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I, Donna A Green, hereby submit this original work as part of the requirements for the degree of Doctor of Philosophy in Nursing Research.

It is entitled:

The Effect of Independent Computer-Based Simulation on Neonatal Resuscitation Skills

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The Effect of Independent Computer-Based Simulation on Neonatal Resuscitation Skills

A dissertation submitted to the

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Doctor of Philosophy

in the College of Nursing

by

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Abstract

Background & Purpose: Annually, almost 1 million babies die across the world due to birth asphyxia. In the United States, 400,000 infants will require assistance with breathing and approximately 40,000 infants will require extensive resuscitative measures. Performing neonatal resuscitation accurately is critical to saving these infants' lives. Integrating various simulation-based opportunities, including independent computer based simulation (CBS), into the adult learning environment provides an approach to assist neonatal healthcare professionals through experiential development, application, and maintenance of their neonatal resuscitation knowledge and skills.

Methods: Using a quasi-experimental, longitudinal, pre-test, post-test design, this study examined the effect of independent CBS on performance and retention of neonatal resuscitation concepts of airway, chest compressions, pulse oximetry integration, and communication. The convenience sample (N = 32) included Registered Nurse (RN) participants who are employed at a Mid-Western suburban family birth center that delivers over 2000 babies annually.

Participants were randomly assigned to the control or intervention group. Both groups completed a demographic questionnaire followed by participation in a video taped, neonatal high fidelity simulation (Phase I) for evaluation of baseline knowledge and performance during month 0. During Phase II (month 1) the control group received a clinical update document including neonatal resuscitation steps and processes; the intervention group completed an independent CBS scenario of neonatal resuscitation skills and processes. An evaluation of retention of neonatal resuscitation knowledge occurred in Phase III with the control and intervention groups participating in a second, video taped, neonatal high fidelity simulation for evaluation of performance and retention. Phase I and Phase III simulation performance was scored by two trained experts using an adapted version of the tool "*Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* ".

Results: A total of 32 participants completed this study. The control group (N = 15) showed sample means (M) and standard deviations (SD's) of total performance score 70.94 (13.74), 73.13 (10.93) at Phase I and Phase III respectively. The M's (SD's) of total performance score were M = 78.94 (9.74) and 78.77 (10.64) respectively in the intervention group (N = 17). The change of the total performance score was (M = -1.06, SD = 12.2) in the intervention group and (M = -1.73, SD = 13.10) in the control group. The difference was not significant between groups (p = 0.881). Overall interpretation is that the impact of independent CBS was not statistically significant in improving performance or retention of neonatal resuscitation skills in either cross-sectional or longitudinal comparisons.

Conclusions: Repeated education on the neonatal resuscitation skills can assist in providing lifesaving care. The healthcare providers must maintain competence in order to rapidly and accurately assess, recollect, act, and analyze the lifesaving interventions needed for compromised neonate. While independent CBS provides reinforcement of neonatal resuscitation concepts, the translation effect in simulation and clinical practice remains undefined. Future research should include interdisciplinary studies with statistical power and larger sample sizes for measurement and evaluation of various resuscitation training strategies, exploration of education cost impact, error reduction approaches, and patient outcomes.

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CHAPTER I

Introduction

In obstetric and neonatal practice, nursing plays a vital role in the delivery of safe patient care to the neonatal patient population. This role holds even higher importance when obstetric and neonatal emergencies occur in the patient care setting. The percentage of newborns in the United States requiring resuscitative assistance at birth is approximately 10%, with 1% of these infants requiring substantive resuscitative measures (American Academy of Pediatrics, 2011). While this percentage may be low, it must be considered in relationship to the number of births (American Academy of Pediatrics, 2011). In the year 2015, there were almost 4 million births in the United States with 10% accounting for approximately 400,000 infants and 1% accounting for 40,000 infants respectively (Centers for Disease Control, 2017). The births of these compromised neonates require the perinatal nurse and health care delivery team to rapidly and accurately assess, recollect, act, and analyze the lifesaving interventions needed for the significantly compromised neonatal patient as they transition from intrauterine life. In efforts to prepare perinatal health care providers involved in the neonatal emergency care, the American Academy of Pediatrics has restructured the Neonatal Resuscitation Program (NRP). The revised 7th edition education program provides independent self-study of the eleven modules with the completion of an online exam and independent computer-based simulations (NRP eSim) which is then followed by skills stations and group based simulation activities (to be conducted within 90 days of completing the online exam) for the practicing nurses, nurse practitioners, physicians, anesthesia personnel, and respiratory therapists who are involved in neonatal care.

The integration of this revised education format and instruction may influence the perinatal nurses' acquisition, application, behaviors, and retention of NRP knowledge, and ultimately, neonatal patient safety.

The NRP has been recognized as the standard of care related to resuscitation of the newborn for the almost 30 years (American Academy of Pediatrics, 2011; Sawyer, Ades, Ernst, & Colby, 2016). Completion of this program is a form of mandatory professional education required by organizations of neonatal health care providers within the United States. Through the year 2011, this education program had been delivered to the participants via didactic, CD-ROM, hands-on training, and mock codes. The developers of the NRP, American Academy of Pediatrics, and the American Heart Association, have since identified that these educational formats are promoting passive learning without quality participant engagement in the learning process. The assimilation of content knowledge and technical skills alone is insufficient related to the delivery of time intense neonatal resuscitative care (American Academy of Pediatrics, 2011). Allowing opportunities to practice technical skills along with the behavioral skills, such as communication, required during resuscitation has been reported as an imperative component of patient care and the elimination of sentinel events (American Academy of Pediatrics, 2011; The Joint Commission, 2017; The Joint Commission, 2004). In efforts to meet the recommendations of the Joint Commission and the needs of the NRP participants, the program has been revised to transfer the responsibility of learning to the participants who are enrolled in this educational program. It has been expanded to include an assessment of the behavioral aspects and communication that occurs among a health care delivery team in a neonatal resuscitation situation. The

NRP 7th edition is now including independent computer-based simulation training followed by live simulation-based training in efforts to improve the acquired knowledge, behavioral aspects and communication, and improve correct application of the skills provided within this educational program (American Academy of Pediatrics, 2016; American Academy of Pediatrics, 2011; McGowan & Zaichkin, 2011).

Statement of the Problem

On an annual basis almost 1 million babies die across the world due to birth asphyxia (American Academy of Pediatrics, 2011; World Health Organization, 2015). In the United States, 400,000 infants will require assistance with breathing and approximately 40,000 infants will require extensive resuscitative measures (Centers for Disease Control, 2011). Performing neonatal resuscitation accurately and efficiently is critical to saving these infants' lives. Integrating simulation-based opportunities into the adult learning environment is believed to assist nurses and other neonatal health care professionals move from their previous role as a passive learner of NRP content to an active participant with experiential application and development of their neonatal resuscitative knowledge and behaviors (American Academy of Pediatrics, 2016; American Academy of Pediatrics, 2011; Jefferies, 2007; Yaeger & Arafeh, 2008).

Effective education and learning opportunities of personnel involved in neonatal resuscitation is lagging behind the advances being made in the care of the vulnerable neonatal population of patients, most specifically related to communication among perinatal team members during resuscitation emergencies (American Academy of Pediatrics, 2011; The Joint Commission, 2004; Yaeger & Arafef, 2008). Addressing these areas of practice improvement fueled the development of the 6th edition NRP and subsequent revision of the 7th edition NRP in 2016. While a great deal of literature exists related to the value of various modes of simulation as a teaching method in health care, aviation and the military, the efficacy of this added methodology and program change in relationship to neonatal resuscitation skill application and retention has not been specifically explored. The effects of online refresher sessions, such as independent computer-based simulations, on these same constructs of skill application and retention also must be explored in light of these pedagogical changes, healthcare organization educational challenges, and the American Academy of Pediatrics research priority identifying the need to further identify approaches to use in optimal NRP education.

Purpose of the Study

The purpose of this study was to examine the effects of adding independent computer-based neonatal resuscitation simulation to current NRP live simulations when examining participant knowledge and performance of required NRP behaviors which are used by perinatal nurses in lifesaving neonatal patient care.

Theoretical Framework

The American Academy of Pediatrics (2016) does not specifically identify a theory used to guide the revisions to the 7th edition NRP and standards. The NRP does recognize the importance of adult learning principles such as interaction, application, and manipulation of the content knowledge provided within the course as a rationale for this paradigm shift (American Academy of Pediatrics, 2011). The revised format and the course objectives of the 7th edition NRP are in close alignment with Experiential

Learning Theory (ELT) proposed by Kolb (1984); therefore ELT has been chosen to guide this study.

ELT is focused on the adult learner, closely aligned with simulation based teaching methodologies, and requires the use of various teaching methods in order to obtain an optimal learning opportunity for the various learning styles of individuals (American Academy of Pediatrics, 2011; Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999; Yaeger & Arafeh, 2008). Kolb's ELT has been used as the theoretical framework for thousands of studies across various professions. This learning theory has been used in education, psychology, medicine, computer and information sciences, and also nursing (Kolb, Boyatzis, & Mainemelis, 1999). Nursing has identified this as a useful theory in the development of the nursing role, decision-making skills, and one's diagnostic abilities (Kolb, Boyatzis, & Mainemelis, 1999), which are also objectives of the NRP.

According to Kolb (1984), the four dimensions of learning include concrete experience, reflective observation, abstract conceptualization, and active experimentation. Kolb hypothesizes that effective and deeper learning occurs when individuals cycle through the four stages in order to provide a holistic learning perspective that combines experience, perception, cognition, and behavior (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999). A reality based, simulation focused program for synthesis of knowledge is a goal of the revised NRP and is the rationale for using Kolb's ELT to guide this study.

Kolb's ELT (Kolb, 1984) (Figure 1) will provide the foundation for this proposed research study that will explore the effects of the revised education format of the 7th

edition NRP (which includes self- study, an online test, independent computer-based simulation, skills practice stations, and live resuscitation simulations along with debriefing) related to nursing practice and NRP knowledge retention. ELT was identified for use in this study due to the strong relationship the propositions have with adult learning principles of motivation, the role of previous experiences, and interest in learning how to apply newly acquired knowledge. Furthermore, ELT supports the importance of experience, the development of concepts, and practice on achieving optimal learning opportunities for the involved individuals. These ELT concepts are parallel to the objectives of the 7th edition NRP.

ELT proposes that a holistic learning process consists of four dimensions that move the learner from initial experience(s) and actions (concrete experience), to watching and reflecting upon others actions (reflective observation), that is followed by the development of new implications for action (abstract conceptualization), and then cycles into the developed implications being actively tested with the creation of the new experience (active experimentation) (Kolb, Boyatzis, & Mainemelis, 1999). The initial completion and further continuation of this cyclical learning process has a direct effect on the development and application of acquired knowledge through the use of multiple learning opportunities in a specific learning situation. Although the American Academy of Pediatrics and the NRP do not directly state that ELT was used in the development of the 6th and 7th edition revisions, the use of multiple and immersive learning techniques have been identified as useful tools in the development and reinforcement of knowledge and appropriate skill acquisition.

Kolb's ELT provides an explanation for the multifaceted nature of learning and adult development. ELT has the epistemological basis that ideas and concepts do not remain constant and are further able to be formed and re-formed through experience (Kolb, 1984). The main assumption associated with Kolb's theory is that experience with ideas and concepts are most influential in an individual's learning process. Based upon this assumption, components of Kolb's ELT, i.e. the role of experience, practice, and identification of areas for improvement, support the underpinnings for the NRP 6th and 7th edition revisions.

