance-based assessment, and was the basis for determining sample/effect size. Although the authors suggest that progressive learning modalities as described here may reduce cost and demands on simulation educators time (p. 811), the additional training time may be concerning, especially in healthcare institutions where staff are often paid by the organization for attending training events.

The researchers in the Brydges intravenous catheterization study (Brydges, 2010) arbitrarily assigned the three fidelity levels based on the researchers' judgment. While a full body mannequin looks more realistic, the Laerdal computerized IV trainer may provide more realistic feedback through its haptic system. Because of this, different researchers may consider that the Laerdal IV trainer is more realistic and thus higher fidelity, resulting in different outcomes and interpretations.

Varying Levels of Fidelity

Brady, Bogossian & Gibbons (2015a) replicated the Brydges study but with midwife students performing vaginal exams instead of IV starts. They also studied the effect of three varying levels of fidelity on performance using a task trainer. Sixty-nine midwifery students were randomized to a low-fidelity, moderate-fidelity and progressive-fidelity group. The low-fidelity group consisted of a pelvic trainer, the medium fidelity group had the same pelvic trainer positioned appropriately on a one-dimensional photo of a pregnant woman. The high fidelity group included the same pelvic trainer but a live model, a senior student, was used instead of a photograph. Participants were rated on their technical ability to perform a vaginal exam and also on their ability to communicate with the patient. Like the Brydges study, the progressive-fidelity group performed better than the low ($p=.01$) and medium-fidelity ($p=.05$) groups. It is important to note that the progressive group performed the skill three times, once at each fidelity level. Where as the low- and medium-fidelity groups only had a single opportunity to perform at their assigned fidelity level. Finally, the high-fidelity option was only included with the progressive-fidelity group. Performance using the pelvic trainer and live model was not assessed independently. As a result, it is difficult to know if it was the progression, the three opportunities (compared to one), or the addition of the higher fidelity option that resulted in increased participant performance.

Computer-based Simulations

Simulators can also include computer-based systems where the participant interacts with screen actions through an avatar (Maran & Glavin, 2003)**.** The American Heart Association (AHA) utilizes this method for their online ACLS and BLS training

courses (AHA, 2014). Virtual reality/haptic systems utilize computer programs, video screens and instruments to mimic sensations and observations that the operator would experience in real life. VR/haptic simulators include IV trainers, laparoscopic surgical trainers, endoscopy and bronchoscopy simulators and ultrasound trainers. Because full body mannequins will be the simulator used for this dissertation, the remaining discussion will focus on mannequins rather than all simulators.

Mannequin Fidelity

Two spellings are found in the literature: mannequin and manikin. Mannequin will be used in this publication because it is the recommended spelling used by the Journal of the Society for Simulation in Healthcare (Gaba, 2006). Mannequins range from "static" mannequins that provide a physical representation but do not move or interact in any way with a participant, to computer-driven, high-fidelity mannequins that can be programmed to replicate a variety of patient conditions. Some high-fidelity mannequins have drug recognition software where the mannequin's vital signs will change automatically based on the medication type, rate, and amount administered. Several models also have computer programming built in to the software, termed *physiologic modeling,* by the manufacturers. With physiologic modeling, the mannequin is programmed to respond in a certain way based on physiologic conditions. For example, one manufacturer has a modeling program that replicates a 60-year-old overweight, hypertensive male, with a decreased ejection fraction and increased systemic vascular resistance. If the mannequin operator overlays this program during the scenario, the mannequin responds to medications and actions/lack of actions like someone with these physiologic changes would respond. Like other aspects regarding naming and

functionality, physiologic modeling functionality is inconsistent across all manufacturers. The value of this modeling for the end-user of the mannequin has not been established.

In addition to advanced software and programming, one model, the Human Patient Simulation (HPS) by CAE Healthcare, exhales carbon dioxide (CAE Healthcare, 2017). Participants can feel the exhaled gas from the mannequin's mouth. For simulations where advanced airways are placed, participants can check for placement using methods that they would use in their actual practice, and see realistic end-tidal carbon dioxide readings as the mannequin operator adjusts the amount of carbon dioxide exhaled. Another high-fidelity mannequin, 3G, by Laerdal, sweats, has tears, oral secretions and bleeding wounds (Laerdal, 2015), yet lacks articulating limbs.

Unlike aviation or the military (Estock, Alexander, Gildea, Nash, & Blueggel, 2006; Rehmann et al., 1995), health care simulation has not adopted research-based criteria designating fidelity level or guidelines for the use of specific types of simulators and fidelity levels to meet identified goals. The aviation industry has identified specific criteria for different simulator applications. For example, a flight simulator that does not have motion systems could be used for training, but not for testing (Caro, 1988). This lower fidelity simulator may not need to be exact, but just needs to show the appropriate cues for the task at hand. Unfortunately, health care simulation has not identified common definitions, or physiological/functional attributes that must be included for specific applications.

As technology has advanced, the engineers and developers of mannequins have included additional features, some of which are not needed, desired, or helpful. Sometimes the additional technology leads to incorrect assessments and subsequent

management decisions (Johnson, 2012). However, focusing on the design and technology at the expense of the goal of the simulation, such as nurse performance, transfer of knowledge/skills to the bedside, or maximizing patient safety, results in "too expensive and unnecessarily high fidelity simulators, which do not fulfill all user training needs satisfactorily" (Roza, p. 12). The following table (Table 1) provides an example of the functions and costs of select adult mannequins available from the three main manufacturers CAE Healthcare, Gaumard, and Laerdal.

Significant financial resources are required for this educational methodology. Costs to purchase a mannequin range from $4,000 to $250,000 depending on level of fidelity and manufacturer (CAE Healthcare, 2017; Gaumard, 2017; Laerdal, 2017). In addition to the cost of the mannequin, there are additional costs associated with simulation. These include the cost of staff to develop the scenario and facilitate the simulation/operate the mannequin, additional supplies and equipment necessary to provide a realistic clinical experience, and mannequin maintenance expenses such as replacement parts, annual maintenance warranties, and repair (Battista, Phrampus, & Pozner, 2015).

Lapkin and Levett-Jones (2011) conducted a cost-utility analysis using medium and high fidelity mannequins and the following outcomes: knowledge acquisition, clinical reasoning, and student satisfaction. Using a quasi-experimental design, 352 Australian nursing students were randomly assigned to a medium-fidelity (Laerdal Megacode Kelly) or high-fidelity (Laerdal 3G) group. The instructor remained in the simulation room for the medium fidelity simulations and was in a control room for the high fidelity simulations. Three researcher-designed instruments were used: a checklist to

Table 1. Features of Adult Simulation Mannequins

Manufacturer Mannequin	Eye Opening	Active Pupils	Cyanosis	Tongue, airway edema	Lung/Heart/ Bowel sounds	Chest rise	Pulses central & ext	Articulating limbs	Lung compliance	Able to use real monitors	Exhales CO2	Physiologic modeling	Start IV	Weight	Fidelity	**Cost in 2015**
CAE HPS (not wireless)	X	X		X	X	X	X	X	X	X	X	X	X	75	High	$200,000
CAE METIman	X	X			X	X	X	X	X	X		X	X	100	High	$42,500
CAE Caesar	X	X		X	X	X	X	X				X	X	150	High	$75,000
CAE iStan	X	X	Curcumoral & peripheral	X	X	X	X	X	X	X	X	X	X	124	High	$68,000
Gaumard HAL	X	X	Curcumoral	X	X	X	X	X	X	EKG SPO2		X	X	80	High	$48,995
Laerdal 3G	X	X	Curcumoral	X	X	X	X		X	EKG	X	X		125	High	$70,125
Laerdal Essentials	X			X	X	X	(L) side only		X	EKG	X		X		High	$39,995
Laerdal ALS				X	X	X	Central & L arm only			EKG			X		Medium	$12,410
Laerdal VitalSim				X	X	With BVM	Central & L arm only			EKG			X		Medium	$8250

measure clinical reasoning, a pre-posttest with questions selected from a commercial question bank, and student satisfaction. There were no statistically significant differences in knowledge acquisition or student satisfaction between fidelity groups. However, the difference between fidelity groups for clinical reasoning were significant, p=.001 for medium-fidelity (M = 19.2, SD = 11.09) and high-fidelity (M = 42.9, SD = 15.78). For this study, all three outcomes were given equal weight resulting in the medium-fidelity mannequin utility score of 37.80 and high-fidelity mannequin score 46.36. When considered with the cost of the mannequin, the cost to obtain one unit increase of clinical reasoning, knowledge acquisition, and student satisfaction were $1.14 and $6.28 respectively per student. It is important to note the very significant difference in clinical reasoning identified by this study. Despite the significantly increased clinical reasoning noted with the high fidelity simulation, the authors found that the increase in cost negated any difference in outcomes and state that similar outcomes could be achieved by lower fidelity mannequins. However, this claim was not demonstrated across all identified outcomes in this study as the high-fidelity group scored twice as high as the medium-fidelity group with clinical reasoning.

Despite Gaba's assertion that simulation is the educational methodology and the simulator is the technology (Gaba, 2004, 2007), simulation fidelity often only refers to a mannequin (Basak et al., 2016; Blum & Parcells, 2012; Bussard, 2015 ; V. Hallenbeck, 2012; Hauber, Cormier, & Whyte, 2010; Hayden, Smiley, et al., 2014; Kirkman, 2013; Lapkin & Levett-Jones, 2011; Tosterud et al., 2013; Voscopoulos et al., 2013; Zapko et al., 2017). In 2010, the National Council of State Boards of Nursing (NCSBN) surveyed

all pre-licensure RN programs in the United States and used the following definitions of simulation (Hayden, 2010):

> *High-fidelity simulation.* A patient-care scenario that uses a standardized patient or full-body simulator that can be programmed to respond to affective and psychomotor changes, such as breathing chest action. Examples of high-fidelity manikins include SimMan 3G, METIman, and Noelle with Newborn HAL.
>
> *Medium-fidelity simulation*. A patient-care scenario that uses a full-body simulator with installed human qualities such as breath sounds without chest rise. An example of a medium- fidelity mannequin is VitalSim.

The NCSBN study did not differentiate between high-fidelity and medium-fidelity mannequin use, nor did the study identify other aspects of simulation beyond the mannequin. Because of this, it is difficult to truly understand how realistically the simulation was implemented. This lack of specificity is common in simulation literature. When studies only refer to high-fidelity simulation, or limit high fidelity simulation to the use of a mannequin, it is impossible to know how other aspects of the simulation experience were conducted. This makes it challenging to reproduce a study or conduct meta-analysis.

In contrast, Buckley and Gordon (2011), provided a detailed description of the high-fidelity simulations during their study on how nurses recognize and respond to clinical emergencies. The researchers described the simulation experience as "immersive high fidelity simulation training" (p.716), and included the description of the clinical environment, the type of mannequin, the planned interaction/communication between the mannequin (patient voice) and participant, and type of scenario. Baptista et al., (2016)

also included environmental fidelity aspects in their study examining differences in satisfaction and perceived gains of nursing students in high and medium fidelity simulation. The authors state that the environment in the high fidelity simulation room "was prepared to simulate a real context" (p. 129). Unlike Buckley and Gordon, Baptista et al., did not provide specific details about the high fidelity room or any information about the room set up for the medium fidelity simulation.

Other limitations in the literature regarding mannequin or simulator fidelity include comparisons to traditional classroom training, case studies (Thompson et al., 2012; Yang & Thompson, 2011), on-line learning(Foronda et al., 2013), and problem based learning s(Smithburger, Kane-Gill, Ruby, & Seybert, 2012). While it is important to compare different education methods, these do not provide a greater understanding of simulation or the factors that impact its effectiveness.

Rehmann, Mitman, and Reynolds (Rehmann et al., 1995) proposed a multi-dimension fidelity model that includes equipment, environment, and psychological fidelity.

Psychological Fidelity

While all dimensions are interrelated, psychological fidelity is considered by some to the most important in order to get buy-in from participants and to maximize retention (Beaubien & Baker, 2004; Bryson & Levine, 2008; Demaria et al., 2010). Without dispelling disbelief, participants are unlikely to engage and act as they would in the real world. One component of psychological fidelity is the feeling of stress by participants. While some recommendations are to minimize the stress in educational events to maximize retention (Pike, 2003), others recommend the opposite. DeMaria et

al. studied medical students' retention of knowledge and performance in managing a cardiac arrest. A convenience sample of 25 first and second year medical students attended a didactic session on cardiac arrest management and then were randomly assigned to either a control or study group for the simulation. Both groups used a high fidelity mannequin, identical scenario progression, a clinically realistic setting with typical clinical equipment during the scenario and had a similarly structured debriefing session following the simulation. However, for the study group (high stress), the speech and actions of embedded actors in the simulation were designed to increase participant stress and anxiety. The control group (low stress) also had embedded actors in their simulations, but they were calm and followed the lead/directions of the participant. Stress response was determined by participants self-reporting heart rate and the State Anxiety Score. After six months, participants were retested using identical scenarios and no embedded actors. DeMaria found that creating emotional stress increased performance retention (p=.0003), but had no effect on written test knowledge scores (CI=.71-.77, p=.95). Emotional events tend to be remembered and may be more important than the physical setting or the simulator (Groom et al., 2014). While performance was impacted in DeMaria's study, there was no difference in knowledge acquisition.

Beischel had similar findings regarding stress and cognition. In her study of beginning nursing students, n=124, stress experienced during a simulation was not a mediating factor on scores on a post-simulation knowledge test. Stefaniak found the opposite. In a pilot study of 29 new critical care nurses, randomized to either a didactic then simulation group or a simulation followed by didactic group, the simulation then didactic group scored higher on a post-simulation knowledge test than the group who had

didactic first. This was despite the preference of participants who preferred having the simulation after the didactic (Stefaniak & Turkelson, 2013).

Environmental/Equipment Fidelity

The environment and equipment are components that contribute to both physical and functional fidelity of a simulation. Highly realistic environments can be achieved by conducting simulations within an actual clinical environment or by creating a similar environment in a simulation space. There are few descriptions when high fidelity environments are included in a research study (Baptista et al., 2016; Buckley & Gordon, 2011; Calhoun et al., 2014); despite expert opinion articles that describe the important contributions of the environment on the ability of participants to engage in the simulation.

Scenario Fidelity

The realism of the scenario helps participants suspend disbelief (Chow & Naik, 2008). This is important so participants consider the situation and patient as real and act as though they would in an actual clinical environment/patient encounter (Alinier, 2010). Research studies describing scenario fidelity are limited (Meyer, Wong, Timson, Perfect, & White, 2012; Nanji, Baca, & Raemer, 2013; Paige & Morin, 2013), although there are expert opinions and recommendations on this topic (Alinier, 2010; Beaubien & Baker, 2004; Chow & Naik, 2008; Lioce et al., 2015). The INACSL Standards of Best Practice: Simulation Standard IX: Simulation Design (Lioce et al., 2015), uses the term *conceptual fidelity* in lieu of scenario fidelity. This Standard suggests that "conceptual fidelity ensures that all elements of the scenario or care relate to each other in a realistic way so that the case makes sense as a whole to the learner(s)" (p.311). With scenario or conceptual fidelity, patient presentation, including vital signs, are consistent with

diagnosis and the flow of the scenario and corresponding mannequin/patient changes makes sense. This avoids participants' subconscious or overt response of "this would never happen in real life".

One way to provide scenario realism is through cues. Cues include observations, statements from the patient (i.e. mannequin) and embedded actors, lab values, vital signs and assessment data, mannequin/patient response or a lack of response (Groom et al., 2014).

> We can't perfectly duplicate or replicate reality with simulation and we don't need to, but we can present cues that are sufficiently realistic to get buy-in and elicit desired actions and behaviors from the learner. A fake wound on the mannequin's back with a bloody sheet underneath and a low blood pressure should lead the learner to believe there is significant blood loss occurring with their patient (Chow & Naik, 2008, p. 89).

Nanji, Baca & Raemer (2013), studied the impact of visual and olfactory cues with 103 anesthesiologists and anesthesia residents during regularly scheduled crisis management courses that occurred at a simulation center. The subjects were randomly assigned to a simulation where an electrosurgical cautery unit was applied to bovine muscle to replicate the smell and smoke that normally occurs in the operating room. The control group participated in the same scenario without the smoke and odor. Participants were surveyed post-simulation on their perceptions/reactions to the realism of the situation; there was no statistically significant difference between groups, with most participants in both groups strongly agreeing that the simulation looked and felt realistic.

The researchers acknowledge that this may be in part to the fact that there were other fidelity elements, other than the smell and smoke that contributed to the realism.

When scenario fidelity was addressed in simulation studies, it was in conjunction with the simulation activity being addressed, and provided additional detail regarding the simulation, as opposed to comparing different levels of scenario realism. This detail provides context for the reader and assists in the ability to reproduce the study.