Learning is defined by Kolb as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" (1984, p.41). The action of "grasping" the experience occurs in the dimensions of concrete experience and abstract conceptualization. The "transformation" of the experience occurs with reflective observation and active experimentation (Kolb, 1984, p.41). The attainment of new knowledge, skills, attitude, and/or deeper learning is positively related to the continual cyclical interaction within concrete experience, reflective observation, abstract conceptualization, and active experimentation (Figure 1).

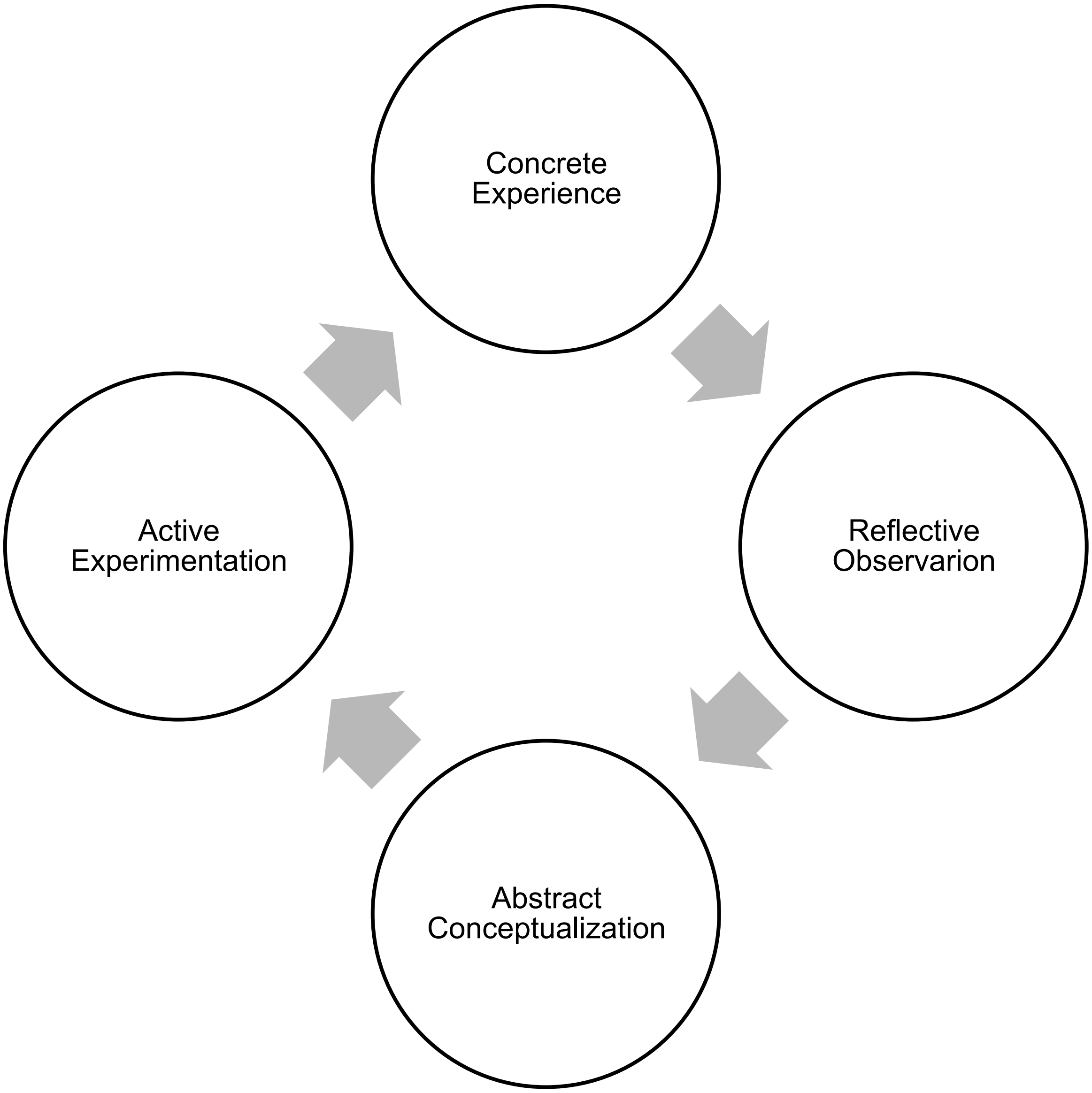

Figure 1. Kolb's Experiential Learning Theory (1984).

Concrete experience refers to the ability of the learner to be fully involved in the new experience with tangible and felt qualities of the learning environment through the use of senses and immersion in the content (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999). An identification of knowledge foundation and initial application occurs within the concrete experience dimension. In this study, the concrete experience was examined through participant active involvement in resuscitation scenarios aligned with the revised 7th edition NRP objectives.

Reflective observation is the second phase and refers to watching others who are involved in an experience and reflecting upon the observed experiences from multiple perspectives. Abstract conceptualization occurs after concrete experience and reflective observation and refers to the ability to create concepts and integrate new information into one's knowledge through analyzing and systematically planning (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999). Within this phase, individuals have moved from their initial knowledge and experience through observation of behaviors and skills (previously and newly acquired) toward making decisions about revisions to one's practice. Active experimentation is the fourth phase of the ELT, that refers to when the learner is directly involved in the experience and their ability to apply and use the newly acquired information within the problem solving process (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999). The importance of the cyclical movement throughout these four concepts allows for the learner to use and then further develop their knowledge toward the deeper learning levels of analysis, synthesis, and evaluation and provides support for the choice of ELT as theoretical guidance in this study of NRP and practice implementation (Figure 2).

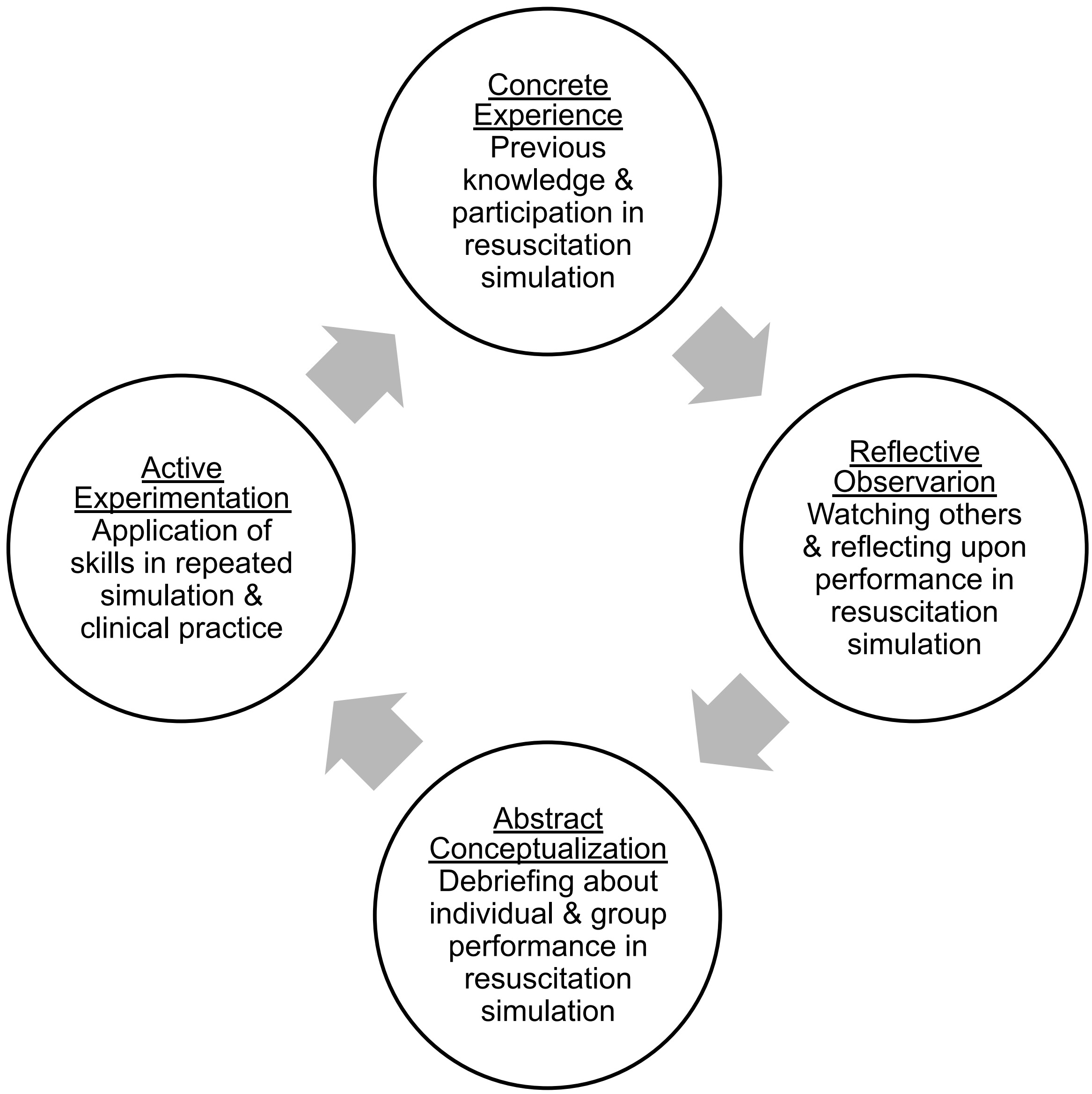

Figure 2. Research Design & ELT. This figure illustrates the application of ELT in the research design.

An individual's prior knowledge and experience, i.e. NRP knowledge, is an additional factor which influences one's learning. According to Hailikari, Katajavuori, and Lindblom-Ylanne, "The amount and quality of prior knowledge positively influence both knowledge acquisition and the capacity to apply higher order cognitive problem solving skills." (2008, p.1). Based upon this finding, relational variables that contribute to prior knowledge of NRP content have been identified for exploration within this study. These variables include years of experience with the NRP course content, neonatal resuscitation experience, and individual nursing practice roles related to NRP education program content. The nursing practice roles to be further explored will be that of individuals who practice in the labor and delivery unit, mother/baby unit, special care nursery, and any combination of these roles. These variables were identified in order to explore previous exposure with the NRP course content (i.e., those who have never taken NRP to those who have taken NRP a number of times) and the clinical practice opportunities for application of the NRP concepts within nursing practice roles and in neonatal resuscitative care. The variables contribute to concrete experience, which relies upon providing the basis for learning and the ability to adapt one's learning. Each of these identified variables further contributes to the level of knowledge, experience, and feelings that the registered nurses have with the NRP material and the volume of concrete knowledge brought to the NRP experience and learning environment.

ELT has been used in the academic nursing environment and in nursing continuing education as a model for the development of educational methods used within the nursing hierarchy of learning and profession. The philosophical basis of experience to enhance the learning of information applies strongly to the nursing profession. Experiential educational processes can be used to develop adequately prepared clinicians for the decision-making responsibilities of this human service based profession, including perinatal nurses seeking education from the NRP.

Research Questions

This study was proposed to examine the effectiveness of integrating independent computer-based simulation into traditional NRP self-study and “live” simulation activities to enhance the ability of the Registered Nurse (RN) to perform the pivotal components of life-saving neonatal care including airway, chest compressions, pulse oximetry, and communication in these low frequency, high crises situations.

Research Question 1: Are there differences in the three-month retention and performance of NRP concepts of airway, chest compressions, pulse oximetry, and communication between participants who receive self-study and live NRP simulations compared to those who receive self-study, live NRP simulations, and an independent computer-based neonatal resuscitation simulation experience?

Research Question 2: Are there differences in the application of NRP concepts of airway, chest compressions, pulse oximetry, and communication between participants who receive self-study and live NRP simulations compared to those who receive self-study, live NRP simulations, and an independent computer-based neonatal resuscitation simulation experience?

Significance of Study

Organizations are challenged to provide nurses and members of the health care team with valuable educational opportunities for life-long learning that promote active participation within a health care setting while ensuring patient safety (Institute of Medicine, 2010). These challenges become further complex when teaching neonatal resuscitation, which involves rapid life saving decisions and interventions to be completed accurately within a short period of time in emotionally charged resuscitation situations. With approximately 4 to 10% of infants requiring some degree of resuscitative intervention at the time of birth (American Academy of Pediatrics, 2016), ensuring that the nurses and other health care providers involved in these deliveries are adequately prepared at all times to deliver the recognized standard of care (NRP content) to neonatal patients is imperative to patient safety.

The NRP 7th edition offers eleven educational lessons with textbook based content that integrates and builds upon the information introduced in the prior module. The eleven educational lessons represent the concepts associated with conducting a neonatal resuscitation. For example, the education program begins with a provider course overview which then leads into the foundations of neonatal care, preparing for resuscitation, initial steps of newborn care, positive-pressure ventilation, alternate airways including endotracheal tubes and laryngeal masks, chest compressions, medications, post-resuscitation care, resuscitation and stabilization of preterm babies, special conditions and considerations in neonatal resuscitation, and ethical decisions along with end of life care (American Academy of Pediatrics, 2016). Each session is structured to provide introduction to types of equipment utilized, assessment techniques, appropriate psychomotor skills, medication and administration information, and situations in which adaptations need to be made within a neonatal resuscitation. The content from each lesson builds upon the prior lesson with the lesson information and concepts integrated throughout the NRP. The essential aspects of neonatal resuscitation situations involve the components of key behavioral skills and communication, principles of resuscitation, the resuscitation steps, use of ventilation devices, pulse oximetry use, and chest compressions. The focus of this study are these common steps, most of which are performed universally at all deliveries, and newly added components to neonatal resuscitative care.

The American Academy of Pediatrics (2010) and American Heart Association (2010) identified the need to integrate learner based activities, such as independent internet based learning, skill practice, simulation, and debriefing into the educational methods used in the delivery of NRP. This change in methodologies has occurred with the organizations realizing that lecture was not the most effective teaching method and promoted passive learning, and the “feeding of information” to the participant for a quick method of compliance check off for an organization (American Academy of Pediatrics, 2011; McGowan & Zaichkin, 2011). Furthermore these methods did not address development of behavioral skills and communication needed for prevention of sentinel perinatal events (American Academy of Pediatrics, 2011; Joint Commission Resources, 2007). The integration of simulation into rarely seen clinical events, such as neonatal resuscitation, is in alignment with Kolb’s (1984) view of learning in which knowledge is created through the transformation of experience (Kolb, 1984). Additionally, research related to simulation and the integration of independent computer-based simulation in nursing has shown promise in areas such as knowledge retention and critical thinking abilities (Dutile, Wright, Beauchesne, 2011; Bloomfield, While, & Roberts, 2008; Jefferies, 2007).

The NRP paradigm shift requires examination of the interaction between the instructional dimensions being used (self-study followed by online examination, independent computer-based simulation, skill practice, simulation, and debriefing), participant knowledge levels obtained and retained over time, and the participant ability to successfully apply, retain and interact with the correct application of NRP content. Obtaining knowledge associated with participant use of the revised NRP can be used to promote best practices in the delivery of NRP to course participants and ultimately in the professional development of health care providers prepared to care for the most at risk neonatal population.

Knowledge related to theoretically-based nursing education research is important in understanding the implication of adult education principles on the achievement of knowledge integration and synthesis of information (Yaeger & Arafeh, 2008). Understanding this information gains further importance as the nursing profession continues to face the integration of technology that is current, relevant, and efficient into various education modalities (Jonassen, Davidson, Collins, Campbell, & Bannan Haag, 1995). While the impact of well designed, self-study learning modules followed by an online exam, combined with independent computer-based simulation and live simulation activities (such as the NRP) holds the promise to be essential educational strategies, more research is needed to validate the worth of these strategies as teaching and evaluation methods (Jeffries, 2007). Consideration of these statements in relationship to exploring the effects of the revised NRP on application, competency, and retention of skills when comparing this approach and the additive feature of repeated independent computer-based simulation experiences on application, competency, and retention of skills lies the significance of this study.

It is widely accepted that learning is best achieved when we become engaged in the cognitive, psychomotor, and affective learning domains related to an experience (Dewey, 1938; Fowler, 2008; Halamek, 2008; Jefferies, 2007; Kolb, 1984; Yaeger & Arafeh, 2008). Computer-based simulation offers this within a simulated, nonthreatening environment with ease of access and flexibility to each individual learner (Bell, Kanar, Kozlowski, 2008; Bloomfield, While, & Rodgers, 2008). Engagement in learning has contributed to the recent revisions of the NRP with the education focus being shifted from the instructor to the participant. These program changes were widely implemented in the year 2012 with the NRP 6th edition and expanded upon in 2016 with the release of the NRP 7th edition, that includes the addition of the independent computer-based simulation program (eSim®). Exploring participant outcomes related to behavior, skill performance, retention, and examining the effects of additional online learning approaches (i.e. computer-based simulation) to the traditional NRP educational approaches requires examination by the nursing profession. All of these changes have been identified as a research priority by the American Academy of Pediatrics (2015).

Over 28,000 NRP instructors, many of whom are nurses, function to develop neonatal care providers across the world (over 3,000,000 trainees since the program's development in 1987) (American Academy of Pediatrics, 2016; American Academy of Pediatrics, 2011; Halamek, 2008). Therefore, assessments of these educational revisions, alongside an examination of the impact of independent computer-based simulations on participant behavior, skill performance, and retention of this content, are important considerations in evaluation of this widely used education program focused on neonatal patient safety and professional nursing education development.

Definitions

The following definitions were applied to form the basis of this research.

Neonatal Resuscitation Program (NRP)

Conceptual Definition. An evidence-based educational program that introduces the concepts and skills associated with neonatal resuscitation to health care providers in the development of their professional practice (American Academy of Pediatrics, 2011). The eleven lesson program provides education associated with (Preface) neonatal resuscitation program course overview, (1) foundations of neonatal resuscitation, (2) preparing for resuscitation, (3) initial steps of newborn care, (4) positive pressure ventilation, (5) alternate airways including endotracheal tubes and laryngeal mask, (6) chest compressions, (7) medications, (8) post-resuscitation care, (9) resuscitation and stabilization of babies born preterm, (10) special considerations, (11) ethics and care at the end of life (American Academy of Pediatrics, 2016). Each of the eleven lessons integrates prior lesson content and evidence based practice changes into neonatal resuscitation care as an individual progresses through the educational program. The 7th edition NRP course requires participants to self-study the 7th edition textbook followed by an online exam and independent computer-based simulations. Participation in performance skill stations and simulation/debriefing associated with the eleven lessons of NRP are additional components to this education program (American Academy of Pediatrics, 2016). The focus of this study will be on resuscitation overview and principles, initial steps of resuscitation, the use of resuscitation devices for positive pressure ventilation, pulse oximetry, and chest compressions. These are the common and newly added components to neonatal resuscitative care.

Simulation

Conceptual Definition. "Activities that mimic the reality of a clinical environment and are designed to demonstrate procedures, decision-making, and critical thinking through techniques such as interactive mannequins (Jeffries, 2005, p.97) as described in the Neonatal Instructor Manual, Appendix F (American Academy of Pediatrics, 2011).

Independent Computer-based Simulation

Conceptual Definition. The use of a two-dimensional screen-based computerized technology to facilitate the educational process to provide a degree of real-world application that will focus on the performance of identified NRP skills (Bloomfield, et al., 2008; Jeffries, 2005).

Perinatal Sentinel Event

Conceptual Definition. "…any perinatal death or major loss of function not related to a congenital condition in an infant who weighs more than 2,500 grams at birth" most commonly related to inadequate communication, assessment skill, competence, and organizational culture (Joint Commission Resources, 2004, p.141).

Knowledge retention

Conceptual Definition. The ability to store information for a period of time and then retrieve the correct information related to a situation (Su and Osisek, 2011).

Concrete Experience

Conceptual Definition. The ability of the learner to be fully involved in the new experience with tangible and felt qualities of the learning environment through the use of senses and immersion in the content (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999)

Reflective Observation

Conceptual Definition. The watching of others who are involved in an experience and reflecting upon the observed experiences from multiple perspectives (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999).

Abstract Conceptualization

Conceptual Definition. The ability to create concepts and integrate new information into one's knowledge through analyzing and systematically planning (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999)

Active Experimentation

Conceptual Definition. When the learner is directly involved in the experience and their ability to apply and use the newly acquired information within the problem solving process (Kolb, 1984; Kolb, Boyatzis, & Mainemelis, 1999).

Demographic Variables

Conceptual Definition. Demographic variables that may affect the study results will be attained from the RN participants in order to assess for the influence and/or potential relationships of these variables to study findings. This is based upon findings that individual differences in ability and prior experience can have on "…how participants approach, interpret, and respond to the simulation experiences" (Bell, et al., 2008, p.1421).

Follow up assessment time frame

Conceptual Definition. Time frame identified for re-evaluation of NRP content knowledge and neonatal resuscitation simulation performance assessment is between 6 weeks to 18 months post education program. This is based upon data and recommendations that skills deteriorate rapidly (Bruno, Ongaro, & Fraser, 2007; Sisson, Swartz, & Wolf, 1992; Trevisanuto, Ferrarese, Cavicchioli, Fasson, Zanardo, & Zacchello, 2005) and overall the finding that NRP skills decline sharply starting at 2 to 3 months from the initial delivery of the NRP education program (Patel, Posencheg, & Ades, 2012).

Summary

Approximately 400,000 infants annually in the United States require varying degrees of resuscitative assistance at birth. Members of the health care team, including nurses, depend upon the knowledge obtained from the NRP to guide their decision making processes when making fast paced, lifesaving judgments at the infant's bedside. The American Academy of Pediatrics (2011) revised the NRP to include self-study, online testing, performance skill stations, and resuscitation based simulation/debriefing sessions as the educational methodologies used to promote a hypothesized optimal learning environment. Examination of these educational methods related to skill application, behaviors, and retention in comparison to these educational methods with the addition of NRP 7^{th} edition independent computer-based simulations were explored in this study. The ELT provided the theoretical support for the educational methods and approaches used within the NRP and also within this study.

CHAPTER II

Review of the Literature

As discussed in the introduction, the literature surrounding the use of independent computer-based simulation for high crisis low volume events, such as neonatal resuscitation, is limited. Alternatively, the literature surrounding the use of simulation (low and high fidelity) as an educational modality is widespread. The 7th edition of the NRP has responded to the simulation based education paradigm shift. The revised program includes a self-study format and testing for knowledge attainment, followed by independent computer-based simulation (eSim®) and interactive live simulations completed by participants in evaluation of skill delivery. The merging of independent computer-based simulation and high fidelity simulation as a format to augment the development and retention of neonatal resuscitation knowledge, procedural skills, and teamwork is proposed within this study. The combination of these dual active learning strategies is hypothesized to address the individual needs of the NRP participant thus enhancing the life saving care delivered to the compromised neonate.