Although modern healthcare simulation has been part of healthcare education for over 50 years, there remains a lack research-based validation of many theoretical and practical considerations regarding fidelity. Few research studies substantiate the theoretical suppositions described in published articles. Andreatta and Lori (2014) suggest that a high level of fidelity is important during simulation to ensure that the actions done in the simulated setting transfer to clinical performance. Groom, Henderson, and Sittner (2014) found that "there is a notable lack of empirical evidence to support the presumption that the closer the level of fidelity matches that of reality, the better the learning outcomes" (Groom et al., 2014, p. 339). Based on their review of 101 simulation articles, Foronda, Liu, and Bauman (2013) also concluded that the information regarding the optimal level of fidelity to produce significant learning outcomes is limited and inconclusive.

Years of Nursing Experience, Fidelity and Simulation Performance Outcomes

One of the constructs of the NLN/Jeffries Simulation Framework is *Outcomes* (Jeffries, 2005; Jeffries & Rogers, 2012; J. O'Donnell, S. Decker, V. Howard, T. Levett-Jones, & C. Miller, 2014a). In 2014, O'Donnell, Decker, Howard, Levett-Jones & Miller,

published the findings from their systematic review of the literature as part of the INACSL NLN/Jeffries Simulation Framework project. Although the construct is titled *Outcomes,* the focus within the framework is only on learning outcomes. It doesn't include all outcomes, such as improved patient safety or system/process evaluation and improvement.

Performance. Performance is one of several outcomes of simulation, and the outcome investigated in this study. Performance requires a synthesis of knowledge, application of knowledge (clinical reasoning) situational awareness, and technical skills. A number of studies deal with participant performance. However, the reliability and validity of the instrument used is not consistently established and reported. The realism of the situation may also impact study results. S. Cooper et al. (2012) conducted a study assessing individual performance and teamwork during deteriorating patient conditions with 44 nurses working in a rural Australian hospital. The nurses' performance during three patient deterioration simulations were captured and compared to their score on a knowledge test and situational awareness score. There was a positive correlation between increased knowledge and increased situational awareness, regardless of nurse experience level. Despite this, skill performance was poor with participants missing up to 50% of the items. For example, as the patients' conditions deteriorated, a statistically significant number of participants failed to obtain the patient's heart rate. The scenarios increased in complexity and difficulty. Despite this, performance didn't decline. The researchers addressed environmental and psychological fidelity, including the use of a standardized patient (actor) for each scenario to maximize realism.

Yang, Thompson, & Bland (Thompson et al., 2012; Yang & Thompson, 2011) used judgement in their study to look at how staff nurses and students recognize and respond to cues. They compared paper case scenarios to "high fidelity simulation" using SimMan. The researchers found that increasing the realism of the judgment tasks reduced judgment accuracy and participant confidence levels. This was interpreted as negative by the researchers. However, the type of mannequin used in the study has limited functional fidelity as it does not open or close eyes; eyes remain closed (Laerdal, 2017). To convey deteriorating neurological conditions, the researchers used different vocalizations and moans.

Participant Satisfaction. Another subcomponents of *Learning Outcomes* is participant satisfaction (Jeffries, 2005; Jeffries & Rogers, 2012; J. O'Donnell et al., 2014a). Participant satisfaction with simulation has been well established in the literature (Issenberg et al., 2005; McGaghie et al., 2010; Nehring, 2010; Tosterud et al., 2013), and despite recommendations to move beyond this basic evaluation (Debacker et al., 2012; Dieckmann, Phero, et al., 2011; Kardong-Edgren & Roche, 2013; McGaghie et al., 2010) research questions regarding satisfaction and self-confidence remain prevalent. Baptista et al. (2016) randomly assigned fourth year nursing students to high or medium fidelity simulation and studied student satisfaction and perceived gains. The authors found statistically significant differences in the recognition and decision dimension when comparing medium and high fidelity simulations (U Mann-Whitney = 63, Wilcoxon = 1292, $p = .02$). It is important to note that this was based on the students' perceptions of their gains, however, not object observations of a difference in performance.

Knowledge Acquisition. Knowledge acquisition is another subcategory within the Learning Outcomes construct (Jeffries, 2005; Jeffries & Rogers, 2012; J. O'Donnell et al., 2014). While the literature supports knowledge acquisition with simulation, achieving greater knowledge acquisition based on simulation fidelity level is inconclusive. Hoadley (2009) conducted a randomized control study with health care professionals completing an advanced cardiac life support (ACLS) course. Participants were assigned to either a control group (low-fidelity mannequin) or an experimental group (high-fidelity mannequin). There were no statistically significant difference in posttest scores or skill performance between groups. There may be other factors, including elements from the other NLN/Jeffries Simulation Framework constructs, which impact outcomes beyond the fidelity of the mannequin.

Stefaniak and Turkelson (2013) conducted a randomized control study to investigate if the sequence of simulation and instruction mattered regarding knowledge acquisition. Twenty-nine novice critical care nurses were randomized to completing a simulation followed by didactic content during the debriefing, or didactic content prior to the simulation, followed by a debriefing. Participants who completed the simulation first had statistically significant ($F=(a = .05; 4.54) = 176.07$; $P < .0001$) post test scores than those who received didactic content prior to the simulation

Cognitive Load

One consideration regarding fidelity may be how the level of simulation fidelity impacts cognitive load. Cognitive load is the amount of information that someone is trying to process in working memory at one time. Cognitive load theory (CLT) is an instructional theory that describes learning and problem solving within the context of

how information is processed and addresses the limitations of working memory (Cooper, 1998; Josephsen, 2015; Sweller, 1988; van Merrienboer & Sweller, 2010). According to CLT, new information is processed in working memory and through schema development, transferred to long-term memory. Schemas are "hierarchical information networks" (Cooper, 1998, p. 8) or "domain specific knowledge structures" (Kalyuga, Chandler, & Sweller, 2001, p. 6) that are developed over time and can house complex and detailed information. With repetition and practice, schemas may become automated, which can then free up working memory for more complex tasks (Kalyuga et al., 2001; van Merrienboer & Sweller, 2010), and allow complex steps and copious amounts of information to be treated like a single element (Sweller, 1988) resulting in more rapid processing. Sweller (1988) suggests that domain-specific schemas differentiate experts from novices in their ability to solve problems.

While long-term memory can store a limitless amount of information, the capacity of working memory is limited to five to nine informational elements and most information is lost after 20 seconds, unless it is rehearsed or practiced (van Merrienboer & Sweller, 2010). If the cognitive load is too high, learning and performance will be impacted. any increase in resources required during problem solving must inevitably decrease resources available for learning. Tasks with high levels of interactivity require that learners deal with multiple elements simultaneously. This can increase cognitive lead and reduce learning. Because high fidelity environments are more interactive than low fidelity environments, van Merrienboer & Sweller (2010), recommend that for novice learners, it may be better to start with low-fidelity simulations. Fraser et al. (2012)

found that increased cognitive load with first year medical students was associated with poorer learning outcomes.

Simulation Design Scale

The Simulation Design Scale (SDS), developed by the National League for Nursing in 2003, was designed to evaluate five components of effective simulation design, now formally part of the NLN/Jeffries Simulation Framework *Simulation Design* construct (NLN, 2017). Participants answered questions about the presence of specific features in the simulation, and the importance of those features. A number of studies have used the SDS (Adamson et al., 2012; Basak et al., 2016; Kardong-Edgren et al., 2010; A. Wang, Fitzpatrick, & Petrini, 2016). Basak et al. (2016) conducted high and low fidelity simulations with beginning (first year) and advanced (fourth year) nursing students. Following the simulation, students completed the SDS. There was a statistically significant difference between the low and high fidelity groups in all five categories of the SDS, including the Fidelity category ($F = 5.86$, $p < .05$). Both beginning students ($Z = -4.48$, $p = .001$) and advanced students ($Z = -4.21$, $p = .001$) had higher SDS Fidelity scores for the simulation with the high fidelity mannequin. The authors did not define low fidelity and high fidelity mannequins.

Wang, Fitzpatrick, and Petrini (2013) also compared SDS scores with nursing students in China completing moderate and high fidelity simulations. In this study, the authors categorized Laerdal's SimMan as a high fidelity mannequin and a computer-based program, MicroSim, was used as the moderate fidelity simulation. There was a statistically significant difference between groups on the total SDS score ($t = 2.20$, $p < .05$). There was no statistically significant difference between groups when evaluating

the sub-score from the Fidelity category. However, the high fidelity group did score slightly higher (M = 4.30, SD = .75) than the moderate fidelity group (M = 4.12, SD .64) in the Fidelity category.

Issues with Simulation Research

In 2005, Issenberg et al. published a review of 34 years of simulation research. McGaghie et al. (2010) built on this work with a critical review of simulation-based research published between 2003-2009, identifying 12 features and best practices for simulation-based medical education as well as limitations in current research. During this same time, internationally recognized multidisciplinary researchers and leaders in simulation conducted an Utstein-style meeting (Debacker et al., 2012; Issenberg, Ringsted, Ostergaard, & Dieckmann, 2011) in Copenhagen, Denmark, followed by a State of the Science Research Summit at the International Meeting for Simulation in Healthcare in 2012. Meeting goals were to identify the state of the science of simulation research, identify future directions for simulation-based research, and to identify methodological issues when conducting simulation-based research. A number of research foci and questions were identified including "How do theories of cognitive load inform the design and structure of simulation programs, courses, and concrete scenarios based on the complexity of tasks required for learners to acquire and maintain?" and "How do different simulation modalities and their contextualized use affect skill development and retention?" (Issenberg et al., 2011, p. 157).

The lack of rigor in simulation research is well documented (Dieckmann, Issenberg, et al., 2011; Hayden, Smiley, et al., 2014; Issenberg et al., 2005; Issenberg et al., 2011; Kardong-Edgren & Roche, 2013; McGaghie et al., 2010). Many studies lack

an identified theoretical or conceptual framework (Dieckmann, Phero, et al., 2011) , although including a framework is more common in nursing-related simulation research (Kardong-Edgren & Roche, 2013). Also concerning are issues related to the lack of rigorous metrics, including a lack of randomized controlled studies/use of control groups, issues with sampling, including small sample size, no reference to effect size/power, variability in study design, and challenges with reproducibility and the use of instruments without established reliability/validity (Hayden, 2010; Hayden, Keegan, Kardong-Edgren, & Smiley, 2014; McGaghie et al., 2010).

A number of instruments have been used to measure participant satisfaction in simulation, effective teamwork, clinical judgment, and performance using a global rating scale, but few evaluate performance based on specific actions (Adamson et al., 2012; Kardong-Edgren et al., 2010). Equally sparse are published studies documenting instrument use with registered nurses. Most instruments have been used with nursing students. Unfortunately, many instruments lack established validity and reliability (Adamson et al., 2011).

The lack of methodological rigor "makes it difficult to reach firm conclusions about aggregate research outcomes and to identify SBME (simulation-based medical education) best practices" (McGaghie et al., 2010, p. 61). Although simulation articles are prolific, Hayden (2014) recognized that because of the lack of rigor and quality, there are very limited studies for a meta-analysis.

Summary

Conflicting findings are present in the literature regarding the effectiveness of high fidelity simulation compared to low or medium fidelity simulation. However, many

of the studies have either only compared mannequin fidelity, or compared high-fidelity simulation to another educational tool like a paper case study, task trainer, or computer program. A significant knowledge gap remains regarding the effectiveness of fidelity levels when all aspects of fidelity are compared. Therefore, the purpose of this project was to examine the effects of simulation fidelity and nurse experience on performance during simulation. The study also examined the interaction between level of experience and level of fidelity on performance during simulation.

CHAPTER THREE

METHODS

This chapter describes the methods and procedures for this study. It provides a description of the research design, subjects, protection of human subjects, method of data collection, instruments, and the statistical procedures used to analyze the data. The purpose of this quantitative study was to examine the effects of simulation fidelity and nurse experience on performance during simulation. The study also examined the interaction between level of experience and level of fidelity on performance during simulation. The purpose of this study was examined by the following research aims:

1. To determine the demographic characteristics of novice and experienced practicing nurses participating in low and high fidelity simulations.
2. To examine differences in simulation performance scores of novice and experienced nurses.
3. To examine differences in simulation performance scores of registered nurses during low and high fidelity simulations.
4. To examine differences in Simulation Design Scale scores between the high and low fidelity groups.
5. To examine the association among nurses' demographics, years of nursing experience, fidelity levels, and simulation performance scores.

Research Design

A descriptive, correlational study design was used to examine the effect of simulation fidelity and nursing experience on the performance of registered nurses using simulation for clinical practice. This design was chosen to look at the impact of one independent variable (fidelity) versus another independent variable (experience) and the interaction between independent variables on the dependent variable (performance in simulation). It was hypothesized that different levels of fidelity would result in variations in performance as measured by the CSET score. It was further hypothesized that variations in performance (CSET score) may be explained by interactions between level of fidelity and nurse experience.

Population and Sample

The target population for this study were novice nurses and experienced registered nurses working in an acute care setting in a Midwestern metropolitan area. According to published data from the Minnesota Department of Health (MDH), there were 105,998 RNs licensed in Minnesota in 2016, with 52%% (55,119) of the nurses working in the largest metropolitan areas (MDH, 2017). The largest metropolitan area has 17 hospitals, three of which are designated as Level-1 Trauma Centers. Whereas in 2014 there were 20,130 working at hospitals in this large metropolitan area (personal communication Minnesota Hospital Association 4/16/15).

Of the registered nurses working in these hospitals, 91% were female and 88% were self declared as Caucasian (personal communication Minnesota Hospital Association 4/16/15). Although there has been an increase in workforce diversity over the

past 10 years (MDH, 2017), the percentage remains low, with the 12% reported as follows: Black, 4.8%, Asian 3.7%, Hispanic 1%, American Indian 0.3%, other 1.9%.

Those in the study were recruited from a sample population of registered nurses at a Level-One Trauma Center and tertiary care facility in a large metropolitan area. The accessible population from this hospital was 2400 registered nurses. A sample of 68 registered nurses was initially planned to achieve a medium effect size (Cohen, 1992; Faul, Erdfelder, Buchner, & Lang, 2009). This *A priori* determination was calculated in G*Power, a computer program to compute statistical power analyses (Faul, Erdfelder, Lang, & Buchner, 2007). Using G*Power, the statistical test ANOVA: Fixed effects special, main effects and interactions and input parameters of f^2*=0.34, alpha=0.05, Power 0.8*).

Due to recruitment challenges, 35 nurses completed the study. Based on data from 35 participants and the actual effect size based on the SPSS analysis (*partial* η^2 *= 0.248, effect size f* = .574), the power was recalculated using G*Power and the computed achieved power was 91%.

Recruitment

Through recruitment efforts, a representative sample for gender, race/ethnicity and educational preparation was obtained. While hospital specific data was not available, State-wide data from the Minnesota Department of Health was used (MDH, 2017). Recruitment was as follows.

Flyers (Appendix G) were posted in staff breakrooms on nursing units and within the Simulation Center as well as emailed to registered nurses employed at the hospital. In addition, this researcher met with simulation educators, hospital educators and nursing

managers to explain the study, criteria, and request assistance in promoting the participation opportunity. The opportunity to participate was mentioned at the conclusion of simulation-based nursing classes that were sponsored/co-sponsored by the simulation program. This researcher contacted RNs who had indicated their interest in participating to provide information, obtain consent and schedule a simulation time. Despite verbal or written confirmation of interest, 27 potential participants did not show up for their scheduled appointment, nor respond to follow-up phone calls/emails from this researcher. After obtaining permission from the unit managers, this researcher also went to nursing units on day, evening, and night shifts during the week and weekend to discuss the study face to face with nurses in an attempt to increase participation. Ultimately, 35 registered nurses provided consent and completed the study.

Protection of Human Subjects

Protection of the participants in this study followed the policies and procedures of the Institutional Review Boards (IRB) for both the University of North Dakota and the IRB of the participating health care institution. IRB approval for the study was obtained prior to recruitment and initiation of the study. Informed consent with incomplete disclosure was provided to participants in order to avoid study bias. Because this study examined participant performance during high or low fidelity simulation experiences, participants could alter their performance and skew the data if they were aware of the exact purpose of the study. As a result, participants were provided with a more general purpose statement during recruitment and consent. They were informed that the study was to explore how nurses with different levels of experience perform in simulation. Participants were informed of the exact purpose after the study was completed. There

were no adverse effects. However, since there is a risk of psychological distress during simulation, participants were told that they could stop the simulation at any time and were provided with contact information for the Employee Assistance Program and Chaplaincy Department. This information was provided verbally and in writing. Once consent had been obtained, participants were provided with a written informed consent document as well as orientation to the mannequin and simulation setting prior to collection of data.

Participants were assigned a subject number. This number, along with their name and contact information was kept in a password protected electronic file separate from study data. The PI was the only person with access to this file. Study instruments (Demographic Data, Simulation Design Scale, CSET, C-CEI), did not contain personal identifying information. Although simulation recordings were saved to DVD and labeled by participant study number, participant identity was visible on their simulation recordings and most nurses introduced themselves to the simulated patient by sharing their first name. Labeled DVDs were locked in a cabinet in a secured location accessible only by this researcher. Paper evaluation tools were also stored in the secured location. Five years after the study completion, the paper documents will be destroyed; DVDs will be destroyed at the completion of the study. The computerized database (SPSS 25) used for data coding and analyses was maintained on a password protected computer and encrypted backup drive.