This chapter provides an in depth review of neonatal resuscitation, simulation, independent computer-based simulation, and the learning theories supporting this proposed teaching model in the education of perinatal nurses involved in neonatal life saving care. A synthesis and critique of the related simulation and computer-based simulation literature is included as a basis for the development of this educational modality. The effect of these pedagogical approaches and theoretical underpinnings on the Psychomotor and Behavioral domains of learning and the retention of lifesaving skills pertaining to neonatal resuscitation will be discussed.

Neonatal Resuscitation Program

In 1987, the International Liaison Committee on Resuscitation and its delegate, the NRP of the American Academy of Pediatrics established the evidence-based guidelines for neonatal resuscitation. NRP is the “gold standard” for the education and development of the required knowledge and skills needed in neonatal resuscitation for health care providers in the United States and other developed countries around the world. The primary goal of NRP was to ensure that at least one person at each hospital birth was trained in neonatal resuscitation (DeGarmo, Rodriguez, Amer, Wang, 2011; Halamek, 2008; Zaichkin & Weiner, 2011). Since the beginning of NRP, more than 3 million health care providers have completed the course and there are over 28,000 instructors of this program reaching across the world (Zaichkin & Weiner, 2011).

The education of health care providers and the delivery of optimal resuscitation efforts are pivotal to the survival of neonates around the world. This is evident among the approximate 4 million births that occur annually in the United States. Within these births, resuscitation assistance is required for up to 10 % (400,000 neonates) and up to 1% (40,000 neonates) will ultimately require substantive resuscitative measures (American Academy of Pediatrics, 2016; American Academy of Pediatrics, 2011; CDC, 2013). Through the integration of the NRP evidence-based practices and algorithms, health care providers are given the knowledge to plan, assess, administer, and evaluate the initial and subsequent steps needed in neonatal resuscitation (Jukkala & Henly, 2009).

Movement through the NRP evidence-based practices and algorithms requires the health care provider to be fluent in the sequence and delivery of resuscitative interventions. The interventions most frequently used in the approximate 10% of births requiring resuscitation assistance include the management of the neonate's airway, assessment of heart rate and potential delivery of chest compressions, pulse oximetry use with integration into the resuscitation interventions, and communication among the health care team (American Academy of Pediatrics, 2011). The seamless and effective delivery of these resuscitation components require "A solid knowledge base, recent practice with skills, and comfort in their application (Blakely, 2007)…for each team member, as individual provider performance will impact the function of the overall resuscitation effort (Baker, Salas, King, Battles, & Barach, 2005) and thus neonatal outcomes" Jukkala & Henly, 2009, p.443).

Currently the recommended interval for participation in NRP is on a biannual basis to facilitate compliance with institutional policies. The NRP Steering Committee also states that biannual training "…is often not consistent with achieving optimal educational outcomes" (American Academy of Pediatrics, 2011, p.11), but the committee does not provide an alternative NRP delivery timeframe for consideration of use by institutions. Efforts to optimize the acquisition of NRP skills and behaviors, despite the timeframe of biannual training, have now transitioned the program into simulation-based training. This education format shifts the responsibility for learning from teacher focused to learner focused. This education method is the revised approach utilized to meet the NRP course objectives within an active, immersive, team based, simulated environment.

NRP Research Studies

Support for the transition of NRP to simulation-based training is largely documented within the literature as being based upon the historical contributions that simulation has made in the fields of aviation, the military, and nuclear engineering. The use of Root-Cause-Analysis (RCA) within airline accidents found that two thirds of the problems were related to the flight crew and not mechanical failure. This identification led to the introduction of simulation as an educational modality with a goal of training behavioral skills across personnel (DeGarmo, Rodriguez, Amer, & Wang, 2011; Fanning & Gaba, 2008; Gaba & Howard 1998; & Rosen, 2008). Through simulation, cognitive, technical, and behavioral skills have been embedded into the airline and military culture, thus improving safety. These premises have since been transitioned into health care training and into the neonatal resuscitation program.

For more than 25 years, neonatal resuscitation and the NRP has been evaluated for effectiveness in the domains of participant satisfaction, confidence, simulation performance, and written test scores. Rakshasbhuvankar & Patole (2014) conducted a systematic review using the key words simulation and infant, newborn, or neonate and yielded a total of 1084 citations related to simulation based training and neonatal resuscitation education. Despite the abundance of citations found related to the NRP concepts stated above, only three small studies have been conducted which meet the Cochrane guidelines for systematic reviews as a randomized controlled trial (RCT) (Cavaleiro, Guimareaes, Calheiros, 2009; Lee, Brown, Bender, Machan, & Overly, 2012; Weiner, Menghini, Zaichkin, Caid, Jacoby, & Simon, 2011); and one quasi-experimental study with controls (non-RCT) (Curran, Aziz, Yound, & Bessell, 2004).

This is attributed to barriers in educational based research, such as variations in study designs, indirect outcome measurements (i.e. perceived confidence versus clinical observations), inadequate sample sizes, and availability of resources such as human, financial, and environmental (simulation equipment) (Cant & Cooper, 2009 & Kilday, Spiva Barnett, Parker, & Hart, 2013; Sawyer et al, 2016).

The objective of the study conducted by Lee et al. (2012) was to determine if a medical simulation-based neonatal resuscitation educational intervention was more effective than the current-lecture based teaching method being used in an Emergency Medicine residency program. This RCT included a convenience sample size of 27 Emergency Medicine residents and the evaluation of confidence and simulation performance. The participants in the intervention group of this study received several simulation scenarios using a high-fidelity mannequin, video debriefing, and review of the NRP algorithm by a neonatologist. Significant improvement in resuscitation scores were found in the intervention group compared to the control group related to performance of critical actions and less time to complete the steps of warming, drying, and delivery of tactile stimulation. A baseline assessment of confidence in leading neonatal resuscitation was reported at 25%. The value increased to 65% at the final assessment. Within this RCT, repeated simulation was provided to the intervention group within a single 4-hour session. Lee et al (2012) further stated that intervention group participants retained knowledge several months after the intervention, but failed to identify the timeframe of the knowledge retention assessment and modality of evaluation.

In addition, Weiner, Menghini, Zaichkin, Caid, Jacoby, & Simon (2011) conducted a study comparing neonatal resuscitation self-directed training to the traditional classroom format. The study was a RCT with utilization of standardized outcome measures (knowledge test scores and mega-code simulation scores) within a homogenous sample of 46 postpartum nurses that were novices to neonatal resuscitation. The aim of the study was to compare findings among participants in the self-study group to the participants in the traditional classroom delivery group. Basic NRP concepts were evaluated in this study and simulation scenarios. The findings of this study were that there were no significant differences in the domains of satisfaction, confidence, simulation performance, and knowledge based written scores among the control and intervention groups when evaluated immediately following the delivery of course content and the high fidelity simulation scenario. Data assessing the reliability and validity of the knowledge test were not provided. However, the NRP Steering Committee develops materials and knowledge tests based upon the American Heart Association and American Academy of Pediatrics Guidelines established by the International Liaison Committee on Resuscitation (ILCOR). Weiner et al. (2011) did not conduct a follow up assessment with the evaluation of results limited to immediate pre-course and post-course assessment data. One wonders about confounders in this study, such as the participants being novice learners to the NRP course and the small sample size (n=46), but despite these considerations, independent learning of NRP content and skills was not found to be inferior to traditional educational modalities.

In another study, Curran, Azis, Yound, & Bessell (2004) conducted a non-RCT study to evaluate the effect of a computer-training simulator versus a training video on retention of neonatal resuscitation skills. A randomized pretest posttest control group study design was used with a convenience sample of 60 medical students. The evaluations were conducted at the time points of 4 and 8 months. Knowledge levels were found to decrease significantly at the 4 and 8-month intervals, and there were no significant differences between the control and intervention groups at 8 months in relationship to their neonatal resuscitation knowledge, confidence, or skills. The identification of the significant decrease in knowledge at the 4 and 8-month time frames leads to the consideration of the frequency in which simulation should be repeated for retention of NRP content. The medical student participants within the study did report satisfaction with the remote computer simulation training, a finding in alignment with adult learning theories (Curran, Azis, Yound, & Bessell, 2004). Confounding variables that occurred included a high rate of participant (medical student) attrition, a highly controlled and artificial environment in which skills were evaluated, and a "testing sensitization" effect which may have resulted in higher scores due to prior test item exposure. Of overall interest from the study conducted by Curran et al (2004) is the discussion that significant knowledge and skill deficiencies were noted in the timeframe between the initial and 4 month assessment with the results between 4 and 8 months remaining relatively consistent. This leads to further consideration about the importance of earlier timing and more frequent dosing of NRP content and skills.

Among the controlled studies on neonatal resuscitation education and simulation-based training, there currently is insufficient data demonstrating a difference between neonatal resuscitation education and neonatal resuscitation supplemented with simulation-based training. The small sample sizes, the variable study designs, and the differences among the variables evaluated within each study do not provide enough evidence to make generalizable recommendations to a preferred neonatal resuscitation education format (Rakshasbhuvankar & Patole, 2014; Sawyer et al, 2016). Confounding variables further influencing generalizability included participant characteristics such as age, equivalent group distribution related to experience of with neonatal resuscitation, and the use of medical student/resident cohorts as participants in the majority of the published studies. These inconclusive findings could be attributed to the challenges that exist in educational research, such as multiple components of an education program, difficulties identifying the significance of each education component separately, difficulties in measuring effectiveness related to clinical outcomes (i.e. active resuscitation performance), and participant biases (supportive or against) toward the educational intervention (Rakshasbhuvankar & Patole, 2014).

Additional studies, not RCTs, have been conducted on the effects of the NRP on knowledge attained, retained, and simulation performance at varied time intervals from pre course, to immediately post course, to up to 12 months following completion of the neonatal resuscitation course. Improvement in levels of knowledge, confidence, and performance in resuscitation skills have been documented in various studies (Graham et al., 2006, Jukkala and Henly, 2007, Rovamo et al., 2013, Singh et al., 2006, & Van Schaik et al., 2008). The use of simulation in neonatal resuscitation training provides an opportunity to replicate the management of a real resuscitation and has been identified as an effective teaching method for use in the NRP (Campbell et al., 2009, Cates, 2011, Halamek et al., 2000, Hamalek, 2008, Rovamo et al., 2013, Sawyer et al., 2011, & Yaegar and Arafeh, 2008).

The use of simulation as an education methodology is further supported in the Consensus on Science and Treatment Recommendations (CoSTR) published by the International Liaison Committee on Resuscitation (ILCOR) in 2010. The document states, “Use of simulation as an adjunct to traditional education modalities, may enhance performance in the healthcare professionals in real-life clinical settings and simulated resuscitations” (Perlman, Kattwinkel, Wyllie, Guinsburg, Velaphi, & Singhal, 2012, p. 549). Perlman et al (2012, p. 549) further state that “…the most effective interventions and evaluation methodologies (related to simulation) remain to be defined”.

Literature Gap

The status of the existing literature surrounding neonatal resuscitation and the NRP has focused on knowledge, confidence with neonatal resuscitation, satisfaction with simulation-based education compared to traditional classroom education, and retention of skills. The literature further includes an abundance of documentation surrounding the importance of integrating simulation-based learning into neonatal resuscitation education and the documentation of this evolution. Research gaps still exist in relationship to optimal simulation delivery and format, the evaluation and measurement of retention, neonatal resuscitation with RNs as the study participants, and the effects of simulation-based learning on actual resuscitation performance and neonatal clinical outcomes.

Simulation strategies & retention

The contribution of simulation as an educational method has been documented throughout the health sciences literature and originated in the discipline of anesthesia.

The replication in the clinical environment and health care situations has been identified as one of the best ways to prevent medical error and manage any risk to the patient (Kassab & Kenner, 2011). Simulation has been identified as an effective teaching strategy and is recommended over other teaching methods (Fanning & Gaba, 2008; Kneebone, 2005). As a comprehensive teaching tool, simulation offers many pedagogical techniques to implement, or combine, to facilitate learning and transfer of skills into a challenging health care environment, such as neonatal resuscitation (Fanning & Gaba, 2008). The identification of an optimal simulated education method or combination of approaches is yet to be identified; however the need for innovative strategies has been reported in the literature (Jeffries, 2001; Salyers, 2007).

Retention and adherence to the NRP algorithms guide resuscitation decisions and are the foundation of efficient neonatal life saving care. Despite emphasis being placed upon the NRP concepts, retention of skills continues to be a problem for resuscitation programs. Knowledge and skills have been shown to deteriorate within 3 to 8 months following the completion of a NRP course, which currently occurs every 24 months (Carbine, Finer, Knodel, & Rich, 2000; Curran, Aziz, Yound, & Bessell, 2004; Kaczorowski, Levitt, Hammond, Outerbridge, Grad, & Rothman, 1998; Patel, Posencheg, & Ades, 2012; Weiner, Menghini, Zaichkin, Caid, Jacoby, & Simon, 2011). Retention and application of interventions used in all deliveries (drying, stimulation, APGAR score assessment) are maintained and routinely utilized. Conversely, the more complex interventions (suctioning, ventilation and chest compressions) deteriorate due to the low frequency of the events and a to a lack of their integration into a care delivery routine. Additionally, studies have demonstrated a health care provider error rate of 16-

55% related to retention and adherence to the NRP algorithm that requires the identification of neonatal resuscitation needs accompanied by the timed and successful delivery of skills (Fuerch, Yamada, Coelho, Lee, Halamek, 2015). Errors in ability to accurately assess heart rate, significant delays in airway management (i.e. initiation of positive pressure ventilation), the delivery of chest compressions prior to or in absence of positive pressure ventilation, and the delivery of chest compressions for an insufficient period of time are example of skills not effectively administered during a neonatal resuscitation (Chitkara, Rajani, Oehlert, Lee, Epi, Halamek, 2013; Fuerch et al, 2015; & Mitchell, Niday, Boulton, Chance, Dulberg, 2002). These deficiencies in neonatal resuscitation performance can lead to an increased risk of mortality, severe intraventricular hemorrhage, and poor developmental outcomes for neonates (Finer, Horbar, & Carpenter, 1999; Shah, Shah, & Tai, 2009; Shah, 2009; Wyckoff, Salhab, Heyne, Kendrick, Stoll, & Laptook, 2012). Identifying educational approaches to support the retention and delivery of neonatal resuscitation skills is critical to clinical neonatal outcomes (Fuerch, Yamada, Coelho, Lee, Halamek, 2015).

The NRP 6th edition previously removed the simulation evaluation component (i.e. the Megacode) from the course (American Academy of Pediatrics, 2011) and this program update has been maintained with the NRP 7th edition released in 2016 (American Academy of Pediatrics, 2016). Currently, there is not a summative evaluation conducted upon the individual or team resuscitation performance competence. The rationale for this program change was to shift the emphasis toward the learning that occurs throughout the simulation and debriefing process (Zaichkin & Weiner, 2011). This omission of performance, informal or formal evaluation, may be a variable affecting skill delivery and retention. The contributions of a summative assessment should be considered, even for use formatively, to guide educational intervention efforts and activities, such as debriefing, to enhance the delivery and retention of these critical skills.

Role development of nurses & neonatal resuscitation

RNs who work in Labor and Delivery, Postpartum Units, and Level I & II Special Care Nurseries comprise the majority of the roles on the resuscitation team within community and rural hospitals. This team composition contrasts to that of tertiary care facilities where pediatric residents, attending physicians, a nurse, and other members of the health care team comprise the neonatal resuscitation team. The role development and enhancement of the RNs' resuscitation skills and retention within community and rural hospital settings is pivotal to the "…fundamental implementation of quality neonatal resuscitation" (Jukkala & Henly, 2009, p. 444). In contrast to this state of practice, the available research literature on NRP performance has been primarily focused upon pediatric residents and medical student knowledge, performance, satisfaction, and confidence with neonatal resuscitation. No studies have been identified in relationship to neonatal resuscitation knowledge, skill performance, and/or retention within a representative sample of RNs. Moreover, the NRP 7th edition identifies the need for team based learning in the simulated environment, but the composition of resuscitation of team members in the actual clinical practice environment can vary based on organization type.

In community and rural hospital settings, it is common for RNs to manage the care of patients in labor, during the postpartum period, and neonates admitted to a

Level I or Level II Special Care Nursery. Physicians are "on call" until the birth is imminent or a change in a neonate's status requires their presence, at which point they will come to the hospital (Jukkala & Henly, 2009). These environments of care require RNs to consistently maintain a competence in their resuscitation knowledge base, rapid assessment of the neonate's status, and delivery of skills across all roles required in a neonatal resuscitation. The limited frequency of neonatal resuscitation events, especially in community and low birth volume rural hospitals, creates additional challenges due to the few opportunities to integrate NRP knowledge into skills, practice, and actual neonatal resuscitation situations. Competence in the management of NRP key components, frequently conducted by RNs, of airway management, heart rate assessment, chest compressions, pulse oximetry, and communication must be optimally established and maintained between NRP intervals.

Overview of NRP Educational Modalities

The NRP of the American Academy of Pediatrics has set the standard of practice for the national and international communities with their standardized approach to neonatal resuscitation. The longevity of the program can be attributed to its ability to evolve based upon the discovery of best practices in neonatal emergencies and the flexibility of the program to adopt new educational modalities in order to meet the need of the diverse population of over 3 million trainees (American Academy of Pediatrics, 2011; Yaeger & Arafeh, 2008; Zaichkin & Weiner, 2011). Key guiding principles were identified at the start of the NRP and continue to provide a successful course framework. These principles include: "(1) Base practice recommendations on the best available evidence; (2) Recognize the different types of skills necessary for successful neonatal resuscitation; (3) Understand the importance of self-education for the adult learner; (4) Adequately prepare instructors; and (5) Regionalize training" (American Academy of Pediatrics, 2011, p. 3).

Using these guiding principles, the NRP recognized the need to adapt from the traditional classroom setting using lecture materials, videos, and PowerPoint slides into a revised model of active learning experiences to promote the acquisition of cognitive, technical, and behavioral skills needed in neonatal resuscitation (American Academy of Pediatrics, 2011; Halamek, 2008; Zaichkin & Weiner, 2011). The NRP 6th edition was revised to address these needs and in further expanded upon with the release of the NRP 7th edition, which included the integration of independent computer-based simulation into the program format. The NRP is formatted into independent self-study and the completion of an online exam, which is then followed by completion of independent computer-based simulations (eSim®), skills stations and group based simulation activities (to be conducted within 90 days of completing the online exam). This revised format provides successful "Self-directed education… (and) shift(s) the acquisition of cognitive and basic procedural skills outside of the classroom, which allows instructors to shorten the course while adding simulation and debriefing activities" (Weiner, Menghini, Zaichkin, Caid, Jacoby, & Simon, 2011, p.718).

Contribution of Computer-Based Simulation

Computer-based simulation is defined as "…the use of computerized technology to facilitate the educational process" (Bloomfield, While, & Roberts, 2008, p.223). Within the literature a variety of terms are found in reference to computer-based simulation (i.e. computer assisted instruction, computer-based learning, online learning, etc.). Computer-based simulation offers an approach to provide a shared learning strategy (i.e. computer-based simulation and high fidelity neonatal resuscitation simulation) to facilitate the development of individual competence and deepen the understanding of various roles involved in the delivery of health care.

An additional advantage of computer-based simulation is that this strategy provides a mechanism for consistent delivery of content at timed intervals with feedback provided to the user. The use of this format allows an individual to access education independent of a scheduled classroom course or simulation event. In alignment with adult learning theory, it further offers flexibility, control over the pace of learning, and the ability to repeat portions of content as needed. These attributes of computer-based simulation are also sources of satisfaction to the learner.

The integration of computer-based simulation offers a mechanism for deliberate practice of neonatal resuscitation skills with the goal of skill improvement. As a consistent educational method, computer-based simulation promotes information processing, skill acquisition, and maintenance (McGaghie, Issenberg, Cohen, Barsuk, & Wayne, 2011). A effective computer-based simulation will contain well defined learning objectives, an appropriate level of difficulty, focused repetitive practice, informative feedback for error correction, and an evaluation of performance (McGaghie et al., 2011; McGaghie, Siddall, Mazmanian, & Meyers, 2009; Wayne, Butter, & Siddall, 2006).

Computer-based simulation of NRP content offers an educational method in which to augment the retention of critical neonatal resuscitation skills. This method further provides the ability to dose users with NRP content at prescribed intervals between the bi-annual NRP course offerings. Literature has demonstrated a rapid deterioration of skills used infrequently, such as neonatal resuscitation. Computer-based simulation offers the capability to optimally space materials in efforts to offset the effects of time by promoting the active retrieval of learning. Implementing this pedagogy provides spaced repetitions to scaffold and master course material and critical skills (Rohrer & Pashler, 2007). Rohrer & Pashler further identified that optimal spacing depends on the time period in which the material should be retained (i.e. 10-20% of the interval) (2007). Therefore, in reference to the NRP being offered every 24 months, this calculation provides an optimal spacing interval of NRP course content of every 2 to 4 months, which can be accomplished with computer-based simulation.

Experiential Learning Theory and NRP Pedagogies

As discussed in Chapter 1, the American Academy of Pediatrics does not specifically identify a theory used to guide the revisions to the 7th edition NRP and standards. The NRP does recognize the importance of adult learning principles such as interaction, application, and manipulation of the content knowledge provided with the course as the rational for this paradigm shift (American Academy of Pediatrics, 2011). The revised NRP course format, objectives, and the use of computer-based simulation are in close alignment with ELT. Although ELT is not tested with NRP studies, this theory allows for application in a variety of disciples while providing the abstract boundaries for studies based in adult learning principles and active learning. Therefore, ELT and the constructivist literature will be used to support this study.

Kolb states that, “Learning, the creation of knowledge and meaning, occurs through the active extension and grounding of ideas and experiences in the external world and through internal reflection about the attributes of these experiences and ideas” (1984, p.52). ELT describes a cyclical process of an Act (concrete experience); Reflection on the experience; Conceptualization of the experience; and Experimentation (Action or decision making) (Kolb, 1984). Engaging in this continuous process leads the learner through the process in which “…knowledge is created by transforming experience into existing cognitive frameworks changing the way a person thinks and behaves” (Kolb, 1984, Lisko & O’Dell, 2010, p106). In order for learning to be effective, all phases of the learning cycle need to be experienced. Learners typically gravitate toward one or two of the phases to meet their individual learning needs, and may progress at differing speeds through the other phases of the experiential learning cycle (Kolb, 1984, Lisko & O’Dell, 2010).