Informed Consent

This researcher met with interested individuals to discuss the study and answer questions. Potential participants were informed that the time commitment was 20

minutes. During this time, they would participate in a 12-minute simulation session that would be recorded and reviewed by the PI. Their manager and educators would not have access to the recording or study data, participation would not impact their employment. Participants were also informed that they could stop their participation any time during the simulation session. No adverse reactions were anticipated; however some individuals might feel stress or anxiety when participating in simulation. Incentives to participate in the study included entry into a drawing for one of three $100 Visa gift cards.

Study Procedure

After obtaining consent, this researcher randomly assigned participants to either a high fidelity or low fidelity group. Randomization occurred as follows. Because the planned sample size was 68, thirty-four cards labeled "High Fidelity" and 34 labeled "Low Fidelity" were placed in an envelope. After obtaining consent, this researcher drew a card from the envelope. The researcher drew the card to ensure that participants were blinded to the fidelity level of their simulation. The participant was scheduled to participate in a high fidelity or low fidelity simulation session based on the card drawn. A form was created to document the assigned fidelity level and study number. This was maintained with other study documents, but separate from the consents and study key. Participants were not told what fidelity group they were assigned to reduce any effect on experience or expectations. Prior to starting the simulation session, the participant completed the Demographic Survey Form (Appendix D) and, in accordance with normal procedures for all simulations, received a prebrief. The prebrief included the following:

- orientation to the mannequin used with an opportunity to find pulses, listen to abnormal/normal lung and heart sounds, eye opening/lack of eye opening, and cyanosis feature if applicable;
- how movement, skill temperature and skin color will be conveyed;
- communication with the mannequin, including mannequin voice;
- available resources including the process for contacting a physician or additional help;
- orientation to the environment including bed and medical equipment; and
- process for obtaining and administering medications.

Scenario

After the prebrief, the participant completed a high or low fidelity simulation. The scenario (Appendix E) was developed by this researcher as follows. The scenario was designed at a medical-surgical level and involved a 55-year-old male trauma patient. The patient was admitted to their area two hours ago and sustained the following injuries: two broken ribs on the right and chest wall bruising. The patient initially complained of pain and requested pain medication. Over the course of the scenario, the patient ultimately developed respiratory distress, decreased level of consciousness and ultimately cardiac arrest. The scenario was scripted to allow opportunities for the participant to:

- introduce themselves,
- demonstrate hand hygiene and other patient safety measures,
- recognize and resolve a patient safety error.
- complete an assessment, recognize normal and abnormal findings,

- take appropriate action including medication administration, use of oxygen delivery devices and chest compressions, and
- provide effective communication to the patient and any team members.

The scenario was developed specifically for this study to reduce any possibility that study participants may have experienced the scenario in a previous simulation. Also, most commercially available simulation scenarios are designed at a student level, and not for graduate or experienced nurses. Content validity and authenticity of the scenario were established through a panel of simulation and clinical experts. The same scenario (Appendix E) was used for all simulation sessions regardless of the fidelity level. The scenario was pilot tested by six nurse who were not study participants. The scenario was modified following the pilot testing to include an option if the nurse gave a lower dose of narcotic. During the scenario, the patient would have a change in level of consciousness after receiving the higher narcotic dose. If a lower dose was given, this wouldn't occur. In addition to the correct actions for managing the patient changes as a result of a higher narcotic dose, the scenario was changed to include correct actions if the nurse opted to give a lower narcotic dose.

Simulation Activity

The 12-minute scenario was the same for both fidelity groups but the simulation experience differed based on whether the participant was randomly assigned to the high fidelity or low fidelity groups (Table 2). Differences between the high fidelity and low fidelity simulations are explained in Table 2.

Table 2. Simulation Plan: High vs Low Fidelity

Category	**High Fidelity**	**Low Fidelity**
Mannequin	Laerdal 3G	Laerdal Megacode Kelly
Facilitator location	Outside simulation room. Facilitator uses wireless mic/speaker system to "speak" for patient.	Inside simulation room. Facilitator "speaks" for patient from within room where simulation is occurring.
Mannequin voice	"Patient's" voice reflects clinical situation, age, level of consciousness, appropriate	No differentiation between facilitator's natural voice and "patient's" voice/speech patterns or word choices.
Table 2. (Continued)		
Category	**High Fidelity**	**Low Fidelity**
	terminology (i.e. non medical words), and appropriate level of anxiety. Clear difference in tone for "patient's" voice compared to other vocal sounds in room (i.e. lab result, physician)	
Assistance	Scenario continues; if assistance is required, the facilitator or designee will participate in a role representative of what would occur in an actual clinical event (i.e. PCA, Charge Nurse).	Scenario stopped for facilitator to assist as needed.
Environment: Location	Clinically realistic room within Simulation Center or actual patient room.	Conference or class room.
Oxygen	Oxygen delivery device (i.e. cannula, face mask, and BVM device) can be attached to functioning flow meter. Participant will select flow level and have visual confirmation; air flow will be audible.	Oxygen delivery device (i.e. cannula, face mask, or BVM device) can be attached to non-functioning flow meter taped to IV pole. Sign taped to flowmeter identifies flow rate. Participant asked to verbalize flow.
Infection control	Gloves, functioning sink and hand foam are present in	Gloves available. Signs labeled sink and hand foam taped on wall.

	simulation room/actual patient room.	
Vital signs	Dynamic vitals signs (BP, HR, RR, SpO2, Temp) sent to a monitor at bedside. Changes are made automatically as scenario progresses. Vital signs are displayed when participants attach appropriate monitoring equipment.	Facilitator provides vital signs verbally when participants ask.
Assessment equipment	Stethoscope & penlight available	Stethoscope & penlight available

Table 2. (Continued)

High Fidelity	Low Fidelity	High Fidelity
IV infusions	IV infusions administered through functioning IV pump. Pump has medication and rate programmed in the usual manner.	Laminated tag used to reflect IV infusion rate. Tag is taped to IV tubing
Medications	Patient MAR and simulated medications in computerized medication dispensing system.	Labeled syringes/simulated medications on counter in simulation room. Alcohol wipes available.

Each participant was scheduled for a 20-minute session which included a prebrief, the 12-minute simulation session and completion of two brief surveys. This researcher facilitated the simulation and recorded the sessions. The simulations were recorded using the standard recording equipment used by HealthPartners Clinical Simulation. The recordings were used to complete the Clinical Simulation Evaluation Tool (CSET) and Creighton Clinical Evaluation Instrument (C-CEI) instruments to calculate performance.

After the simulation, participants answered questions in the Fidelity section of the Simulation Design Scale.

Data Collection

Data collected during the study included demographics, participant perceptions about their simulation experience (Simulation Design Scale), performance scores were calculated from the CSET and the C-CEI. This researcher collected the completed Demographic Survey (Appendix D) and the Simulation Design Scale (Appendix C) and coded them with the participant's study number.

After the simulation was completed, the video was copied to DVD and then deleted from the camera system. The DVD was labeled with the participant study number and scored performance using the CSET (Appendix A) and C-CEI (Appendix B). Participant study numbers were placed on the CSET and C-CEI by this researcher. This researcher will enter the scores into SPSS.

Variables

There are two independent variables and one dependent variable. Independent variables are fidelity and experience level. Fidelity was based on the card drawn (high fidelity or low fidelity) during random assignment after consent and is a categorical variable. The high fidelity group had the simulation experience listed in Table 2 High Fidelity column. The low fidelity group had the simulation experience listed in Table 2 Low Fidelity column. High fidelity was coded in SPSS with a "1" and low fidelity with a "0". Experience level was based on participant self-reported data from the Demographic Survey (Appendix D). Initially, this was a continuous variable as participants listed their actual months or years of experience. During data analysis, this was changed to a categorical variable with two groups: The lower experience (0-3 years) group was

labeled “novice” and coded with a “0” in SPSS, and higher experience (over 3 years) labeled “expert” and coded with a “1”.

The dependent variable was the total score on the Clinical Simulation Evaluation Tool (CSET) instrument. This is a calculated score based on performance of the nurse during the simulation of 0 to 40.

Instrumentation

Three instruments were used in this study: an author designed questionnaire to capture participant demographic data, the Demographic Survey; the Simulation Design Scale (SDS) to capture the participant’s perception of fidelity level; and the Clinical Simulation Evaluation Tool (CSET) to identify performance during the simulation scenario. The Creighton Competency Evaluation Instrument, formally known as Creighton Simulation Evaluation Instrument, was used to establish construct validity of the CSET.

Simulation Design Scale

The Simulation Design Scale (SDS) is a 20-item, Likert based instrument, designed to evaluate learner satisfaction with five categories within the Simulation Design Construct of the NLN/Jeffries Simulation Framework. It was originally used in the NLN/Laerdal study (Tosterud et al., 2013). The SDS has five focus areas: 1) objectives/information, 2) support, 3) problem solving, 4) feedback, and 5) fidelity. For each focus area, there are questions about the presence of specific features in the simulation and how important the feature was to the learner. Content validity was established by Pam Jeffries, PhD, and nine other content experts in simulation, development and testing. The instrument’s reliability was tested using Cronbach’s alpha

which was found to be .92 for presence of features and .96 for the importance of features (SIRC, 2015). The National League for Nursing has given permission to use the instrument for this study. For the purposes of this study, participants only answered the eight fidelity-related questions. The original SDS only had two questions regarding fidelity: "The scenario resembled a real-life situation" and "Real life factors, situations, and variables were built into the simulation scenario". These two questions did not adequately capture all of the aspects of fidelity. As a result, six additional questions were added by this researcher. The following six questions and the two original questions in the Fidelity section were answered by participants.

- The realism of the mannequin helped the situation feel real.
- The vital sign changes allowed me to recognize changing conditions.
- The realism of the environment helped the situation feel real.
- The equipment worked like I expected it would in real life.
- The patient voice was convincing and the patient responded to me realistically.
- The situation felt real.

Because the additional questions were added, Cronbach's alpha was conducted with the two original and six additional questions. The revised Fidelity construct of the Simulation Design Scale has a Cronbach's alpha of .82. Because the Cronbach's alpha is higher than .8, there is a high level of internal consistency and reliability.

Although the question "Real life factors, situations, and variables were built into the simulation scenario had a total correlation of .27, and the Cronbach's alpha would be

higher at .84 if the question was deleted, it was not removed as it was part of the original Simulation Design Scale.

Table 3. Simulation Design Scale Author Added Fidelity Questions

Fidelity Construct Questions	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
The scenario resembled a real life situation*	30.69	10.93	.60	.81
Real life factors, situations, and variables were built into the simulation scenario*	30.63	13.18	.27	.84
The realism of the mannequin helped the situation feel real	30.97	10.44	.73	.80
The vital sign changes allowed me to recognize changing conditions	30.49	13.14	.32	.84
The equipment worked like I expected it would in real life	31.03	9.79	.65	.80
The realism of the environment helped the situation feel real	30.83	11.68	.58	.81
The patient voice was convincing and the patient responded to me realistically	30.66	10.52	.74	.79
The situation felt real	31.11	10.63	.58	.81

*Original SDS questions

Clinical Simulation Evaluation Tool

Participant performance was based on the total score of the CSET. The CSET was chosen because it was designed to measure clinical performance in simulation (Grant et al., 2010; Radhakrishnan et al., 2007) and detailed enough to discriminate between levels of performance. The instrument includes expected actions and behaviors within the context of a designated clinical condition. Performance is divided by categories and uses a numeric point system to indicate performance of the listed behavior. Unlike a global rating scale, the CSET assigns points for each observed action, providing a clear and objective documentation of performance. Categories include 1) Safety &

Communication, 2) Assessment & Critical Thinking, 3) Diagnosis & Critical Thinking, 4) Interventions, 5) Evaluation & Critical Thinking, and 6) Reflection & Critical Thinking. Within each category are a number of subcategories. Expected actions are listed for the subcategories based on the correct actions identified for the specified scenario. Correct actions are assigned a point value if they are completed. For example, within the category Safety and Communication, there are subcategories: utilizes proper hand hygiene before care and as needed, patient identification, introduces self, and error detection. The subcategory of *patient identification* was assigned two points; the correct actions were to check the ID band (1 point) ask patient name (0.5 point) and ask date of birth (0.5 point). The points were allotted for each action instead of based on the subcategory overall, which was the case with the Creighton Competency Evaluation Instrument (C-CEI).

Radhakrishnan et al. used the CSET for nursing students participating in simultaneous two-patient simulations with a maximum of 50 points. Criteria were designed for a pelvic fracture and congestive heart failure scenarios. Grant et.al., used the instrument with student nurses and registered nurses who were students in an nurse anesthesia program. The instrument was adapted to record actions and behaviors related to a patient with a myocardial infarction and a patient with a stab wound to the chest. In addition to changing scenarios, Grant et al. adapted the score to a maximum of 65 points. Unlike Radhakrishnan et al., who had equal points for both scenarios, Grant et al. had a higher number of possible points because of different assessment and intervention items. Participants received points if they performed a correct action. They did not receive additional points for repeating an action more than one time.

Although not specifically articulated, because panels of simulation and clinical experts reviewed the scenarios and CSET criteria, the assumption was made that face validity was established. There was no documentation of internal consistency or construct validity by either author. Grant et al. used Fleiss's Kappa and percentage agreement to establish interrater reliability between five raters. Agreement and the Kappa varied depending on the group of students but ranged from a Kappa of .71 to .94, which corresponded with a percentage agreement of 85.4% to 97.2%.

While validity of the CSET has not been well established, the benefit of the discriminate scoring is the reason this instrument was used for this study. Validity of the CSET for this study was established with face and convergent validity. Face validity was established through a review by a panel of nursing and simulation experts and this researcher. Convergent validity, was established by correlating the CSET scores to the scores from a well-established instrument. For this study, the Creighton Competency Evaluation Instrument (C-CEI) was used.

Creighton Competency Evaluation Instrument

The C-CEI was originally developed as the Creighton Simulation Evaluation Instrument in 2008 by nursing faculty at Creighton University as a way to objectively evaluate nursing students who participated in simulation (Hayden, Keegan, et al., 2014; Todd, Manz, Hawkins, Parsons, & Hercinger, 2008). The instrument has four categories and a number of subcategories. The original instrument was based on the core competencies identified in the AACN's 1998 *Essentials of Baccalaureate Education for Professional Nursing Practice* and included assessment, communication, critical thinking and technical skills. In 2012, the instrument was revised to reflect the 2008 *Essentials of*

Baccalaureate Education for Professional Nursing Practice and incorporate wording from Quality and Safety Education for Nurses (QSEN) around patient safety and from the International Nursing Association for Clinical Simulation & Learning (INACSL) regarding clinical judgment (Hayden, Keegan, et al., 2014). Additionally, there were minor semantic changes in order to be able to use the instrument in clinical practice as well as in simulation. The current categories are Assessment (no change), Communication (no change), Clinical Judgment (changed from critical thinking), and Patient Safety (changed from technical skills). Within these categories are 22 subcategories, participants are scored based on how they complete the subcategory; they receive a 1 if it was performed as expected or 0 if not. Faculty are expected to define what correct actions and behaviors are for each of the subcategories prior to implementation of the instrument. Because the points are assigned by subcategory and not specific actions, the C-CEI may not provide an adequate level of discrimination to determine differences in performance between groups.

Articles referencing the C-CEI (Adamson, 2011; Adamson & Kardong-Edgren, 2012; Adamson et al., 2012; Adamson et al., 2011; Franklin, Sideras, Gubrud-Howe, & Lee, 2014; Hayden, Keegan, et al., 2014; Jeffries & Rizzolo, 2006; Kardong-Edgren et al., 2010; Todd et al., 2008) address its use with nursing students, including most recently, the landmark National Council of State Boards of Nursing (NCSBN) simulation study (Hayden, Smiley, et al., 2014). Unlike the CSET, validity, reliability, and internal consistency have been established. Adamson (2011) conducted a study of 29 baccalaureate educators from across the United States, to establish reliability and internal consistency data from the C-CEI. Video-archived simulations were viewed and scored by

study participants using the C-CEI. Interrater reliability was established using Interclass correlation .95 (95% CI=.70, 1.0), intra-rater reliability was .88 (95% CI=.-.001, .99) and internal consistency was established by a Cronbach's alpha of .98 (Adamson et al., 2011). Hayden et al. (Hayden, Keegan, et al., 2014) published similar results with the revised C-CEI instrument. Content validity was established by a panel of 35 experienced nursing faculty using a 1-4 Likert scale to rate each item based on three criteria: necessity of the item as a measure of clinical competency (M = 3.89, SD = .19), fitness (i.e. alignment) with its competency category (M = 3.86, SD = .22), and understanding of the item (M = 3.78, SD = .27). Interrater reliability was established by comparing the individual scores of 31 raters to the score of an expert rater. Overall agreement was 79.4% with Cronbach's alpha above .90. The Kappa was significantly different, where the Cronbach alpha was .98 for one video, the Kappa score was .32. Agreement varied by scenario and also whether the reviewers were from AD or BSN programs (Hayden, Keegan, et al., 2014).