A concrete experience provides the foundation for the learning (simulation and/or clinical experience). This foundation evolves with adapting concrete experiences (the act). Reflective observation encompasses the articulation of various perspectives of the concrete experience and “…includes opposing dialectical thoughts that weigh what is currently experienced (seen, heard, touched) and what is known about similar situations from past experience, intuition, and cognitive knowledge” (Weatherspoon & Wyatt, 2012, p. 483). Reflective observation occurs at the start of debriefing following simulation as participants share their thoughts on what occurred during the concrete experience. Abstract conceptualization follows reflective observation and occurs as the debriefing process progresses. The abstract conceptualization phase of ELT involves the integration of logic and ideas to deepen comprehension of the situation (i.e. simulation experience) (Kolb, 1984 & Lisko & O’Dell, 2010). It is during abstract conceptualization that the learner understands the occurrence of events and forms decision-making logic, thereby furthering clinical judgment (Weatherspoon & Wyatt, 2012).

Debriefing following simulation is central to the experiential learning process for learners. In order for debriefing and the progression of experiential learning to occur, a supportive environment of respect, freedom to learn, honesty, and trust must be established by the facilitator and maintained by the group as learners may feel vulnerable during this phase (Fanning & Gaba, 2008). The structure of a debriefing includes the phases of description, analogy and analysis, and application (Fanning & Gaba, 2008), which are reflective of the experiential learning process. It is during debriefing (i.e. reflective observation and abstract conceptualization) that the majority of learning and integration of significant concepts into the active memory occurs.

Active experimentation follows the preceding three phases. This phase provides an extension to the learning that has occurred following the concrete experience, reflective observation, and abstract conceptualization phases. Active experimentation is the time in the learning cycle in which learners are able to test their revised knowledge and comprehension (i.e. during a repeated simulation) (Kolb, 1984; Lisko & O'Dell, 2010; Weatherspoon & Wyatt, 2012). Emerging from the active experimentation are the revised decisions and clinical judgment that then form the foundation for another concrete experience within the experiential learning cycle.

Moreover, ELT provides the process that can help education programs and educators guide learners. In neonatal resuscitation, the educator uses observed real world and simulation experiences as a facilitator for the learning and not as a method to dispense information (Sewchuk, 2005). Through the process of simulation and the valuable component of debriefing, the facilitator guides the learners through the development of their knowledge (i.e. their transformation of the experience).

The 7th edition NRP used adult learning principles in making its revisions. Reflecting upon these principles it was identified that passive teaching methodologies may not meet the needs of the autonomous, self-directed adult learner (Weiner, Menghini, Zaichkin, Caid, Jacoby, & Simon, 2011). The development of a self-directed education program has arisen in place of the traditional classroom setting combined with the integration of hands-on practice, realistic simulations, and constructive debriefings into the overall NRP education approach. Each of these educational modalities are in alignment with ELT and adult learning principles focusing on the importance of experience, manipulation, and debriefing as one goes through the continual cycle of learning.

Kolb's theory addresses the delivery of learning experiences and integration of various interventions to meet the needs of all types of learners (Kolb, 1984; Lisko & O'Dell, 2010). Independent computer-based simulations offer an additional educational strategy that can be easily accessed and used to meet individualized learning needs. This simulation format also provides a safe and risk free environment to apply learning. Educational strategies that focus upon scaffolding of information and processing (i.e. neonatal resuscitation concepts) can be practiced through interactive computer simulations. Computer-based simulation provides a method to promote the progression of the learner's clinical judgment through descriptive case studies requiring the learner to identify a course of action that is then followed by feedback, all of which are components of ELT (Weatherspoon & Wyatt, 2012).

The integration of ELT and adult learning principles into the NRP format of self-directed study and simulations has been made evident in this literature review. Supplementing the NRP format with independent computer-based simulation, which also supports ELT and adult learning principles, provides RNs (and other neonatal resuscitation providers) an independent process to promote their critical thinking and development of clinical judgment. Characteristics such as flexibility in timing and delivery of content for frequent distribution, control over the pace of learning, ability to repeat portions, and an opportunity to reflect upon new skills produces an interactive and stimulating environment for the adult learner. Furthermore, independent computer-based-simulation as the new 7th edition supplement to the prior NRP formats is an innovative approach to promote application and retention of neonatal resuscitation skills and behaviors required during low frequency, high crisis neonatal resuscitation events.

Definitions of Terms

The conceptual and operational definition of terms was discussed in Chapter 1. The refinement of the terms used to guide this study emerged from this literature review.

Summary

Simulation has been identified worldwide as a valuable component to health care education within the literature. In order for simulations to be effective and valuable they must be structured with the identification of specific learning objectives, the identification of participant roles, fidelity levels identified, have opportunities for the learner to progress through the stages of the experimental cycle in a structured manner, and a safe, controlled, non-threatening environment must be provided to permit practice of skills (Fanning & Gaba, 2008; Jeffries & McNelis, 2008). This comprehensive teaching tool when used appropriately facilitates learning in challenging environments with various pedagogical approaches used in its application. The use of all modes of simulation as an active learning strategy is further supported by ELT as a platform for the transformation of an experience into knowledge.

These requirements of an effective simulation influenced the 7th edition NRP format developed by the American Academy of Pediatrics. The need to actively experience and incorporate the concepts of NRP into team-based practice has been recognized within the literature as the gold standard approach for professional neonatal resuscitation education. In light of these revisions, the NRP no longer uses a scoring rubric nor evaluates individual performance in neonatal resuscitation simulations. This is based in the foundation that simulation is to be used for learning, but leaves one to consider the effect of omitting this process on the recognition of a provider's individual areas of improvement needed related to neonatal resuscitation and ultimately its impact on care and clinical outcomes.

Neonatal resuscitation is a low frequency, high crisis event occurring in approximately 10% of births requiring health care providers to retain their knowledge and skills across time despite limited use and practice of neonatal resuscitation skills, including communication and coordination of resuscitation responsibilities. The current format of bi-annual delivery of the NRP course has been identified within this literature review as a barrier to optimal learning and retention of course content. Significant skill deficits that have been identified within the literature to occur across time may impact neonatal resuscitation provider performance. Closer spacing of simulation experiences, including the use of independent computer-based simulation, of every 2 to 4 months should be considered for continual learning, retrieval, and retention of NRP performance and behavioral skills.

Independent computer-based simulation can provide organizations an additional simulated approach for delivery of frequent, consistent, and timed dosing of neonatal resuscitation content. Deliberate practice and repetition through various simulation strategies can provide opportunities for health care providers (i.e. RNs in community and rural hospitals) to master NRP algorithms and skills. Embedding these principles into the clinical reasoning and the rapid decision making required is critical to the timely delivery of life saving care neonatal care. To date, investigating the role of computer-based simulation on clinical skill acquisition and retention as in intervention to the 7th edition NRP format has not been conducted.

It has also been identified that the literature conducted on NRP performance, skills, and retention is highly focused upon the pediatric resident population of participants. This confounding variable is highly significant in the evaluation of program effectiveness. Recognition of the diverse knowledge base and skill set that exists between physicians and RNs, and the hospital type setting of the studies must be considered. For example, RNs routinely comprise the majority of the neonatal resuscitation team roles in the community and rural hospital settings. Research needs to be conducted to address performance, skill delivery, and retention needs of the RNs involved in neonatal resuscitation and the evaluation of interventions used to support the acquisition. Competence in the management of NRP key components of airway management, heart rate assessment, chest compressions, pulse oximetry, and communication must be optimally established and maintained between NRP intervals, as these components and roles are frequently conducted by RNs.

Plus, ELT provides this study with a framework that supports experience being central to learning. Simulation and independent computer-based simulation will offer the experiences within this study. Through the debriefing processes, aligned with reflective observation and abstract conceptualization, neonatal resuscitation skills, communication, and retention effects will be optimized. Additional exposure to NRP content with independent computer-based simulation offers an opportunity to further explore these concepts in relationship to ELT principles.

The maintenance of high levels of provider readiness for neonatal resuscitation events is fundamental to the care of the fragile neonatal population. More frequent refresher training, such as computer-based simulation, aligned with adult learning theories may impact the safe delivery of high-quality neonatal resuscitation care. Therefore, based on the synthesis of the literature and application of Kolb, this study's research questions emerged. This study offers the potential to expand the knowledge surrounding the development and retention of skills and behaviors required in the delivery of neonatal resuscitation care.

CHAPTER III

Methodology

This chapter describes the methods and procedures that were used to explore the effects of an independent computer-based simulation on neonatal resuscitation skills focusing on the pivotal components of life-saving neonatal care including airway, chest compressions, pulse oximetry, and communication in these low frequency, high crises situations. Details of the research design, sample selection criteria, ethical considerations, variables measured, and methods of data analysis are discussed below.

Design

A quasi-experimental longitudinal pre-test post-test study was the design that consisted of a control group and an intervention group. The components assessed include: 1) baseline evaluation of RN neonatal resuscitation simulation performance within the control group and the intervention group; 2) the completion of independent computer-based simulation of neonatal resuscitation by the RN intervention; and 3) a repeated evaluation of RN neonatal resuscitation simulation performance within the control group and the intervention group four months post initiation of this study. A quasi-experimental design was chosen because of the characteristics that randomization of subjects would be impractical within the research site and population. The design also permits the examination of findings within a natural setting (potentially allowing for generalizations to be made about the population). The following research questions were examined:

Research Question 1: Are there differences in the three-month retention and performance of NRP concepts of airway, chest compressions, pulse oximetry, and communication between participants who receive self-study and live NRP simulations compared to those who receive self-study, live NRP simulations, and an independent computer-based neonatal resuscitation simulation experience?

Research Question 2: Are there differences in the application of NRP concepts of airway, chest compressions, pulse oximetry, and communication between participants who receive self-study and live NRP simulations compared to those who receive self-study, live NRP simulations, and an independent computer-based neonatal resuscitation simulation experience?

The recommendations of Polit and Beck (2014) were used as the standards for the Content Validity Index (CVI) of the adapted tools used in this study. Polit and Beck (2014) recommend a panel of at least three experts to be used in the evaluation of inter-rater reliability of the items and overall tool in development. An I-CVI of 0.70 or higher was the standard of this study, as recommended by Polit and Beck (2014). A scale-level content validity score of 0.80, as recommended by Davis (1992), was used in the assessment of agreement among reviewers of the adapted tool (Appendix A).

David E. Kolb's Experiential Learning Theory (Kolb, 1984), an adult educational learning theory closely aligned with simulation based teaching methodologies, provided the theoretical basis for this study. Although the American Academy of Pediatrics (AAP) does not specifically identify a theory used to guide the pedagogical approach of the 7th edition NRP, the NRP and AAP does recognize the importance of adult learning principles such as interaction, application, and manipulation of the content knowledge provided within the course as a rationale for the paradigm shift (American Academy of Pediatrics, 2011). The impact of these educational modalities on retention and performance of behaviors were explored within this research design.

The independent variable manipulated within this study is the delivery and completion of an independent computer-based simulation scenario (eSim®) by RNs that includes the concepts of airway, chest compressions, pulse oximetry, and communication. The dependent variables are performance and retention within the context of the neonatal resuscitation skills of communication, airway management, pulse oximetry use, and chest compressions. These variables were evaluated with a live simulation performance. The live baseline (Phase I) and live post intervention (Phase III) simulations, which were delivered at month 4 of the study, were videotaped, analyzed, and scored. The adapted *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006) was used to evaluate the effect of independent computer-based simulation (independent variable) on RN performance and retention of the neonatal resuscitation skills of communication, airway management, pulse oximetry use, and chest compressions.