CSET and C-CEI Convergent Validity

For this study, the total scores for the CSET and C-CEI were used to establish Convergent Validity. Scores were compared between the two instruments using the Pearson correlation coefficient. Because an r of >.5 indicates a strong correlation (Pallant, 2013), there was a large positive correlation between nurse performance scores using the CSET and the C-CEI instruments, r = .86.

Table 4. Correlation Between CSET and CCEI Instruments

		Performance Score from CSET	Performance Score from CCEI
Performance Score	Pearson Correlation (*r*)	1	.86**
from CSET	Sig. (2-tailed)		.001
	N	35	35

** Correlation is significant at the 0.01 level (2-tailed).

The C-CEI was only used to establish convergent validity. The performance scores from the CSET instrument was used for data analysis regarding the research questions.

Data Analysis

The SPSS data analysis software program (IBM SPSS Statistics version 25, 2017) was used to perform descriptive and inferential statistics. Once the Demographic Survey and Simulation Design Scale (SDS) were completed by a participant, this researcher entered their responses into SPSS. The data was examined by this researcher to ensure the data was correctly entered and reviewed for missing responses. Demographic data and the SDS were analyzed using descriptive statistics. The descriptive analysis included frequencies and percentages for the participant responses related to their gender, race, educational degree, RN experience, acute care experience (i.e. general floor, ICU/ED, etc.), simulation experience, and fidelity questions from the SDS. Mean and *SD* was calculated for age.

To determine that "Experience" was an independent variable and not a covariance of the dependent variable, "Performance", a Pearson Correlation was conducted in SPSS 25 using the original continuous variable data for Experience. However, the Pearson Correlation between experience and the CSET score revealed no relationship ($r = .07$; p

= *.69).* Therefore, because there was no relationship between the variable "Experience" and the dependent variable, CSET score, it was established as a moderator not covariate.

In order to run an independent samples t-test and meaningful factorial ANOVA, the continuous variable, "Experience", was transformed to a two-group categorical variable with 0-3 years = Novice and > 3 years = Experienced. These categories were chosen based on Benner's Novice to Expert model, with Novice/Proficient considered 0-3 years and Competent/Expert over 3 years.

To examine the research questions, independent *t*-tests and a 2X2 factorial, analysis of variance (ANOVA), also called a two-way ANOVA, were used (Field, 2013). These statistical analyses approaches were appropriate as the study had two categorical independent variables (Fidelity and Experience), and a continuous dependent variable (CSET score). Each independent variable consisted of two categorical independent groups. In addition, there was independence of observations; there were different participants in each of the groups (between-subjects factors).

Using SPSS, a t-test for independent means was conducted between the two groups within the experience variable (novice and experienced) to assess for differences between means. A t-test for independent means was also conducted between the two groups within the fidelity variable (low and high).

The data was analyzed for main effects (fidelity and experience) as well as interaction effects between fidelity and experience. Variance in the CSET score, (dependent variable), was analyzed to determine if it could be explained by fidelity (independent variable 1), by experience (independent variable 2), as well as by the interaction between fidelity and experience. Fidelity was divided into two groups or

factors, high fidelity and low fidelity. Experience data was also categorized into two groups, novice (0-3 years) versus experienced (>3 years). Dummy variables were used for each of the independent variables with low fidelity assigned "0" and high fidelity assigned "1". Nurse experience was also coded as "0" novice nurses and "1" for experienced nurses.

Assumptions

Two-way ANOVA

The analyzed data was assessed for the presence of outliers, normality, and homogeneity. The presence of outliers was determined by creating box plots in SPSS. A datapoint outside the confines of the inner fence (the edge of the box) was considered to be an outlier. Data points more than 3 box lengths from the edge of the box or three times the interquartile range (IQ) is considered an extreme outlier. Outliers were reviewed to determine if the outlier was due to a data entry error. There were no data entry errors. Identified outliers were assessed to ensure they were not extreme. Because they were not extreme and actually reflected nurse performance, they were left in without modification.

Assumption of normality means that the data is normally distributed within groups. The Shapiro-Wilk test of normality was used because the sample size for this study was 35. This test is recommended for sample sizes of less than 50 participants (Laerd, 2013). With this test, a significance value of <.05 means that the assumption of normality has been violated and not normally distributed. A value of >.05 indicates that the data is normally distributed.

Homogeneity of variance assumes that each of the groups of independent variables has the same variance. Levene's test of equality of variances was computed using SPSS. This tested whether the variance in the dependent variable was equal across groups.

F-Statistic. Ensuring normality, homogeneity of variance and independent observations were necessary to ensure that the *F*-statistic was reliable. The *F*-statistic or *F*-ratio was used to assess whether the set of independent variables (fidelity and nurse experience) accounted for more variation in CSET scores than extraneous factors (Field, 2013, p. 360). With a two-way ANOVA, the effect of fidelity, the effect of experience, and the interaction between the fidelity and interaction, has its own *F*-statistic.

Because the factorial design was 2 X 2, there were only two levels of fidelity and two levels of experience, there was no need for *post hoc* tests (Laerd, 2013, Field, 2013).

Correlation

An intercorrelation table was created to check for a relationship between select demographic variables as well as fidelity. Demographic variables included: Participant age, years of nursing experience, years of education, number of times participated in simulation.

Multiple Regression

Multiple regression was conducted to determine if demographic variables contributed to the variance in CSET score. Assumptions of a multiple regression analysis were conducted including independence of observations, linearity, homoscedasticity and multicollinearity. There was independence of observations (residuals), as assessed by a Durbin-Watson statistic of 2.11. A value of approximately 2 indicated that there was no

correlation between residuals (Laerd, 2015). Collinearity statistics were analyzed to ensure an absence of multicollinearity, as all variables had a tolerance of >.1 and VIF of <10.

Summary

This chapter reviewed the research design, population and sample, instrumentation, data collection procedures and data analyses that was used to address the research questions. This descriptive study allowed the researcher to determine differences in nurses performance when comparing two independent variables experience and fidelity, as well as the effect of the interaction of these variables on nrses simulation performance.

The findings from this study will be used to expand the body of knowledge regarding the use of fidelity in simulation design and facilitation. It will also contribute to the body of knowledge to substantiate aspects of the constructs of the NLN-Jeffries Simulation Framework. The following chapter will focus on the results of the data analysis from this study.

CHAPTER IV

RESULTS

The purpose of this study was to examine the effect of simulation fidelity and nursing experience on the performance of registered nurses in a simulation. This study was guided by the NLN/Jeffries Simulation Framework, focusing on the constructs of fidelity, participant experience, and outcomes. It was hypothesized that different levels of fidelity may result in variations in simulation performance scores and that variations in experienced nurses and novice nurses simulation performance scores would be explained by interactions among the levels of simulator fidelity and the nurses' experience.

The specific aims examined in this study were to: 1) determine the demographic characteristics of novice and experienced practicing nurses participating in low and high fidelity simulations, 2) examine differences in simulation performance scores of novice and experienced nurses, 3) examine differences in simulation performance scores of registered nurses in low and high fidelity simulations, 4) examine differences in Simulation Design Scale scores between the high and low fidelity groups, and 5) examine the association among nurses' demographics, years of nursing experience, fidelity levels, and simulation performance scores.

Study Aim 1

The first specific aim was to determine the demographic characteristics of novice and experienced practicing nurses participating in low and high fidelity simulations. This aim was addressed by using descriptive statistics to describe the sample.

Demographics and Characteristics

A sample of 35 registered nurses (RNs) providing patient care in an urban trauma center/tertiary care facility were recruited from a population of 2400 RNs and completed the study. Detailed information regarding recruitment and enrollment is provided in Chapter 3. The number of years of nursing experience among study participants ranged from 1 month to 39 years with a mean of 9.4 years (M=9.4; SD=10.1). Using SPSS 25, the variable, Years of Experience, was transformed from a continuous variable to a categorical variable with two groups: Novice and Experienced. Using Benner's *Novice to Expert* as a guide, participants with 0-3 years of experience were categorized as Novice and those with ≥4 years were categorized as Experienced. Demographics` based on experience level grouping are listed in Table 5. Demographics based on fidelity level are listed in Table 6.

Of the study participants, 32 (91.4%) were female and 3 (8.6%) were male. This compares to the 92% female and 8% of male nurses working in Minnesota (MDH, 2017). The study participants identifying themselves as white was comprised of 88.6% (n=31), of the study sample; 91% of registered nurses in Minnesota are Caucasian. The second most frequently reported race among RNs according to the MDH was African American (3%), followed by Asian (2%), Hispanic/Latino (1%), American Indian (1%) (MDH, 2017). The second most frequently reported race among study participants was Asian (n=2, 5.7%), followed by African American (n=1, 2.9%), and Native American (n=1, 2.9%). The mean age for the study sample was 37.8 years (M=37.8, SD11.4) with a range of 23 to 62 years.

Table 5. Demographic Characteristics of Novice and Experienced Practicing Nurses by Experience Level

Variable	Novice n(%)	Experienced n(%)	Total n(%)
Gender			
Female	13(92.9%)	19(90.5%)	32(91.4)
Male	1(7.1%)	2(9.5%)	3(8.6)
Total	14(40%)	21(60%)	35(100)
Race/Ethnicity			
White	14(100%)	17(81%)	31(88.6%)
African American	0	1(4.8%)	1(2.9%)
Asian	0	2(9.5%)	2(5.7%)
Native American	0	1(4.8%)	1(2.9%)
Total	14(40%)	21(60%)	35(100%)
Education Level			
Associate Degree	8(57.1%)	6(28.6%)	14(40%)
Bachelor's Degree	5(35.7%)	12(57.1%)	17(48.6%)
Master's Degree	1(7.1%)	3(14.3%)	4(11.4%)
Total	14(40%)	21(60%)	35(100%)
Area of Practice			
Med/Surg	8(57.1%)	7(33.3%)	14(40%)
Tele/Progressive	5(35.7%)	3(14.3%)	8(22.9%)
Critical Care/ED	1(7.1%)	7(33.3%)	8(22.9)
Mental Health	0	4(19.0%)	4(11.4%)
Total	14(40%)	21(60%)	35(100%)
Participation in Sim			
1-5 Times	5(35.7%)	12(57.1%)	17(48.6%)
6-10 Times	7(50%)	3(14.3%)	10(28.6%)
>11 Times	2(14.3%)	6(28.6%)	8(22.9%)
Total	14(40%)	21(60%)	35(100%)
Fidelity Level			
Low	9(56.3%)	7(43.8%)	16(46%)
High	5(26.3%)	14(73.7%)	19 (54%)
Total	14(40%)	21(60%)	35(100%)
N = 35			

Table 6. Demographic Characteristics of Novice and Experienced Practicing Nurses Participating in Low and High Fidelity Simulations by Fidelity Type

Variable	**Low n(%)**	**High n(%)**	**Total n(%)**
Gender			
Female	15(93.8%)	17(89.5%)	32(91.4)
Male	1(6.3%)	2(10.5%)	3(8.6)
Total	16(46%)	19(54%)	35(100)
Race/Ethnicity			
White	14(87.5%)	17(89.5%)	31(88.6%)
African American	1(6.3%)	0	1(2.9%)
Asian	0	2(10.5%)	2(5.7%)
Native American	1(6.3%)	0	1(2.9%)
Total	16(46%)	19(54%)	35(100%)
Education Level			
Associate Degree	8(50.0%)	6(31.6%)	14(40%)
Bachelor's Degree	7(43.8%)	10(52.6%)	17(48.6%)
Master's Degree	1(6.3%)	3(15.8%)	4(11.4%)
Total	16(46%)	19(54%)	35(100%)
Area of Practice			
Med/Surg	9(56.3%)	6(31.6%)	14(40%)
Tele/Progressive	1(6.3%)	7(36.8%)	8(22.9%)
Critical Care/ED	2(12.5%)	6(31.6%)	8(22.9)
Mental Health	4(25%)	0	4(11.4%)
Total	16(46%)	19(54%)	35(100%)
Participation in Sim			
1-5 Times	10(62.5%)	7(36.8%]	17(48.6%)
6-10 Times	5(31.3%)	5(26.3%)	10(28.6%)
>11 Times	1(6.3%)	7(36.8%)	8(22.9%)
Total	16(46%)	19(54%)	35(100%)
Experience			
Novice	9(56.3%)	5(26.3%)	14(40%)
Experienced	7(43.8%)	14(73.7%)	21(60%)
Total	16(46%)	19(54%)	35(100%)
N = 35			

Other sample characteristics included years of education, areas of practice, and the number of times the individual participated in simulation. The largest number of

study participants had a bachelor's degree in nursing (*n*=17; 48.6%) followed by associate degree (*n*=14; 40%), and a small number (n=4; 11.4%) were master's prepared. Most participants worked in medical/surgical areas (*n*=15; 42.9%); telemetry/progressive care and critical care/emergency both tied with eight participants each (*n*=8; 22.9%) and four participants worked in inpatient mental health units (*n*=4; 11.4%). All participants had experience in simulations prior to this study, with most (*n*=17; 48.6%) having participated in 1-5 simulations. This was followed by participation in 6-10 simulations (*n*=10; 28.6%), and the fewest number of participants (*n*=8; 22.9%) participated in 11 or more simulations.

Preanalysis Data Screening

Before performing the inferential statistics, the data was screened to ensure that the assumptions of factorial ANOVA and hierarchical multiple linear regression were met. Assumptions of factorial ANOVA included evaluating for normality, screening for outliers and as well as determining homogeneity of variance. Assumptions of hierarchical multiple linear regression included independence of observations, linearity, homoscedasticity and multicollinearity.

Testing for Normality

The assumption of normality was tested using the Shapiro-Wilk Test of Normality. The Shapiro-Wilk statistic not significant ($p > .05$) for any combination of the two independent variables, fidelity and experience. As a result, the data was determined to be normally distributed.

Outliers

Using SPSS 25, boxplots were created for Fidelity and Experience to check for outliers. A number of outliers were identified in as shown in Figures 3, 4, 6, and 7. No outliers were identified with the Experience group (Figure 2) or Low Fidelity: Novice group as evident in Figure 5. Outliers were identified on the boxplot graphs as dots that were more than 1.5 box lengths, but less than 3 box lengths from the edge of the box.

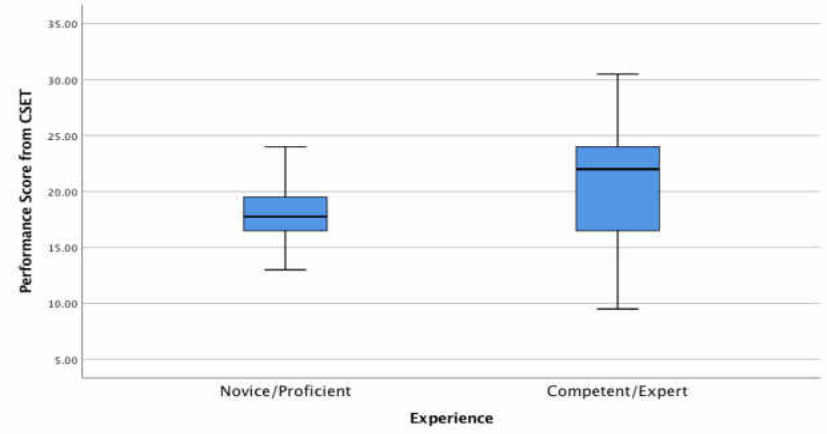


Figure 2. Boxplot for Outliers: Experience Category

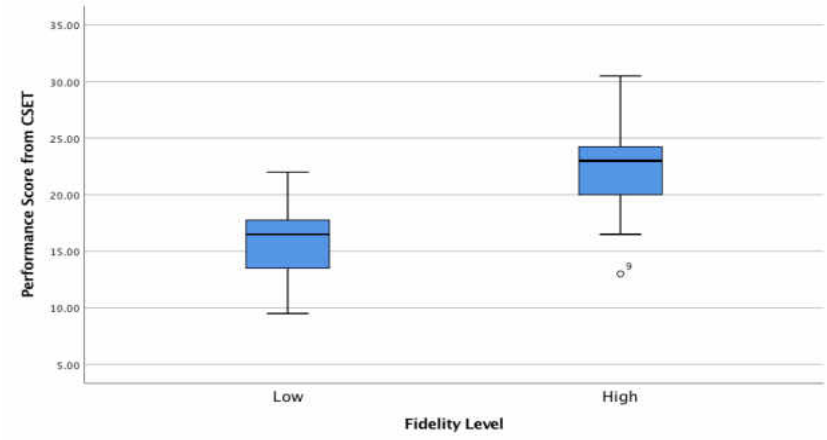


Figure 3. Boxplot of Outliers: Fidelity Variable

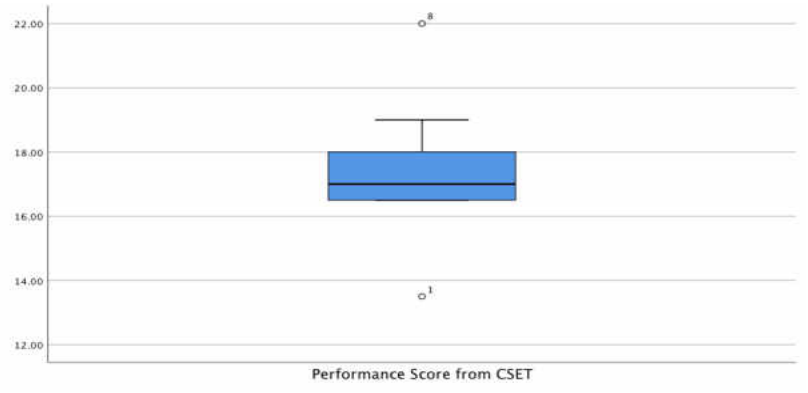


Figure 4. Boxplot of Outliers: Low Fidelity-Novice Nurses

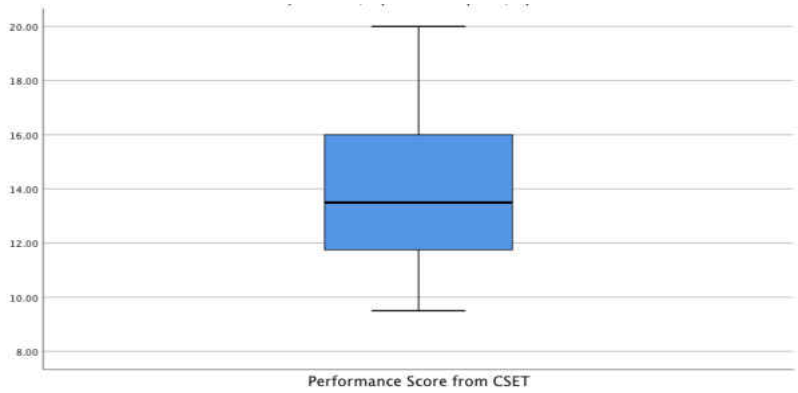


Figure 5. Boxplot of Outliers: Low Fidelity- Experienced

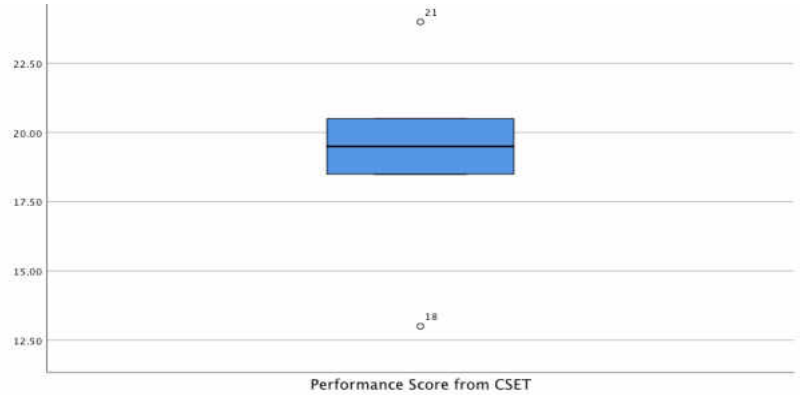


Figure 6. Boxplot of Outliers: High Fidelity-Novice Nurses

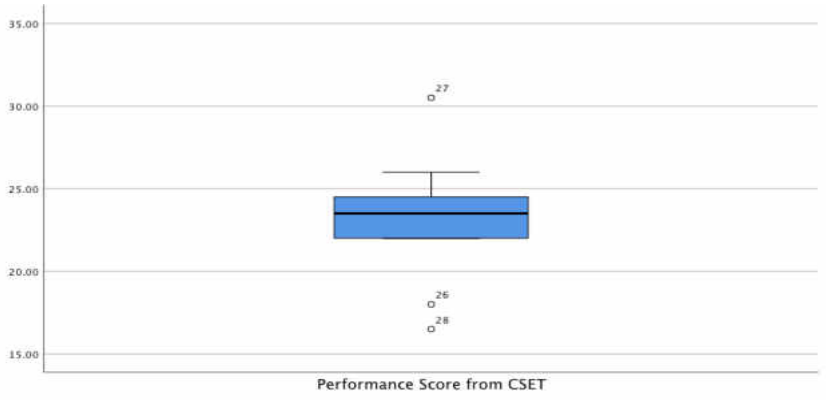


Figure 7. Boxplot of Outliers: High Fidelity-Experienced Nurses

Data were reviewed to ensure that outliers were not a result of data entry errors. Although there were outliers in three out of four combinations, they were not extreme. Because the outliers represented the performance of the study participants and none were extreme, the values were included in the analysis without modification or transformation.

Independence of Observations

There was independence of observations (residuals), as assessed by a Durbin-Watson statistic of 2.08. A value of approximately 2 indicated that there was no correlation between residuals (Laerd, 2015).

Testing for Homogeneity of Variance / Homoscedasticity

The assumption of homogeneity of variances was tested using Levene's Test. There was homogeneity of variances, as assessed by Levene's test for equality of variances. Variances were equal for Fidelity and Experience, $F(3, 31) = .58$, $p = .63$.

Multicollinerarity

Collinearity statistics were analyzed to ensure an absence of multicollinearity, as all variables had a tolerance of >.1 and VIF of <10.

Study Aim 2

The second specific aim was to examine differences in simulation performance scores of novice and experienced nurses. This aim was addressed by using descriptive statistics to describe the sample and the categorical grouping of novice and experienced nurses. Clinical Simulation Evaluation Tool (CSET) scores were assessed for differences in performance score between experience levels by analyzing the means, and conducting an independent t-test, to determine if there were any significance difference in the CSET scores based on experience.

There were 14 participants in the Novice group and 21 participants in the Experienced group. A Welch t-test was run to determine if there were differences in CSET scores between novice and experienced nurses. The Welsch t-test was used because the assumption of homogeneity of variance was violated, as assessed by Levene's test for equality of variance (p = .008). There were no outliers in the data, as assessed by an inspection of an experience category boxplot (Figure 2), and engagement scores for each level of experience were normally distributed, as assessed by Shapiro-Wilk's test (p>.05).

The CSET score for novice nurses (M = 18.0, SD = 2.96) was lower than the CSET score for experienced nurses (M = 20.2, SD = 5.57). However, there was not a

statistically significant difference in CSET scores between novice and experienced nurses M = .2.18, 95% CI (-5.13 to .776), t (31.8) = -1.50, p = .143.

Table 7. Differences in Simulation Performance Scores of Novice and Experienced Nurses

Experience	*N*	**CSET Score** ***M***	***SD***	***t***	***p***
Novice	14	18.0	2.96	-1.50	.143
Experienced	21	20.2	5.57		
N = 35					

Study Aim 3

The third specific aim was to examine differences in simulation performance scores of registered nurses when using low and high fidelity simulations. This aim was addressed by analyzing the means to determine if there were any significance differences in the CSET fidelity scores.

There were 16 participants in the Low Fidelity group and 19 participants in the High Fidelity group. An independent *t*-test was conducted to determine significant differences between performance of nurses that completed a high fidelity simulation and those that completed a low fidelity simulation.

There was one outlier in the data, as assessed by inspection of a boxplot (Figure 3). Because the outlier reflected participant actual performance and was not extreme, it remained in the dataset and was not modified. CSET scores were normally distributed as assessed by Shapiro-Wilk's test ($p > 0.5$), and there was homogeneity of variances, as assessed by Levene's test for equality of variances (p = .66).

The CSET scores for the High Fidelity group (M = 22.2, *SD* = 3.91) were higher than the CSET score for the Low Fidelity group (M = 16.0, *SD* = 3.31) as shown in Table

8. There was a statistically significant difference in CSET scores between nurses completing a Low Fidelity simulation and a High Fidelity simulation (*M* = -6.21, 95% *CI* (-8.73 to -3.70), *t*(33) = -5.02, *p* = .001).

Table 8. Differences in Simulation Performance Scores of Registered Nurses During Low and High Fidelity Simulations

Experience	*N*	**CSET Score** ***M***	***SD***	***t***	***p***
Low	16	16.0	.83	-5.02	.001
High	19	22.2	.89		

N = 35, Significance = *p* = <.05

Study Aim 4

The fourth specific aim, was to examine differences in Simulation Design Scale scores between the high and low fidelity groups. This aim was addressed by using descriptive statistics to describe the sample and conducting independent *t* tests to assess for differences between means. Table 9 lists the modified Fidelity category of the SDS. Table 10 includes how important the item was to the participant. As shown in Table 9, all items, and the overall total score, were ranked higher by the high fidelity group than by the low fidelity group. However, not all differences were statistically significant. Three items were significant: the realism of the mannequin (*t* = -2.90, *p* = .007), the realism of the environment (*t* = -2.39, *p* = .023), and the equipment worked like expected (*t* = -3.21, *p* = .003).

Importance of the items also differed between groups (Table 10), although not all were significant. In addition to mannequin (*t* = -2.27, *p* = .03), environment (*t* = -2.24, *p*

= .03), and equipment (t = -3.81, p = .001), there were statistically significant differences between the importance of the patient's voice being convincing and responding realistically (t = -2.03, p = .05).

Table 9. Difference in Simulation Design Scale Scores Between Low and High Fidelity Groups ($N = 35$)

SDS Question	Fidelity Level	N	Mean	Std. Deviation	*t*	*p*
The scenario resembled a real life situation	Low	16	4.44	.89	-.56	.58
	High	19	4.58	.61		
Real life factors, situations, and variables were built into the simulation scenario	Low	16	4.50	.52	-77	.45
	High	19	4.63	.50		
The realism of the mannequin helped the situation feel real	Low	16	3.88	.72	-2.90	.01
	High	19	4.53	.61		
The vital sign changes allowed me to recognize changing conditions	Low	16	4.69	.48	-.31	.76
	High	19	4.74	.45		
The realism of the environment helped the situation feel real	Low	16	4.13	.50	-2.39	.02
	High	19	4.58	.61		
The equipment worked like I expected it would in real life	Low	16	3.69	1.015	-3.21	.00
	High	19	4.58	.61		
The patient voice was convincing and the patient responded to me realistically	Low	16	4.25	.86	-2.30	.03
	High	19	4.79	.42		
The situation felt real	Low	16	4.00	.89	-.56	.58
	High	19	4.16	.77		
Total Fidelity Score from SDS	**Low**	**16**	**33.25**	**4.40**	**-2.68**	**.01**
	High	**19**	**36.53**	**2.78**		

N = 35, Significance = p <05

Table 10. Differences in Simulation Design Scale Importance Scores Between Low and High Fidelity Groups (*N* = 35)

How important were the following:	**Fidelity Level**	**N**	**Mean**	**Std. Deviation**	***t***	***p***
The scenario resembled a real life situation	Low	16	4.44	.63	-1.49	.15
	High	19	4.74	.56		
Real life factors, situations, and variables were built into the simulation scenario	Low	16	4.44	.63	-1.91	.07
	High	19	4.79	.42		
The realism of the mannequin helped the situation feel real	Low	16	4.00	.89	-2.27	.03
	High	19	4.58	.61		
The vital sign changes allowed me to recognize changing conditions	Low	16	4.75	.45	.08	.94
	High	19	4.74	.56		
The realism of the environment helped the situation feel real	Low	16	3.88	.89	-2.24	.03
	High	19	4.47	.70		
The equipment worked like I expected it would in real life	Low	16	3.94	.77	-3.81	.001
	High	19	4.74	.45		
The patient voice was convincing and the patient responded to me realistically	Low	16	3.88	1.09	-2.03	.05
	High	19	4.58	.96		
The situation felt real	Low	16	4.13	.81	-1.34	.20
	High	19	4.47	.77		
Total Importance Score	**Low**	**16**	**33.19**	**4.00**	-3.05	.004
	High	**19**	**36.95**	**3.291**		

N = 35, Significance = p <05

Study Aim 5

The fifth specific aim was to examine the associations among nurses' demographics, years of nursing experience, fidelity levels, and simulation performance scores. This aim was addressed by analyzing correlations among the participants' demographics, years of nursing experience, fidelity levels, and simulation performance scores, then conducting a multiple regression of fidelity, experience, age, correlations and a two-way (2X2 factorial) Analysis of Variance (ANOVA).

Factorial ANOVA

To address the whether there was an interaction effect between experience and fidelity, data was analyzed using a 2X2 factorial (two-way) analysis of variance (ANOVA). This statistical analysis approach was appropriate for this study as the study has two categorical independent variables (Fidelity and Experience), a continuous dependent variable and each grouping possibility of the two independent categories. Each category was measured using different participants.

When looking at the main effect of Experience, the *F*-ratio of 0.12 is not significant ($p = 0.73$, which is larger than 0.05). This result means that the experience level of participants did not influence their performance in the simulation as measured by the CSET score. There was no statistically significant difference in performance, based on experience alone, $F(1,31) = .12$, $p = 0.73$, *partial* $\eta^2 = 0.004$.

However, there was a significant main effect (Table 10) of Fidelity ($p = 0.0001$) This result means that fidelity level of the simulation influenced the participants' performance in the simulation as measured by the CSET score $F(1, 31) = 21.16$, $p = 0.0001$, partial $\eta^2 = 0.4.1$. Based on a pairwise calculation, high fidelity simulation was

associated with a mean CSET score 5.44 (95% CI, 3.03-7.85) points higher than low fidelity simulations, a statistically significant difference, $p = <0.0001$. Regardless of experience, individuals in a high fidelity simulation have higher CSET scores than those in a low fidelity simulation.

A 2X2 factorial (two-way) between-groups analysis of variance (ANOVA) was conducted to explore the effect of fidelity and experience on the CSET score. In order to identify interactions effects between factors, line plots of the cell means were performed. The lines show that lower levels of fidelity combined with experienced nurses are related to lower performance scores. Higher fidelity with experienced nurses are related to higher performance scores. ANOVA results presented in Table 10 show a significant interaction effect between Fidelity and Experience $F(1,31) = 10.23$, $p = 0.003$, *partial* $\eta^2 = 0.25$ with an 87% power.

Line plots *(Figure 9)* of the cell means were performed to identify interaction effects between factors. Line plots of Fidelity and Experience variables show interaction between factors. Lines show that performance in both high and low fidelity simulations is moderated by experience. Experienced nurses in a high fidelity simulation scored higher ($M = 23.1$, *SD* 5.6) compared with experienced nurses in a low fidelity simulation ($M = 14.1$, *SD* 3.6).

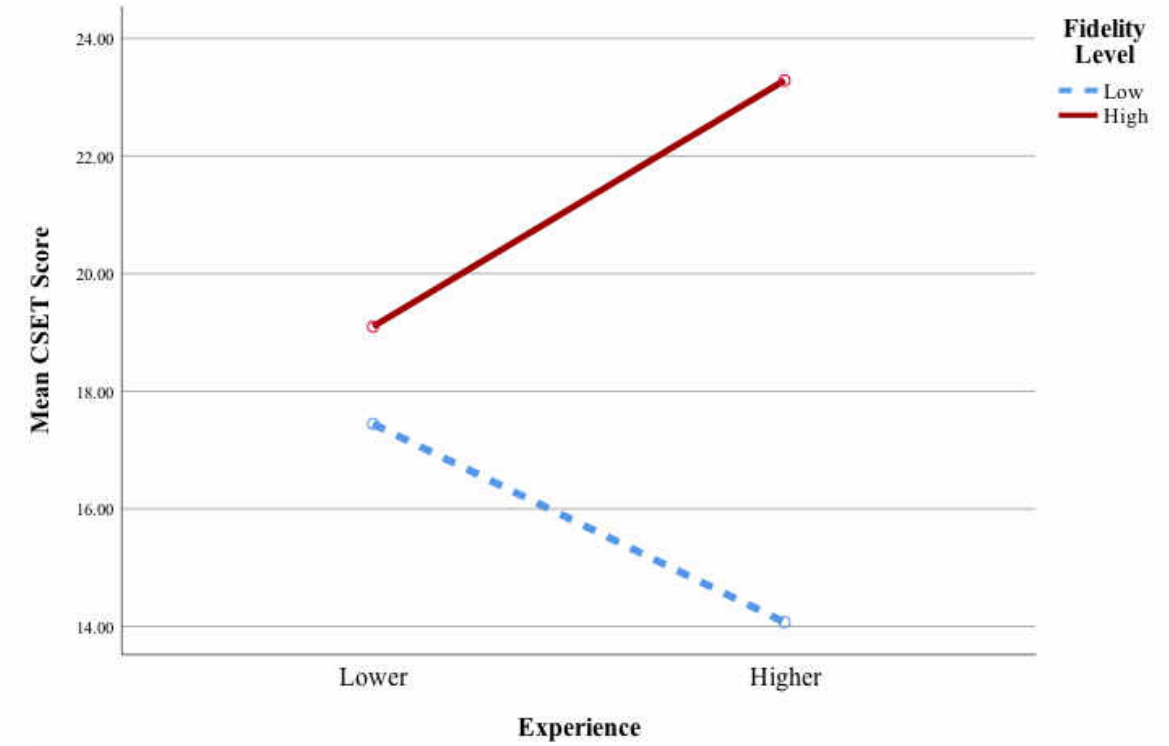


Figure 9. Examining the Moderating Effect of Experience on the Relationship Between Fidelity and Performance

Correlations

In addition to experience and fidelity, associations between other demographic variables were determined using an intercorrelation table (Table 12).