The use of human patient simulators as an educational method is continuing to expand into many programs and levels of nursing education including neonatal resuscitation. This technology involves the use of a "…life-like manikin with sophisticated computer controls that can be manipulated to provide various physiological parameter outputs being either physical or electrical in nature or a combination of the two. The parameters may be controlled through automated software or respond to the actions of an instructor in response to actions" (Bradely, 2006, p.258). The use of a high fidelity simulation experiences with the human patient simulator offers the ability to replicate realistic clinical situations without the risk to the neonate patient population. As discussed in the literature review, there are gaps and differing views on the needed frequency of simulations, the types of simulations to conduct (high fidelity, low fidelity, computer-based, etc.), and how to scaffold simulation experiences. In addition, current simulation research is highly concentrated in the area of nursing students and physician residents. This research project focused on registered nurses (RNs) who are practicing in an acute care setting. Preparation across the cognitive, affective, and psychomotor domains of learning and the evaluation of the transfer and retention of communication, airway management, pulse oximetry use, and chest compressions simulation performance in the lifesaving care of neonates was explored within this study.

Sample

A purposive convenient sample of RNs who are NRP instructors and a expert in nursing education and simulation (n=4) were asked to complete the content validation of the adapted tool proposed for the simulation assessment part of the study. These raters were trained in the use and purpose of the adapted *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006) within the context of this study. The sample size of 4 experts met the recommendations of Polit and Beck (2014) in their recommendation of three or more experts for evaluation of good content validity (I-CVI of 0.90 or higher is considered evidence of excellent content validity). The NRP instructors also reviewed the live simulation scenario for clarity of learning objectives, participant roles, fidelity level, and opportunities for experiential learning to practice skills (Fanning & Gaba, 2008; Jeffries & McNelis, 2008) (Appendix A). Universal agreement (I-CVI = 1.0) was calculated from the 4 expert evaluations of the tool and simulation scenario demonstrating excellent content validity.

The identified hospital study site has 15 labor and delivery rooms, 21 postpartum rooms, and 6 special care nursery private rooms, and deliver approximately 2000 babies per year. A convenience sample of RNs employed at a Mid-Western, suburban hospital was asked to participate within this study. The RNs were employees of a family birth center model of patient care of labor and delivery, mother/baby, and level 2 special care nursery services providing the potential for an approximate sample size of 80 (n=80). A power test was conducted for a moderate effect size of 0.5 with an estimated total sample size requirement of 40 in each group, control and intervention, calculated. All of the currently licensed RNs of the hospital unit have the employment requirement to complete the NRP education. The use of the 7th edition NRP methodologies for neonatal resuscitation education in the perinatal RN population and the effects of an independent computer-based simulation (eSim®) on neonatal resuscitation skills were examined within this study.

The convenience sample of RNs was comprised of participants who have previously taken the NRP within the last two years as an employment requirement. The participant data was obtained via self-report (Appendix C). The sample of RNs had been required to complete the 6th edition NRP self-study and individual Internet based test provided through the NRP website as part of their professional development and education during 2016. The participants then progressed to the live simulation component of the program in the two weeks following their individual success with the Internet based test, as per the format of the NRP. These steps and sample characteristics were in compliance with the NRP education published by the American Academy of Pediatrics (American Academy of Pediatrics, 2011). Within this study it was estimated that the control group would consist of 40 RNs who had received the prescribed educational approach listed above and the delivery of a NRP clinical update at month 1. The intervention group within this study, estimated to consist of 40 RNs, received the prescribed educational approach listed above and the additional educational intervention of an independent computer-based simulation at month 1.

Inclusion and Exclusion Criteria

Participant inclusion criteria for the study included:

(1) Perinatal RNs who have completed the NRP within a timeframe of the last two years.

(2) RNs of any ethnic background, religion, and socioeconomic status

(3) RNs of who are full time, part time, or optional work time employees.

(4) RNs who practice in the perinatal patient care setting at all levels of perinatal practice experience (novice to experts).

Exclusion criteria for the study included:

(1) Perinatal RNs who have not completed the NRP.

(2) RNs who refused to complete the self-report survey tool were excluded because data was not able to be collected from them.

(3) RNs who refused to complete the additional neonatal resuscitation simulation scenarios and/or refused consent to video analysis of behaviors in simulation scenarios were excluded because data was not able to be collected from them.

All members who met these criteria were included in the study and data analysis.

Human Subjects Approval

The proposed quasi-experimental design required research with human subjects through their participation in the neonatal resuscitation simulations. In order to protect the study participants, approval for this study was obtained from the University of Cincinnati Institutional Review Board (UC-IRB). Additionally, a site-specific IRB Waiver of Jurisdiction letter was obtained, as UC-IRB maintained the approval oversight for this study. Informed consent to participate in the study was obtained (Appendix B). The informed consent explained study purpose, risks, and benefits of participation within this study. The researcher completed this informed consent process with the RN participants. RN participants were informed that participation in this study was voluntary, was not a condition or requirement of their employment of the hospital site, that their participation may be withdrawn at any time, and contact information for the researcher of this study, if necessary. Participants, the researcher, and witness signed and dated the informed consent prior to the researcher evaluating data related to this study. A copy of the informed consent was provided to the participant. The study did not pose any threat of harm, risk, or physical discomfort to the participants or research personnel.

Confidentiality of the enrolled participants was protected through the use of a coding system on all instruments used in data collection. The primary investigator maintained the master list of study participants and the research data. This information is located on the University of Cincinnati secured server and in a locked file cabinet in the researcher's office during the study time period and for five years following the completion of the study. Individuals working with the data had no access to personal-identifiers, making data used for analysis confidential. The obtained information from the self-report survey tool and the adapted *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006) is reported as group data.

Compensation was not provided to the study participants. Participation in this study occurred during the participants' scheduled work hours. Participants of this study also received the potential benefit of enhanced NRP knowledge and application to their professional practice as opposed to the facility providing bi-annual NRP training to perinatal RNs. The human subjects participating in this study may potentially benefit the future of neonatal resuscitation education, contribute to the program's body of knowledge, and the evaluation of computer-based simulation effects on perinatal RN simulation performance.

Instrumentation

The purpose of this study was to examine the effects of adding independent computer-based neonatal resuscitation simulation to NRP simulations when examining participant knowledge and performance of required NRP behaviors that are used by perinatal nurses in lifesaving neonatal patient care. In order to evaluate the constructs within this study, an adapted simulation performance assessment tool was used in the control and intervention groups of participants (Appendix D).

A modified simulation assessment tool was used in the evaluation of neonatal resuscitation simulation behaviors. The tool constructs are based upon the learning objectives of the NRP course. The assessment tool maintained alignment with the concepts, skills, and behaviors required of individuals involved in neonatal resuscitation situations. The items are adapted with guidance from the neonatal resuscitation program literature and key behaviors and skills identified by the Joint Commission (2007), Institute of Medicine (2010), and the American Academy of Pediatrics (2011), as behaviors required of individuals involved in resuscitative care.

The adapted simulation assessment instrument was found to be congruent with the NRP content and key behavior skills required in resuscitation performance. Four neonatal resuscitation and education experts evaluated the adapted simulation assessment tool for content validity, per the recommendations of Polit and Beck (2014). An I-CVI = 1 was calculated from the review. The constructs serving as a basis for the RN simulation assessment, as previously identified by Heide, Toledo-Eppinga, Heide, & Lee (2006) and the American Academy of Pediatrics (2011) included:

(1) Group Function: Anticipate and plan for roles and responsibilities; Identify/Assume leadership roles

(2) Preparation and initial steps: Know you environment; Perform equipment check; Know when and who to call for help; Use of all available resources.

(3) Communication: Communication of VS, changes in neonate status; Communication among team members; Use of all available information

(4) Administration of Neonatal Resuscitation Skills: Oxygen administration; Bag and mask ventilation; and Chest compressions.

Participant correct decision-making and proper delivery of procedures was evaluated with the adapted simulation assessment tool and in compliance with the international guidelines for neonatal resuscitation. Efforts to maintain treatment fidelity across the control and intervention groups in all phases of this study were implemented. This researcher delivered the treatments to ensure the integrity and dosing of the interventions across the control and intervention groups at the specified durations and time periods according to the following procedures.

Research Procedures

Phase I- Baseline Neonatal Resuscitation Live Simulation

Participants of this study were invited to complete a self-report survey which identified years of neonatal resuscitation program experience, educational background, primary area(s) of perinatal nursing practice (i.e. labor and delivery, mother/baby, special care nursery, or any combination of these areas of nursing practice), and approximate number of times the registered nurse has participated in a neonatal resuscitation within the last 24 months (Appendix C). These surveys were coded in relation to the master list in order to maintain anonymity of participants.

Neonatal nurses have the employment requirement of obtaining and then bi-annually maintaining their educational program status associated with delivering neonatal resuscitation. The first phase of this study conducted live clinical simulation scenarios within the control and intervention group that lasted approximately 10 minutes (Appendix E) followed by debriefing conducted by this researcher. The simulations were conducted to establish baseline neonatal simulation performance data within the sample population. Group members consisted of varying levels of neonatal resuscitation experience, which allows the data to be generalized across the settings in which the NRP is used. This researcher and an additional expert in neonatal resuscitation completed the video review of group member performance in the simulation scenarios. The additional reviewer was thoroughly trained in use of the adapted simulation-scoring tool by this researcher followed by the review of four videoed simulation scenarios simultaneously for further clarification of tool application. Inter-rater reliability, Kappa (*k*), will be calculated on the obtained simulation performance scores.

The control group and intervention group within the convenience sample was assigned with the use of numbers (1=control group or 2=intervention group) by a computer generated random number assignment. The live neonatal resuscitation simulation scenario is used as baseline data within the control and intervention groups and included background information and situations requiring the participants to demonstrate communication, airway management, pulse oximetry, and chest compressions. These concepts were selected due to their prevalence of use and the scope of practice for RN's within neonatal resuscitation situations.

The simulation scenarios are available in the NRP Instructor manual and are structured to meet the learning needs and experiences of program participants. The simulation scenarios have been evaluated by members of the NRP steering committee, which is comprised of physicians, registered nurses, and a respiratory therapist for content validity in relationship to the NRP learning objectives (American Academy of Pediatrics, 2016, American Academy of Pediatrics, 2011).

The overall learning objectives of the simulation scenarios developed by the NRP steering committee included the following components.

(1) Cognitive skills related to newborn physiology and evidence-based resuscitation practices.

(2) Hands-on skills-i.e. Providing positive pressure ventilation

(3) Effective communication and teamwork as exhibited by performance of NRP Key Behavioral Skills (American Academy of Pediatrics, 2011, p.101).

Behavioral skills included in the neonatal resuscitation scenarios, according to the AAP, include:

(1) Know your environment

(2) Anticipate and plan

(3) Assume the leadership role

(4) Communicate effectively

(5) Delegate workload optimally

(6) Allocate attention wisely

(7) Use all available information

(8) Use all available resources

(9) Call for help when needed

(10) Maintain professional behavior (2011, p.102) (Appendix F)

The live simulations and participant performance was videotaped and used in debriefing and for the scoring of performance. For purposes of this study, an adapted version of the *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006) was used by the researcher in the evaluation of behaviors and performance demonstrated within the live neonatal resuscitation simulation scenarios (Appendix D). In efforts to maintain consistency, the evaluations and scoring were independently conducted with video analysis by the researcher and a second reviewer who is a NRP instructor. The second reviewer was trained on the purpose, use, and interpretation of the tool by the researcher prior to evaluation of study data. Documenting “Yes”= 2 points or “No”=0 points are the parameters in which each behavior and performance was analyzed for a simulation performance score. This researcher and the second reviewer scored three videoed simulations simultaneously for appropriate interpretation and application. Inter-rater reliability will be calculated in the evaluation of group simulation scores for congruency. Kappa values of 0.61-0.80 indicate substantial agreement and 0.81-1.0 indicate almost perfect or perfect agreement, therefore the highest level of substantial agreement would provide for conclusions to be made from the analyzed data (Hallgren, 2012).