Large (r >.50) and medium (r>.30) correlations were identified. There was a high positive correlation (r = .81) between years of experience and age (p=.001), and moderate positive correlations between years of experience and years of education (r = .40, p <.01) and between fidelity level and the number of times someone participated in simulation (r = .35, p <.05). There was a moderate negative correlation between participant age and the number of times they participated in simulation (r = -.34, p <.05), where lower age is associated with a higher number of times of times in simulation.

Table 11. Correlation among CSET scores, fidelity levels, nurses' demographics, years of nursing experience, education and number of simulation experiences

Variable	1	2	3	4	5	7		8
CSET Score	1							
Fidelity Level	.66**	1						
Gender	.07	-.08	1					
Race	-.12	.00	.56	1				
Age	-.14	-.10	-.01	.09	1			
RN Experience	-.05	.06	-.06	.17	.81***	1		
Education Level	.19	.21	.31	.10	.18	.40**	1	
Number of Simulation Experiences	.38*	.35*	.03	-.31	-.34*	-.20	.02	1

($N = 35$)*p<.05. **p<.01. ***p<.001

Hierarchical Multiple Linear Regression

A hierarchical linear regression was conducted to determine the effects of fidelity levels, years of experience as a nurse, participant age, area of practice, years of education and the number of times a nurse participated in simulation, on the simulation performance (CSET) scores of registered nurses in this study. The hierarchical order was determined by the variables of interest for this study, followed by participant characteristics identified by the NLN/Jeffries Simulation Framework, and finally number of simulation experiences. The models were: 1) fidelity, 2) experience, age, work area, education, 3) number of simulation experiences. A hierarchical multiple linear regression was run to determine if the addition of participant demographics (experience, age, practice area, education) and then number of simulation experiences, improved the

prediction of performance (CSET score) over and above fidelity alone. The hierarchical linear regression model (Table 12) was statistically significant for fidelity F(1,33) = 25.23, $p < .0005$. However, the addition of experience, age, work area, and education to the prediction of performance (CSET scores) for Model 2 did not lead to a significant change $R^2 = .02$, F(4,29) = .30, p = .87. Also, the addition of number of simulations to the prediction of performance (CSET score), Model 3, didn't lead to a significant change in $R^2 = .021$, F(1,28) = 1.12, p = .30.

Table 12. Association Among Nurses' Demographics, Years of Experience, Fidelity Levels, and CSET Scores (*N = 35)*

Model	Variable	Partial Correlation	Change in R2	Cumulative R2	Beta Coefficients
1	Constant		.43***	25.23	17.52***
	Fidelity Level	0.66			5.02***
2	Constant		.02	4.86	1.03
	Fidelity Level	0.65			4.56***
	RN Experience	-0.14			-0.76
	Age	0.03			0.18
	Area of Practice	0.09			0.49
	Education	0.12			0.66
3	Constant		.02	4.26	0.74
	Fidelity Level	0.60			3.98***
	RN Experience	-0.15			-0.80
	Age	0.08			0.44
	Area of Practice	0.06			0.31
	Education	0.13			0.69
	Sim Times	0.20			1.06
	Significance = *p <0.5 **p.01 ***p<.001				

Summary

Registered nurses, regardless of experience, performed better in a high fidelity simulation than a low fidelity simulation with a mean difference in CSET scores of 5.44 points. In contrast, the amount of experience working as a registered nurse didn't impact performance in simulation, as indicated by the CSET score. Other demographic factors (age, years of experience, number of simulations, educational preparation) did not have an association with performance.

However, there was an interaction effect between fidelity and experience. Higher levels of fidelity, combined with higher experience levels, were related to higher performance (CSET scores). Lower levels of fidelity, combined with more years of clinical experience were related to lower performance (CSET score). Less experienced nurses performed better in low fidelity simulation than nurses with more experience. Experienced registered nurses performed much better in high fidelity simulations.

In addition, the Simulation Design Scale score was different for high and low fidelity groups, but only significant in mannequin ($p < .01$), environment ($p = .02$), and equipment ($p = .003$). The purpose of this study was to examine the relationship of simulation fidelity and years of nursing experience when measuring simulated performance scores of registered nurses.

CHAPTER V

DISCUSSION

Introduction

The purpose of this quantitative study was to examine the relationship of simulation fidelity and years of nursing experience on the performance of registered nurses in a simulation. This study was guided by the NLN/Jeffries Simulation Framework, focusing on the constructs of fidelity, participant experience, and outcomes. It was hypothesized that different levels of fidelity may result in variations of simulation performance scores, and that variations in experienced nurses and novice nurses performance in simulation would be explained by interactions among the levels of simulator fidelity and the nurses' experience. More experienced nurses in a high fidelity simulation would have a higher CSET score than experienced nurses in a low fidelity simulation, conversely, novice nurses may have a higher CSET score when participating in a low fidelity simulation when compared to participation in high fidelity simulation. The purpose of this study was examined by the following study aims:

Study Aims

1. To determine the demographic characteristics of novice and experienced practicing nurses participating in low and high fidelity simulations.

2. To examine differences in simulation performance scores of novice and experienced nurses.
3. To examine differences in simulation performance scores of registered nurses during low and high fidelity simulations.
4. To examine differences in Simulation Design Scale scores between the high and low fidelity groups.
5. To examine the association among nurses' demographics, years of nursing experience, fidelity levels, and simulation performance scores.

Registered nurses, regardless of experience, performed better in a high fidelity simulation than a low fidelity simulation. There was no difference in simulation performance scores based on years of experience or other demographic factors. However, there was a significant interaction effect between fidelity and experience on nurse performance.

This final chapter presents a summary of this study and includes a discussion of the results of the statistical analysis described in chapter four. Limitations of the study, implications for education and practice, including recommendations for further research are also discussed. The discussion begins with demographic information about the sample.

The *First Study Aim* was to determine the demographic characteristics of novice and experienced practicing nurses participating in low and high fidelity simulations.

A convenience sample of 35 registered nurses were randomized to complete a high fidelity or low fidelity simulation. The following demographic data were analyzed

for this study: gender, ethnicity/race, age, work location, years of experience, and times participating in simulation. Demographic information is more common in studies with nursing students. Few studies were found that had practicing nurses as participants. Therefore, literature on demographic information beyond years of experience and work location was sparse.

Gender

In this study, participants were predominately female (n = 32, 91%). Although the sample didn't include equal numbers of female and male nurses, the percentages were representative of the gender distribution of registered nurses (female = 92%, male = 8%) in Minnesota (MDH, 2017). This percentage is similar to other studies of practicing nurses in studies where gender was addressed (Stefaniak & Turkelson, 2014; Buckley & Gordon, 2010). In studies with nursing students, the percentage of female and male participants are slightly different, ranging from 85% to 88% female (Levett-Jones, Lapkin, Hoffman, Arthur, Roche, 2011; Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries; 2014). Although slight, the difference may reflect the increase in males entering nursing as students.

Race/Ethnicity

The study participants identifying themselves as Caucasian comprised 88.6% (n =31) of the study sample; slightly less than the percent of Caucasian registered nurses in Minnesota (91%). The second most frequently reported race among RNs according to the Minnesota Department of Health's 2017 workforce study, was African American (3%), followed by Asian (2%), Hispanic/Latino (1%), and Native American (1%) (MDH, 2017). The second most frequently reported race among study participants was Asian

(*n*=2, 5.7%), followed by African American (*n*=1, 2.9%), and Native American (*n*=1, 2.9%).

Age

The mean age for this study sample was 37.8 years (*M*=37.8, *SD*11.4) with a range of 23 to 62 years. This is younger than the mean age for registered nurses in Minnesota, but similar (*M* = 36.6, *SD* 10.0) for practicing nurses in other simulation studies (Yang, Thompson, & Bland, 2011, Buckley & Gordon 2011). Participants in this study were older than student nurses; the greatest percentage of the students nurses were 18 to 25 years old. (Zapko, Ferranto, Blasiman & Shelestak, 2017, Hayden, Smiley, Alexander, Kardong-Edgren, & Jeffries, 2014; Levett-Jones, Lapkin, Hoffman, Arthur, & Roche, 2011).

Age is one of the original elements within the Participant Construct of the NLN/Jeffries Simulation Framework (Adamson, 2015; Durham, Cato, & Lasater, 2014, Jeffries, 2007). Although it is included in the framework, participant age is inconsistently included. The exact relationship of participant age on simulation outcomes is also unclear.

Education Level

More study participants had a bachelor's degree in nursing (*n*=17; 48.6%) followed by associate degree (*n*=14; 40%), and a small number (n=4; 11.4%) were master's prepared.

Area of Practice

Most of the nurses in this study worked in medical surgical nursing (*n*=15; 42.9%); this followed by eight (22.9%) nurses in telemetry/progressive care nursing; and

eight (22.9%) critical care/emergency nursing. Four participants who worked in inpatient mental health units (*n*=4; 11.4%). Unlike this study, participants in other studies were from a single practice area: critical care, pediatrics, pediatric critical care, and obstetrics (Bultas, Hassler, Ercole, & REA, 2014); Calhoun, Boone, Dauer, Campbell, Montgomery 2014; Stefaniak & Turkelson, 2013). Buckley & Gordon (2011) reported that most of their sample of graduate students (84%) worked in medical/surgical/oncology areas with only eight percent in critical care/pediatrics, and three percent in mental health areas.

Participation in Simulation

All study participants had involvement in simulations prior to participation in this study. Most nurses (*n*=17; 48.6%) had participated in 1-5 simulations. Ten of the nurses in this study had participated in 6-10 simulations (*n*=10; 28.6%) prior to this study, and the fewest number of participants (*n*=8; 22.9%) participated in 11 or more simulations.

Interestingly, there was a negative correlation (r = -34, p <.05) between the number of times someone participated in simulation and their age. Younger nurses had participated in a greater number of simulations. The use of simulation in nursing schools and in health systems for orientation and onboarding may contribute to this. The effect of the number of simulation experiences on performance in simulation is an area that is not well published in the literature. This is an opportunity for future exploration.

Experience

Experience levels of the nurses in the study ranged from 0 (3 months) to 39 years with a mean of 9.4 years (SD = 10.1). Most studies with practicing nurses included the number of years of experience as a registered nurse. The mean of experience varied

widely from 1 year to 12 years (Bultas, Hassler, Ercole, & Rea, 2014; Calhoun, Boone, Dauer, Campbell, & Montgomery, 2014; Yang, Thompson, & Bland, 2011).

Studies involving nursing students also included participant experience. But instead of years as an RN, it was from the perspective of grade level. Some authors wrote this as year 1 through year 4 in their collegiate nursing program (Baptista, Paiva, Concalves, Oliveria, Pereira, & Martins, 2016; Basak, Unver, Moss, Watts, & Giaoso, 2015) while others used sophomore, junior or senior designation (Zapko, Ferranto, Blasiman & Shelestack, 2017; Basak, Unver Moss, Watts, & Gaioso, 2016; Levett-Jones, Lapkin, Hoffman, Arthur, & Roche, 2011; Radhakrishnan, Roche, & Cunningham, 2007)

For data analysis with this study, the experience variable was changed from a continuous variable to a categorical variable. Categories were based on Benner's *Novice to Expert* classification. Nurses with 0-3 years of experience would be considered in the category of "Novice to Competent", and was titled "Novice" in this study. Nurses with over 3 years of experience were typically classified as "proficient to expert" for this study, are titled as "Experienced".

The National League for Nursing / Jeffries Simulation Framework (NLN/JSF) identified three variables within the participant construct that may influence performance: age, program, and level (Jeffries, 2005; Adamson, 2015). The framework was initially developed with an academic perspective which is why the terms level and program are used (Jeffries, 2007, 2012; Durham, Cato, Lasater, 2014, Adamson, 2015). Since the NLN/ Jeffries Simulation Framework State of the Science Project in 2012 (Duram, Cato & Lassater, 2014; Adamson, 2015), the construct has expanded to include a practice

focus as evident, in part, by nomenclature changes from learner to participant. For this study, the variable of interest within the participant construct is Experience.

The *Second study aim* examined differences in simulation performance scores of novice and experienced nurses.

Performance scores of novice nurses (M = 18.0, SD = 2.96) were not significantly different (t = -1.50, p = .14) from the performance scores of experienced nurses (M = 20.2, SD = 5.57) when comparing the mean Clinical Simulation Evaluation Tool (CSET) scores.

Simulation studies examining outcomes based on different levels of participant experience are very limited. Several studies with varied levels of nursing students are present in simulation literature (Zapko, Ferranto, Blasiman & Shelestack, 2017; Basak, Unver Moss, Watts, & Gaioso, 2016). These studies categorized students by different academic program levels. However, the studies did not measure performance; instead, the outcomes were based on a participant self-assessment of perceived competence and satisfaction.

For this study, the lack of significant performance differences between novice and experienced nurses maybe related to the design of the scenario. This scenario was designed for medical/surgical nurses. As a result, a newer nurse, working in a medical/surgical area should have the appropriate knowledge, judgment, and skills to perform the correct actions in comparison to a more experienced nurse, or someone working in a specialty area such as a critical care or an emergency department. If the scenario was very complex or included advanced concepts, there might be differences.

Another reason there were no differences in performance scores may be related to an individual's comfort and familiarity in simulation. The more practice someone has in simulation, the more they know what is expected and how to interact with the mannequin and equipment. Points were awarded on the CSET based on recognizing a problem and completing an action. In order for points to be awarded in this study, the nurse needed to complete an action, such as checking vital signs, administering a medication, checking the patient's identification, or connecting oxygen to a flowmeter. Although all participants received an orientation which included using the equipment and the simulation environment, nurses who work more extensively with simulation may be more comfortable with the mannequin and engage in the situation more realistically.

The third study aim examined differences in simulation performance scores of registered nurses during low and high fidelity simulations.

It was hypothesized that different levels of fidelity may result in variations of simulation performance scores. In this study, levels of fidelity did impact the simulation performance score. The performance score of nurses in the low fidelity group (M = 16.0, SD = .83) was lower than the score of nurses in the high fidelity group (M = 22.2, SD = .89) at a statistically significant level (t = -5.02, p = .001). Fidelity also had a significant main effect (F = 21.16, p = .0001, η^2 .406, observed power 99%) in a 2-way ANOVA. In this study, high fidelity simulation was associated with higher performance scores. This result is not consistent in the literature (Adamson, 2015, Weaver 2011). Systematic reviews have demonstrated that simulation, when compared with other types of instruction and traditional teaching strategies, may produce more positive outcomes (Adamson, 2015). There is no consistent evidence, however, that high fidelity simulation

is associated with better performance than low fidelity simulation. The literature is inconsistent regarding the effect of fidelity on simulation outcomes. Some studies have found that high fidelity simulation has greater outcomes compared to low fidelity simulation (DeMaria et al., 2010; Bultas, Hassler, Ercole, & Rea, 2014), other studies have found no difference (Hoadley, 2009; Bebe, 2012), and some have found better outcomes with lower fidelity simulation (Chen, Grierson, & Norman, 2015; Yang, Thompson, & Bland, 2011).

Some of the inconsistency may be related to study designs and how fidelity levels are defined. Yang, Thompson, & Bland (2011) found that higher fidelity reduced confidence and judgement accuracy with experienced nurses and that outcomes were better with low fidelity simulation. However, they compared a simulation using a mannequin (high fidelity) with a paper/pencil simulation (low fidelity). The objective was for participants to recognize cues for decreasing levels of consciousness. However, the mannequin used for the simulation did not have eye opening/closing capabilities and verbal cues to denote changing levels of consciousness were pre-recorded statements and various moans. Mannequin features were included in the "prebrief", but it was still artificial; the patient didn't respond as it would in an actual situation. Additionally, patient deterioration is complex. It may be expected that participants would recognize issues in a one dimensional paper case study more frequently than when faced with the complexities of a clinical environment and a "patient" that doesn't accurately reflect what would be encountered in an actual clinical environment.

Other fidelity challenges included a lack of consistent terminology as well as a lack of what the author meant regarding high or low fidelity. Hoadley (2009) compared

high and low fidelity simulation, yet only refers to use of high and low fidelity mannequins. The study doesn't address other elements of fidelity nor specify what mannequin was used for low fidelity and what mannequin was used for high fidelity. Previous studies have also compared high fidelity simulation to other educational and simulation methodologies including case studies, task trainers, and traditional classroom experiences. Although important, it is difficult to extrapolate the impact of fidelity when other elements were compared.

The fact that this study compares high and low fidelity from the perspective of the mannequin, environment, equipment, and psychological aspects, including the style and authenticity of the patient's voice is unique. It allows the fidelity to be compared without extraneous factors. This is important in order to develop a better understanding of the aspects of fidelity that impact performance and develop a standardized process for naming levels and determining when and how a particular level of fidelity should be used.

The fourth study aim examined differences between Simulation Design Scale scores the high and low fidelity groups. `

The Simulation Design Scale was developed to obtain participant feedback on the five elements of the Simulation Design Construct, within the NLN/Jeffries Simulation Framework. Participants in other studies completed all 5 sections. However, for this study, participants only completed the Fidelity section of the Simulation Design Scale. The original instrument only had two questions related to fidelity. To obtain a greater understanding of participant perceptions related to fidelity, six additional questions were added to the Simulation Design Scale. The additional questions were found to have a

high level of internal consistency and reliability. Using a 5-point Likert scale, participants assigned values (strongly agree to strongly disagree) for each item. They also assigned values for how important that item was.

Participants in the high fidelity group gave higher scores for all eight questions regarding the fidelity elements and also ranked the importance of these items as more important than the low fidelity group. However, not all differences were statistically significant. Three features were significant: the realism of the mannequin (t = -2.90, p = .01), the realism of the environment (t = -2.39, p = .02), and that the equipment worked like expected (t = -3.21, p < .00). The difference of the importance of these three features were also statistically significant (mannequin (t = -2.27, p = .03), environment (t = -2.24, p = .03), and equipment (t = -3.81, p < .01)). In addition were statistically significant differences between the importance of the patient's voice being convincing and responding realistically (t = -2.03, p = .05).

These results are similar to Basak et al, (2016) who studied beginning and advanced nursing students' perceptions with low fidelity and high fidelity simulations. In both studies, participants who participated in a low fidelity simulation provided lower scores on the SDS.

The results of this study are consistent with the findings previously published (Basak et al., 2016). Key aspects in the simulation, mannequin, environment, and equipment, were the items that were significantly different between the two fidelity levels. It was interesting that mean differences from the question "the vital signs changes allowed me to recognize changing conditions" were not statistically significant. Participants in another study (Johnson, G. (2012). *Factors that Impact Nurses'*

Experience and Performance During High Fidelity Simulation. (Unpublished research)) have stated that dynamic vital signs were very important in their assessments and decision making. The low fidelity group did not have dynamic vital signs, and instead received verbal vital signs from the facilitator when the appropriate monitoring equipment was applied and when if a repeat measurement was requested.

The final study aim examined the association among nurses' demographics, years of nursing experience, fidelity levels, and simulation performance scores.

To examine association among nurses' demographics, an intercorrelation table was created and correlations between the demographic variables were analyzed. It was hypothesized that variations in experienced nurses' and novice nurses' performance scores would be explained by interactions among the level of simulator fidelity and nurses' experience. More experienced nurses in a high fidelity simulation may have a higher CSET score than experienced nurses in a low fidelity simulation, conversely, novice nurses may have a higher CSET score when participating in a low fidelity simulation when compared to participation in high fidelity simulation.

A 2X2 factorial (two-way) analysis of variance (ANOVA) between groups was conducted to explore the effect of fidelity and experience on the CSET score. There was a significant interaction effect between Fidelity and experience $F(1,31) = 10.23$, $p < 0.01$, *partial* $\eta^2 = 0.25$ with an 87% power. Experienced nurses had a higher simulation performance score when participating in a high fidelity simulation compared with a low fidelity simulation. In fact, in the low fidelity group, experienced nurses scored lower than novice nurses. Novice nurses also had a higher performance score in high fidelity

simulation compared to low fidelity simulation, but the difference was not nearly as significant.

In addition to experience and fidelity, associations between other demographic variables were determined using an intercorrelation table.

Large (r >.5) and medium (r>.3) correlations were identified. There was a high positive correlation (r = .81) between years of experience and age (p <.01), and moderate positive correlations between years of experience and years of education (r = .40, p <.01) and between fidelity level and the number of times someone participated in simulation (r = .348, p <.05).

The correlation between age and years of nursing experience as well as years of experience and years of education is not surprising, since typically nurses with more years of employment are older, and many nurses return to school after their initial nursing degree. However, it is unclear if these correlations have any impact on simulation performance.

The hierarchical linear regression model was statistically significant for fidelity (Model 1) $F(1,33) = 25.23$, $p < .0005$, but not for participant demographics (Model 2), including experience or when the number of simulation experiences (Model 3)was included. Based on the regression model, participants' experience, age, educational level and practice area didn't contribute significantly to an increase in performance as measured by the CSET score.

The lack of significance with the addition of demographic factors, specifically experience is surprising, given that experience had an interaction effect with fidelity. It is also interesting that educational preparation did not impact performance, especially with

studies indicating that organizations with higher rates of nurses with a BSN degree are associated with significant reductions in adverse patient outcomes including failure to rescue.

There is a paucity of literature examining fidelity, experience and performance of practicing nurses. It is difficult to compare this study, with its focus on performance, with others that are focused on participant self-confidence and self-assessed perceptions of cognitive improvement.

Limitations

There were a number of limitations that impact the generalizability of this study's results. One limitation was the small sample size (n = 35). Initially, a sample of 68 nurses was planned. However, many registered nurses stated they did not want to participate because they didn't want to be recorded or they didn't like participating in simulation. Because of recruitment challenges a sample of 35 participants was obtained. Challenges with recruiting practicing nurses is not limited to this study. Other simulation studies (Bultas, et al., 2014; Calhoun, et al., 2014) of registered nurses also documented recruitment challenges. Bultas recruited 66 pediatric nurses and had 33 nurses complete their study. Of the 50 nurses required for Calhoun's study, only 28 nurses were recruited. Despite the small sample size, the effect size was large and the observed power was over 80%. Similar to Calhoun's study, this study also had a large effect size for the main effect of Fidelity and the interaction of Fidelity and Experience. As a result, power was over 80% despite the small sample.

Another barrier to generalizability is that the sample was from one hospital and, while participants were randomized to a low or high fidelity level, convenience sampling

was used. Finally, it is important to note that this study was conducted with registered nurses in an acute care setting. Results may be different with students or other health care professions.

Recommendations for Further Research, Education and Practice

This study contributes to body of work supporting the NLN/Jeffries Simulation Framework. It provides evidence for the constructs of the NLN/Jeffries Simulation Framework, specifically how experience (participant construct) interacts with fidelity (simulation design construct) to impact the simulation performance score (outcomes construct).

Gaps remain in our understanding of simulation fidelity. There are opportunities to quantify what constitutes high or low fidelity within the aspects of mannequin, equipment, environment, scenario and psychological factors. Ideally, the health care simulation community would quantify the appropriate level of fidelity for the different uses of simulation. Like the aviation industry, one level of simulation fidelity might be appropriate for a novice learner education and practice. However, a different level of fidelity would be required for assessment and testing.

As simulation's use continues to increase with high stakes assessment, it is important for educators and practice experts to understand the importance of fidelity in participant performance. As this study indicated, experienced nurses performed poorly in a low fidelity simulation. If simulation is used for high stakes assessment, it would be important to create a high fidelity simulation experience to ensure that an individual's abilities are being measured correctly and that their performance is not negatively impacted by their performance in because of the simulation design.

Because the difference in performance was not as extreme with novice nurses, low fidelity simulation may be more appropriate for novice participants. This is especially important if a simulation program has limited resources and is unable to provide high fidelity simulation to all of the participants.

While this study addressed the importance of fidelity on performance and the interaction with experience, it didn't address how fidelity levels might affect transfer of education to bedside performance, or ultimately the impact on patient care.

Finally, while this study demonstrated a difference in performance scores with acute care nurses, it would be important to replicate the study with different health care professionals.

Conclusion

The results of this study is important for educators, clinicians and administrators who may be designing simulation activities and delegating resources. While high fidelity simulation was associated with higher performance scores for both novice and experienced nurses in this study, it was most significant with experienced nurses. This study demonstrates the importance of considering participant experience level when determining the appropriate fidelity level for a simulation activity.

APPENDICIES

Appendix A

Clinical Simulation Evaluation Tool (CSET) page 1

Clinical Simulation Evaluation Tool (CSET)

Directions: Check the items in Observed Actions area based on performance of participant in the simulation. Calculate score based on possible points. Document points in *Actual Points* column. Add actual points together to obtain total.

Ns	Possible Points	Observed Actions	Comments	Actual Points
Safety & Communication				
***Hand Hygiene:** Performs proper hand hygiene before caring for patient and as needed	1	___ Hand hygiene (foam **or** hand wash)		
***Introduces Self:** (AIDET) States name and role to patient, family member and/or health care provider.	2.5 **(0.5 each)**	___Acknowledge ___ Introduce ___ Duration ___ Explanation Thank you		
***Verifies Patient Identification:** Ask patient to state their name, DOB and verify on ID Band. **OR** verify patient name and Medical Record Number on ID band.	1.5 **(0.5 each)**	___ Verify Patient Full Name* ___ Verify Patient DOB* *OR* MR ___ Checks ID band / Scans band		
***Verifies Allergy:** Asks the patient about allergies AND verifies allergy band.	1 **(0.5 each)**	___Ask about allergies*/ ____Verify allergy band*		
Communication: Explains to patient/ member what they are doing and/or why.	1 **(0.5 each)**	___ Explain Assessment ___ Explain Interventions		
Error: Recognizes error	1 (1 ≤3 min) (.5 >3≤6 min) (0 ≥7 min)	___ O2 disconnected from flow meter		
Error: Corrects error.	1	___ Connects cannula to flow meter		
Communicates with HCP effectively : Gives appropriate info using SBARR guidelines	2 **(0.5 each)**	___Situation ___Background ___Assessment ___Recommendation		
Assessment & Critical Thinking				
Initial Assessment **ABC's & LOC:** Assesses Patient's Airway (able to speak), Breathing (chest rising and falling), Circulation (check pulses) and Level of Conscious-ness	4 **(0.5 each)**	___Airway/Breathing (check lung sounds) ___ Circulation (check pulse/cms) ___ LOC (ask what happened, A & O) ___Neuro (pupils, extremities, movement/sensation ___Check physical site/bruising ___Temp, BP, HR, RR ↑ ___ O2 sat ___Pain 0-10 location, quality		
Complete assessment before administering pain medication	1	___Assessment completed prior to med admin		
Respiratory Change assessment: Assesses appropriately based on patient presentation, signs and symptoms	2.5 **(0.5 each)**	___ Reassesses SpO2 ___ Reassesses resp rate ___ Listens to lung sounds ___ Recognize change in resp/O2 sats Subjective data		
LOC Change Assessment: Assesses systems appropriately based on patient presentation, signs and symptoms.	2.5 **(0.5 each)**	___ RR <6 ___ Response to pain only ___ Check pupils ___ Speech change ___ Recognize changes in LOC		

Follow up Assessment: Assesses systems appropriately based on patient presentation, signs and symptoms.		**2 (0.5 each)**	___Reassess pain relief ___Reassesses & recognize changes is VS ___Reassess changes in O2 sat ___Recognize unresponsive / pulseless < 10 sec	
		Problem ID & Critical Thinking		
Identify Problem/s: Identifies actual and/or possible medical and/or nursing problems *(Can identify while thinking out loud or by actions)*		**3 (1 each)**	___Pain ___Resp depression/narcotic ___Recognition pulseless	
		Intervention / Evaluation		
Priority Interventions: Initiates appropriate priority interventions		**13 (0.5 each)**	Pulmonary Hygiene ___Deep breath / cough or use IS ___Teach splinting/splits side with hands or pillow ___Elevate HOB Narcotic ___Obtain correct med/dose ___Check Pt ID ___Scrub hub or take off/replace green cap ___Administer narcotic dose ___Flush Narcan (if MS 4 mg given) ___Obtain order for narcan ___Obtain correct med/dose ___Check Pt ID ___Scrub hub or take off/replace green cap ___Administer narcan dose/rate/time ___Flush Or If MS dose is <3mg ___Explains to patient why low dose/slow dose ___States reassess in 15-30 min Resp ___Increases oxygen flow ___Change to FM /NRB mask ___Connect FM to flowmeter ___Removes nasal cannula ___Calls MD/Charge/RRT ___Call code ___Remove pillow ___Check pulse ___Put bed flat ___Compressions started within 30 sec	
Delegates appropriate possible tasks to others.		**(0.5 each)**	___Delegation	
Thinking Process: Discusses out loud during/after scenario possible problems, pathophysiology, and/or rationale for assessment and interventions.	**NA**	NA for this study		
Reflection: Identifies strengths and areas for improvement when viewing video with objectives and discussion with faculty& peers.	**NA**	NA for this study		
Final Actual Total Points: Comments (write in columns	**40 possible total points**			

Used with permission College of Nursing, University of Amherst

From: Helene Cunningham <h.cunningham40@gmail.com>
Date: April 9, 2015 at 11:04:04 AM CDT
To: "Johnson, Gail" <gail.l.johnson@my.und.edu>
Subject: Re: CSET Use for Dissertation request

Gail.
Yes feel free to use the tool and give College of Nursing Amherst credit.
Good luck with your study.

Best wishes,
Helene

Helene Cunningham, RN, MS
Director Nursing Clinical Simulation Lab
University of Massachusetts Amherst
School of Nursing
Edna L. Skinner Hall 307
651 No. Pleasant Street
Amherst, MA 01003
413-695-2520
helene@nursing.umass.edu

On Tue, Apr 7, 2015 at 2:24 PM, Johnson, Gail <gail.l.johnson@my.und.edu> wrote:

Dr. Cunningham,

I am writing to request permission to use your instrument, the Clinical Simulation Evaluation Tool, CSET, in my dissertation. My dissertation is *The Effect of Fidelity on Nurse Performance in Simulation.* I am looking at performance (based on the score of the CSET) as my dependent variable and nurse experience (new grad vs experienced) and simulation fidelity---mannequin, environmental, psychological, scenario as independent variables.

I would be modifying the criteria to match my scenario and would be using the instrument with professionals and not students. I appreciate the level of detail in this instrument and believe it will be better at differentiating performance between my groups.

I have not found any validity/reliability studies. Have these been done? If not, I will be using the Creighton Simulation Evaluation Instrument to establish concurrent validity.

Thank you for your consideration of this request.

Gail Johnson
Doctoral Student, College of Nursing & Professional Disciplines

Appendix B

Creighton Competency Evaluation Instrument

Creighton UNIVERSITY College of Nursing

Creighton Competency Evaluation Instrument (C-CEI)

Student(s) Name: Scenario: Evaluator:	0= Does not demonstrate competency 1= Demonstrates competency NA= Not applicable			Date: ____/____/____
ASSESSMENT	Circle Appropriate Score for all Applicable Criteria - If not applicable, circle NA			**COMMENTS:**
1. Obtains Pertinent Data	0	1	NA	
2. Performs Follow-Up Assessments as Needed	0	1	NA	
3. Assesses the Environment in an Orderly Manner	0	1	NA	
COMMUNICATION				
4. Communicates Effectively with Intra/Interprofessional Team (TeamSTEPPS, SBAR, Written Read Back Order)	0	1	NA	
5. Communicates Effectively with Patient and Significant Other (verbal, nonverbal, teaching)	0	1	NA	
6. Documents Clearly, Concisely, & Accurately	0	1	NA	
7. Responds to Abnormal Findings Appropriately	0	1	NA	
8. Promotes Professionalism	0	1	NA	
CLINICAL JUDGMENT				
9. Interprets Vital Signs (T, P, R, BP, Pain)	0	1	NA	
10. Interprets Lab Results	0	1	NA	
11. Interprets Subjective/Objective Data (recognizes relevant from irrelevant data)	0	1	NA	
12. Prioritizes Appropriately	0	1	NA	
13. Performs Evidence Based Interventions	0	1	NA	
14. Provides Evidence Based Rationale for Interventions	0	1	NA	
15. Evaluates Evidence Based Interventions and Outcomes	0	1	NA	
16. Reflects on Clinical Experience	0	1	NA	
17. Delegates Appropriately	0	1	NA	
PATIENT SAFETY				
18. Uses Patient Identifiers	0	1	NA	
19. Utilizes Standardized Practices and Precautions Including Hand Washing	0	1	NA	
20. Administers Medications Safely	0	1	NA	
21. Manages Technology and Equipment	0	1	NA	
22. Performs Procedures Correctly	0	1	NA	
23. Reflects on Potential Hazards and Errors	0	1	NA	

COMMENTS

Total: _____

Total Applicable Items: _____

For more information, please contact Martha Todd, MS, APRN @ mtodd@creighton.edu

Revised 4/22/2014

From: Todd, Martha <MARTHATODD@creighton.edu>
Sent: Monday, December 18, 2017 9:57 AM
To: Johnson, Gail
Subject: Re: Permission to include C-CEI in dissertation

Hi Gail,

Yes you have our permission to include the CCEI in your dissertation.

How were the results?

Martha

Martha Todd, PhD, APRN-NP
Associate Professor
College of Nursing
402-280-2044
mtodd@creighton.edu

Appendix C
Simulation Design Scale

In order to measure if the best simulation design elements were implemented in your simulation, please complete the survey below as you perceive it. There are no right or wrong answers, only your perceived amount of agreement or disagreement. Please use the following code to answer the questions. Place an X in the appropriate boxes.

Use the following rating system when assessing the simulation design elements:	Rate each item based upon how important that item is **to you.**
Strongly Disagree with the statement	Not important
Disagree with the statement	Somewhat important
Undecided—you neither agree or disagree with the statement	Neutral
Agree with the statement	Important
Strongly agree with the statement	Very important
NA Not Applicable; the statement does not pertain to the simulation activity performed.	

ITEM	1	2	3	4	5	NA	1	2	3	4	5
Objectives and Information											
1. There was enough information provided at the beginning of the simulation to provide direction and encouragement.											
2. I clearly understood the purpose and objectives of the simulation.											
3. The simulation provided enough information in a clear matter for me to problem-solve the situation.											
4. There was enough information provided to me during the simulation.											
5. The cues were appropriate and geared to promote my understanding.											
Support											
6. Support was offered in a timely matter.											
7. My need for help was recognized.											
8. I felt supported by the facilitator's assistance during the simulation.											
9. I was supported in the learning process.											
Problem Solving											
10. Independent problem-solving was facilitated.											
11. I was encouraged to explore all possibilities of the simulation.											
12. The simulation was designed for my specific level of knowledge and skills.											
13. The simulation allowed me the opportunity to prioritize nursing assessments and care.											
14. The simulation provided me an opportunity to goal set for my patient.											

Simulation Design Scale Page 2

Use the following rating system when assessing the simulation design elements:
Strongly Disagree with the statement
Disagree with the statement
Undecided—you neither agree or disagree with the statement
Agree with the statement
Strongly agree with the statement
NA Not Applicable; the statement does not pertain to the simulation activity performed.

Rate each item based upon how important that item is **to you.**
Not important
Somewhat important
Neutral
Important
Very important

ITEM	**1**	**2**	**3**	**4**	**5**	**NA**	**1**	**2**	**3**	**4**	**5**
Feedback/Guided Reflection											
15. Feedback provided was constructive.											
16. Feedback was provided in a timely manner.											
17. The simulation allowed me to analyze my own behavior and actions.											
18. There was an opportunity after the simulation to obtain guidance/feedback from the facilitator in order to build knowledge to another level.											
Fidelity (Realism)											
19. The scenario resembled a real-life situation.											
20. Real life factors, situations, and variables were built into the simulation scenario.											
21. The realism of the mannequin helped the situation feel real.											
22. The vital signs changes allowed me recognize changing conditions.											
23. The realism of the environment helped the situation feel real.											
24. The equipment worked as I expected it would in real life.											
25. The patient voice was convincing and the patient responded to me realistically.											
27. The situation felt real.											

 Page 2 of 2

2016, Modified by Gail Johnson, MS, BSN

Appendix D
Demographic Survey Form

1. My age is: _____
2. My gender is : ☐ Male ☐ Female
3. My race/Ethnicity is: ☐ White ☐ African American ☐ Asian ☐ Native American ☐ Hispanic ☐ Other_____
4. My educational degree (nursing) is ☐ Associate degree ☐ Bachelor's degree ☐ Master's degree ☐ Doctoral degree
5. I have worked as a RN for ☐ ≤11 months _____# months ☐ ≥ 12 months _____# years
6. My acute care experience is ☐ Medical surgical floor ☐ Telemetry / Progressive Care ☐ Critical Care / Emergency Dept ☐ OB or Pediatrics ☐ Surgery ☐ Mental Health ☐ Other _____
7. I have participated in simulation: ☐ Never ☐ 0-5 times ☐ 6-10 times ☐ > 11 times

Appendix E

Simulation Scenario

Patient Status	Trigger Conditions	Mannequin settings Operator	Dialogue Statements:	Additional info if asked
Baseline: John Jones	55 YO male in bed/cart; bruising on right ribs/chest. NC on patient but not connected to flow meter. IV right antecubital area D5NS @ 75hr. HOB up 30			
Presentation: c/o pain		**B/P**---135 **HR**---120 **RR**---20 **T** 98 **O2 Sats** 95--- **Eyes** Open PERL **Other** lungs clear bilat sound	• I really hurt—my chest • Pain 10/10	John Jones DOB 3/1/1962 Single Pain X 20 min
Stage 1: NC disconnected from flow meter	**TRIGGER 1:** Recognizes disconnection and reattach	**B/P**---130/80 **HR**---120 **RR**---24 **T** 98 **O2 Sats** 94--- **Eyes** open, BLINKING, PERL **Other**	•	
	Trigger 2: Doesn't recognize disconnection	**Sats 92% Drop 2% every minute until reconnected. RR increase 2 every min**	• Hard to catch my breath	
Stage 2: Increasing c/o pain and increased anxiety After 3 minutes	**TRIGGER 1:**	**B/P**---135/80 **HR**---126 **RR**---26 **T** 98 **O2 Sats** 97 if O2 attached **86% if not** **Eyes** blinking HF **Other**	• I really hurt • Can't you give me anything •	Other pain medicine helped for a short time. No nausea
	TRIGGER 2: Doesn't give pain medicine	**B/P**---138/80 **HR**---130 **RR**---28 **T** 98 **O2 Sats** ---- **Eyes** blinking HF **Other**	I really hurt Why cant you get me anything	
			•	
Stage 3: IF 4 mg MS	**TRIGGER 1:**	**B/P**---94/70 **HR**---100	•	

Appendix F

HealthPartners Institute for Education and Research

Consent to Participate in Research

Title of Project: Simulation Fidelity Study

You are invited to participate in a research project on simulation fidelity. This study is being conducted by Gail Johnson, director of HealthPartners Clinical Simulation and a doctoral candidate in the College of Nursing and Professional Studies at the University of North Dakota. Ms. Johnson is conducting this study for her doctoral dissertation. Dr. Glenda Lindseth, Professor of Nursing at the University of North Dakota is her advisor for this study.

What the study is about: The purpose of this study is to learn how nurses with different levels of experience perform in simulation scenarios. You must be a registered nurse with at least one (1) year of acute care experience or a novice (i.e. recently graduated nurse) nurse with less than 6 months since graduation to take part in this study.

What you will be asked to do: If you agree to be in this study, the following will occur:

- Complete a demographic survey
- Participate in 1 simulation scenario and debriefing session. This will take one hour.
- Complete a post-simulation survey
- The simulations will be recorded (video and audio). The primary investigator will observe the simulations and the AV recordings will be reviewed by members of the research team.

The entire time commitment is less than 60 minutes.

T**aking part is voluntary:** You can choose whether or not to be in this study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any survey questions you do not wish to answer.

Risks: Any risks, discomfort or inconvenience will be minor and no different than participating in any simulation-based activity. There is a slight risk that some individuals may be uncomfortable participating in the simulation activity as well as discussing actions with the investigator during the debriefing session.

Confidentiality: The AV recordings and records from this study will be kept as confidential as possible. No individual identities will be used in any reports or publications resulting from the study. All recordings, review forms, surveys, and study documents will be given codes and stored separately from any names or other direct identification of participants. Research information will be kept in locked files at all times. Only research personnel will have access to the files and recordings. After the study is completed, the recordings will be held for three years and then destroyed.
Participation or not participating in this study will have no impact on employment. Employers/managers will not have access to recordings or individual data.

Benefits: The anticipated benefit of this study is a better understanding of the use of simulation in continuing nursing education.
Compensation for your time: After completing the simulation, debriefing, and surveys, you will earn one (1) contact hour of trauma-related continuing nursing education. In addition, your name will be entered into a drawing for a $100 Amazon Gift Card.

Investigators: If you have any questions or concerns about this research study, please contact

Ms. Gail Johnson
Primary Investigator
HealthPartners Clinical Simulation
640 Jackson Street
St. Paul, MN 55101
Gail.L.Johnson@HealthPartners.com
Gail.L.Johnson@my.und.edu
651-254-1022

Dr. Glenda Lindseth, Professor
Dissertation Chair
College of Nursing & Professional Studies
NPCBR Building
400 Oxford Street Office 380C
University of North Dakota
Grand Forks, ND
Glenda.Lindseth@und.edu
701-777-4506

You will be given a copy of this form to keep for your records.

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent to take part in this study.

Your Signature: _____ Date: _____

Your Name (Print): _____ Phone: _____

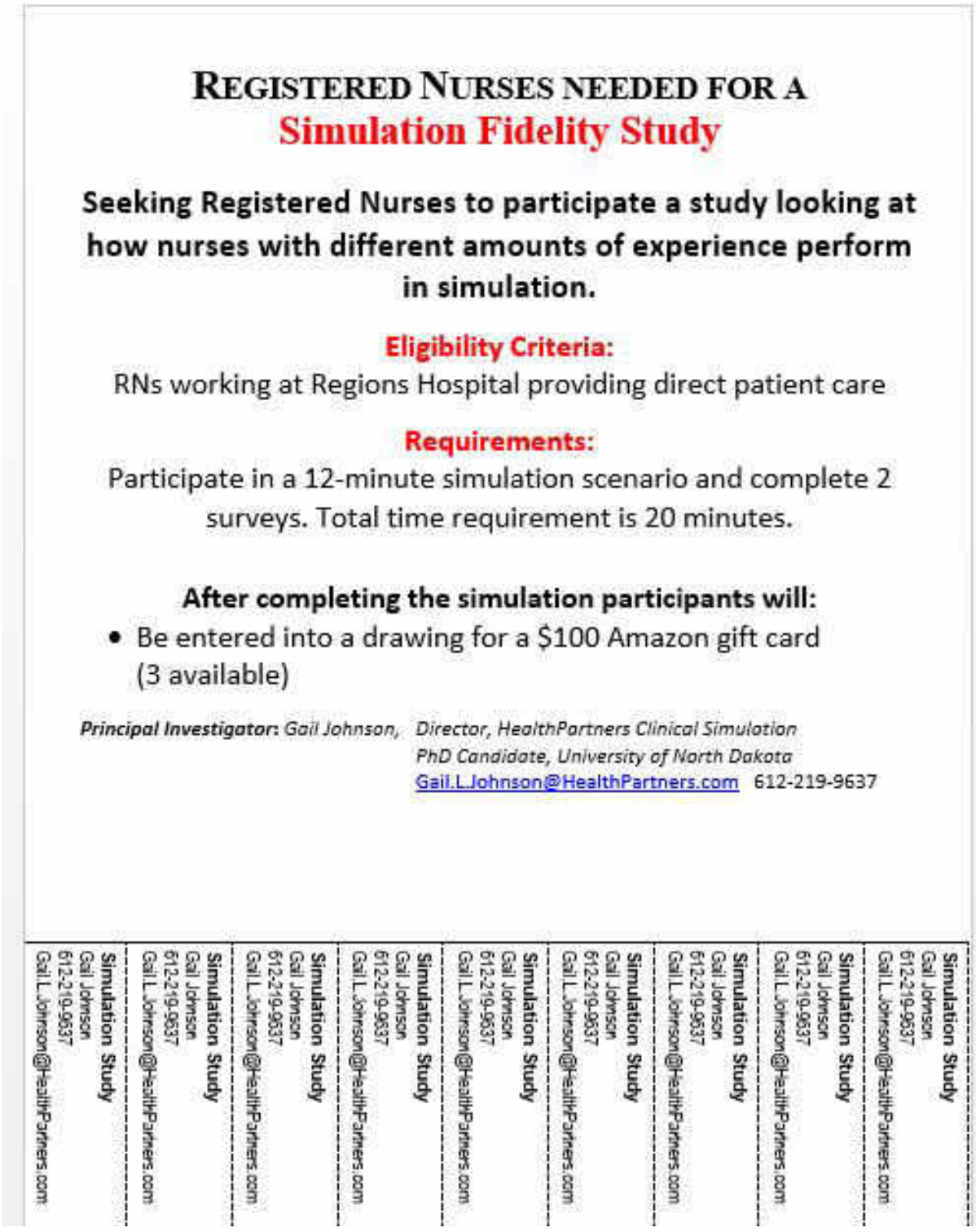
Email address: _____

Signature of person obtaining consent: _____ Date: _____

Printed name of person obtaining consent: ___

Appendix G

Recruitment Flyer



REGISTERED NURSES NEEDED FOR A
Simulation Fidelity Study

Seeking Registered Nurses to participate a study looking at how nurses with different amounts of experience perform in simulation.

Eligibility Criteria:

RNs working at Regions Hospital providing direct patient care

Requirements:

Participate in a 12-minute simulation scenario and complete 2 surveys. Total time requirement is 20 minutes.

After completing the simulation participants will:

- Be entered into a drawing for a $100 Amazon gift card (3 available)

Principal Investigator: *Gail Johnson, Director, HealthPartners Clinical Simulation*
PhD Candidate, University of North Dakota
Gail.L.Johnson@HealthPartners.com 612-219-9637

Simulation Study
Gail Johnson
612-219-9637
Gail.L.Johnson@HealthPartners.com

Appendix H

Institutional Review Board Support Letter UND

UNIVERSITY OF NORTH DAKOTA

UND.edu

DIVISION OF RESEARCH & ECONOMIC DEVELOPMENT

Institutional Review Board
Twamley Hall, Room 106
264 Centennial Dr Stop 7134
Grand Forks, ND 58202-7134
Phone: 701.777.4279
Fax: 701.777.6708

October 28, 2015

Principal Investigator:	Gail Johnson
Project Title:	The Relationship of Fidelity and Experience on Nurse Performance During Simulation
IRB Project Number:	IRB-201510-115
Project Review Level:	Expedited 7
Date of IRB Approval:	10/21/2015
Expiration Date of This Approval:	10/20/2016
Consent Form Approval Date:	10/21/2015

The application form and all included documentation for the above-referenced project have been reviewed and approved via the procedures of the University of North Dakota Institutional Review Board.

Attached is your original consent form that has been stamped with the UND IRB approval and expiration dates. Please maintain this original on file. ***You must use this original, stamped consent form to make copies for participant enrollment. No other consent form should be used.*** It must be signed by each participant prior to initiation of any research procedures. In addition, each participant must be given a copy of the consent form.

Prior to implementation, submit any changes to or departures from the protocol or consent form to the IRB for approval. No changes to approved research may take place without prior IRB approval.

You have approval for this project through the above-listed expiration date. When this research is completed, please submit a termination form to the IRB. If the research will last longer than one year, an annual review and progress report must be submitted to the IRB prior to the submission deadline to ensure adequate time for IRB review.

The forms to assist you in filing your project termination, annual review and progress report, adverse event/unanticipated problem, protocol change, etc. may be accessed on the IRB website: http://und.edu/research/resources/human-subjects/

Sincerely,

Michelle L Bowles

Michelle L. Bowles, M.P.A., CIP
IRB Coordinator

MLB/sb
Enclosures

Cc: Glenda Lindseth, Ph.D.

The University of North Dakota is an equal opportunity / affirmative action institution.

INSTITUTIONAL REVIEW BOARD SUPPORT LETTER HEALTHPARTNERS

HealthPartners Institute
Institutional Review Board
3311 E Old Shakopee Road
Minneapolis, MN 55425
952-967-5025

HealthPartners Institute

May 16, 2017

Gail Johnson, PhD, MSN, BSN
Simulation Center – Regions Hospital

#A15-230 – "The Relationship of Fidelity and Experience on Nurse Performance During Simulation"

Thank you for your submission dated May 4, 2017 in response to Research Review Committee (RRC) and the IRB request for modifications regarding the above referenced study. The RRC reviewed and approved your response. The Institutional Review Board (IRB) reviewed the above referenced project through its Expedited Review procedures and approved the study under 45 CFR 46.110; category 6 (digital recording) and category 7 (survey). This approval includes application, submitted April 12, 2017; scenario protocol; simulation design scale; recruitment flyer; demographic survey form; CSET clinical evaluation tool; CCEI Creighton Instrument and consent form, version date May 4, 2017.

The above "project number" has been assigned to your research. That number, along with the title of your study, must be used in communication with the IRB.

Amendments:
Any changes or modifications to the approved protocol require the prior approval of the Institutional Review Board (IRB). This includes protocol amendments, study materials, changes in numbers of subjects, etc. All subjects enrolled must fulfill all protocol criteria; any exceptions must have prior approval by the IRB. If you have questions about this policy please do not hesitate to call me.

Based on the content of this study and your explanation of the potential risks to subjects, the IRB approved this study on May 1, 2017 for a period of 12 months; this approval will expire on April 30, 2018. In order not to exceed the expiration date, a **Continuing Review form will be due for review in April 2018; you will be notified approximately 2 months prior regarding submission of this form.**

Best wishes on the study!

Kelly McCormick

Kelly M McCormick, MBA
Manager, Research Subjects Protection Program

Appendix I

Organizational Support Letter

Department Commitment Form

LETTER OF SUPPORT FOR RESEARCH CONDUCTED IN A DEPARTMENT AT HEALTHPARTNERS

My signature below means that:

I have reviewed the project and budget;

I am committing department funds for this project: No departmental funds, including staff time, will be used for this project. Any expenses are the responsibility of the primary researcher.

The following expenses will be covered by the department: No expenses will be covered by a HealthPartners Institute for Education and Research department, including Clinical Simulation, for this project. Any expenses are the responsibility of the primary researcher.

Deficits as the result of expenses over and above the approved budget.

Department Number used to cover the above expenses #_____NA_✓_____

Kyfman 10/22/15

Signature of Person Committing Dept. Funds — Date

Kelly Frisch

Printed name of Person Committing Dept. Funds

_____

Print the name of a contact person regarding the budget if different than the person signing this form.

REFERENCES

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