Validity for NRP expert simulation scoring was calculated for interpretation of the obtained kappa value to the content validity score standard of 0.80 with the two reviewers, as stated above. This value was used as a guideline for consistency in the evaluation of live simulation performance.

Phase II- Intervention with Independent Computer-based Simulation

As stated above, the control group received live neonatal resuscitation simulations followed by debriefing and the delivery of a NRP clinical update at month 1. The intervention group consisted of participants who received the live neonatal resuscitation simulations, debriefing, and the additional educational modality of an independent computer-based simulation within month 1 of this study. The independent variable manipulated within this study was the delivery and completion of an independent computer-based simulation scenario by RNs that includes the concepts of airway, chest compressions, pulse oximetry, and communication. It was hypothesized that the integration of this additional independent computer-based simulation attempt will reinforce neonatal resuscitation knowledge, performance, and increase participant retention of behaviors used within these life-saving situations. This hypothesized outcome will be related to the independent variables of timely delivery of independent computer-based simulation and purposeful active learning of NRP content and skills.

The researcher provided an independent computer-based simulation module (eSim® practice case) to participants within the intervention group at month 1. This education module has been developed and reviewed by the NRP (2016), the American Academy of Pediatrics, and is part of the 7th edition NRP as a standard of practice. The NRP developed scenario (eSim® practice case) was used to deliver the computer-based simulation and for the conduction of the intervention group simulation phase of this study. The computer-based simulation (eSim® practice case) is aligned with NRP learning objectives, and provides RNs opportunities to practice and reinforce the foundational concepts pivotal to the initial of neonatal resuscitation. Through the NRP eSim® computer-based simulation participants were able to integrate the NRP algorithmic steps in a virtual environment starting with an equipment checklist and progressed through a clinical scenario with the use of avatars and photographs. Completion of the computer-based simulation eSim® provided participants an overview of the neonatal resuscitation concepts of airway, chest compressions, pulse oximetry, and communication

The independent computer-based simulation module and instructions were delivered to each participant by this researcher during their scheduled work hours. The eSim® practice case module was accessed by the researcher via the NRP website (www.aap.org/nrp) at the time of independent computer-based simulation with intervention group participants (month 1). This intervention delivery method provided the intervention group participant with access to this researcher for technology support during module completion and also provided this researcher the ability to validate that participants completed the learning module. Completion of the independent computer-based simulation module took approximately 10 minutes.

Phase III-Evaluation of Retention

Four months following the initiation of this study, the control and intervention groups were evaluated for performance and retention of skills with the live neonatal resuscitation simulation scenario provided in Phase I. This timeframe was identified in correlation to the literature stating that knowledge and skills have been shown to deteriorate within 3 to 8 months following a NRP course (Carbine, Finer, Knodel, & Rich, 2000; Curran, Aziz, Yound, & Bessell, 2004; Kaczorowski, Levitt, & Hammond, 1998; Patel & Posencheg, 2012;Weiner, Menghini, Zaichkin, Caid, Jacoby, & Simon, 2011).

The live simulations were approximately 10 minutes and the participant performance was videotaped and used in debriefing and for the scoring of performance. A modified version of the *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006), which focuses on the evaluation of the skills being evaluated in this study, was used for scoring simulation performance. The modified version of the *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006) was used by the researcher in the evaluation of behaviors and performance demonstrated within the live neonatal resuscitation simulation scenarios. In efforts to maintain consistency, the evaluations were again conducted with video analysis by the researcher and a second reviewer who is a NRP instructor. Inter-rater reliability was established following the same methods listed in Phase I data evaluation, with an inter-rater reliability guideline of 0.80 identified for conclusions to be made from the video reviewers analyzed data. The intra class correlation coefficient (ICC) was calculated in the evaluation of group simulation scores for congruency and discussed in Chapter 4.

Intervention fidelity strategies were utilized across all phases of this study according to NIH Treatment Fidelity Work Group recommendations to ensure treatment integrity, minimize experimental drift, and minimize contamination across groups (Bell, Borrelli, Resnick, et al., 2004). This researcher conducted the live simulations and debriefing to ensure treatment dose within and across conditions. The computer-based simulations were delivered in person to the intervention group at the specified time period for a set duration. Contact with both groups was equal in frequency and length. The same information reinforced in the computer-based simulation was presented to the control group and intervention group during live simulations and debriefing. Participation in the simulations and computer-based simulation was documented through researcher monitoring of participant status and progression within the study. If there were nurses who did not complete the computer-based simulation, they were to be treated by intention to treat analysis, but this did not occur across the duration of the study with the intervention group.

Table 1. Research Study Procedures

	Control Group	Intervention Group
Month 0: Delivery Live Simulation for Baseline Data	X	X
Month 1: Independent Computer-Based Simulation		X
Month 4: Delivery of Second Live Simulation Performance	X	X

Data Analysis

Data was coded, securely stored, and entered into SPSS statistical software package, Version 23 (SPSS, Chicago, IL.). All data was double checked for accuracy prior to the conduction of any statistical analysis. The obtained data was inspected, cleaned, and corrected if needed. Missing data, any patterns, and extreme observations was examined for prior to conducting the statistical analyses.

Data for each specific aim and hypothesis was analyzed with SPSS statistical software, Version 23 (SPSS, Chicago, IL). The level of significance for each specific aim analysis was set at $p \leq 0.05$.

All variables were summarized using descriptive statistics. Hypotheses were tested using a mixed effects model for each variable of performance and retention. Post hoc means were compared between groups in two time points respectively. Rater's reliability was assessed using an ICC and are discussed in Chapter 4 related to the results. A mixed effects model was identified in order to account for both fixed and random effects that may occur related to the study participants' experiences while also examining correlations which may occur within the study samples' subgroups (i.e. simulation groups of RN's).

A projected sample size of N=40 per group was used as an enrollment target for this study, which was to provide over 85% power to detect an effect size (ES) of 0.7. Oversampling by 10% (i.e. oversampling by approximately 8 total participants) was attempted in efforts to minimize the effects of attrition within this research study. The projected sample of N=40 per group (total N = 80) was unable to be achieved. Active participants enrollment in the study during Phase I and Phase II provided a sample of N = 36. Attrition accounted for a loss of 4 participants prior to the delivery of Phase III simulations, leaving a N=32, which is lower than expected resulting in the loss of statistical power and effect size. The control and the intervention group demographic characteristics are reported allowing consideration for potential attrition bias and its effects upon this study's outcomes.

The collected data from the adapted version of the *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006) was analyzed. Non-parametric Wilcoxon Rank Sum Test was used to validate the results from the parametric mixed effects models. This statistical test has been identified for use, as it does not assume symmetric population distribution among sample sets (i.e. experience and area of perinatal RN practice). Furthermore, the Wilcoxon Rank Sum Test allows for the data to be observed as group ranks versus direct individual participant measurements.

Assumptions and Limitations

Assumptions

1. The NRP accurately addresses the constructs of knowledge and skills required in neonatal resuscitation.
2. The researcher was able to assess participant behavior and performance in live clinical simulations with use of the adapted simulation assessment tool.

Limitations

1. A non-probability, homogeneous, convenience sample was used in this study.
2. A modified instrument, which has limited prior psychometric data published, measures the characteristics of neonatal resuscitation simulation performance.
3. RN neonatal resuscitation knowledge is maintained at 4 months following completion of the live simulation and self-study of the NRP by the RNs.

The three limitations outlined for this study were considered to be acceptable due to the purpose of the research being an examination of retention and performance of neonatal resuscitation skills. A homogeneous sample was selected for the purpose of generalizability, as characteristics of perinatal nurse populations and experience will vary. To date, no evidence exists related to the effects of the 7^{th} edition NRP on performance and retention of behaviors and resuscitation skills as evidenced in clinical simulations nor on the effects of an independent computer-based simulation of these same constructs of RN performance and retention. This research has the potential to guide future neonatal resuscitation program simulation utilization and adaptations related to frequency and delivery approaches of the NRP.

Summary

This study explored the effects of independent computer-based simulation on neonatal resuscitation skills. The methods and procedures proposed for the development, validation, and use of the adapted simulation assessment tool have been described. Content Validity Indexes (CVIs) the tools were established with the responses of the expert panel participants and are discussed in Chapter 4. The adapted tool was used in order to quantify simulation scenario behaviors, skills, and retention. The methods and procedures discussing the implementation and analysis of the study have been described. The self-report survey and simulation scenarios used for data analysis were conducted with a group of perinatal RNs.

This study explored the effects of an independent computer-based simulation intervention on the performance and retention of skills in neonatal resuscitation. The performance and retention of skills evaluation occurred with an instrument that was adapted for use as part of this study. This research measured RN behaviors and skills in live neonatal simulation scenarios; provided an independent computer-based simulation education intervention with the intervention group and a NRP clinical update document was provided to the control group at month 1; and a measurement of RN behaviors and skills were repeated again at 4 months post the initiation of this study. This study aimed to examine: (1) the effect of the revised 7th edition NRP on participant skill performance and retention as measured in a baseline simulation scenario and repeated again at month 4; (2) the effect of independent computer-based simulation on neonatal resuscitation skill performance and retention. This research was conducted as a study in efforts to add to the body of knowledge associated with simulation in professional nursing education within the acute care environment. This study aimed to increase retention and nurse performance in the delivery of safe and evidence based neonatal resuscitation practices.

CHAPTER IV

Analysis and Results

This chapter describes the analysis of data that was used to explore the effects of an independent computer-based simulation on neonatal resuscitation skills focusing on the pivotal components of life-saving neonatal care including airway, chest compressions, pulse oximetry, and communication in these low frequency, high crisis situations. The NRP 7th edition revision and inclusion of independent computer-based simulation required the nursing profession to explore participant outcomes including behaviors, skill performance, retention, and the effect of this additional online learning approach to the previous NRP education strategies related to emergent neonatal care. In this chapter, details of the participant descriptive characteristics, organization of data for analysis, research questions and their associated statistical analyses, and tables/figures related to this study's findings, are discussed below.

Presentation of Descriptive Characteristics of the Participants

A convenience sample of registered nurses (RNs) who are employed at a Mid-Western hospital were invited to participate in this study. The participants included RNs who were employees of a family birth center model of patient care of labor and delivery, mother/baby, and level 2 special care nursery services (N = 32). Descriptive data were obtained from all participants via self-report (Appendix C) which included level of participant education, area of perinatal nursing practice, number of times having taken the NRP training, and the number of neonatal resuscitation events participated in within the last 24 months.

The convenience sample size of participants in this study was originally *N* = 36 (18 per each group) at the time of Phase I (Baseline) and Phase II (Intervention). A sample size of *N* = 80 (40 per group) was initially projected in order to provide over 85% power to detect an effect size (ES) of 0.7. Despite enrollment efforts, this projected sample size was unable to be achieved due to a decrease in the total number of RNs employed on the unit at the study site, organization level budget changes which impacted RN daily staffing numbers, and also a higher than expected number of RNs declining to participate in this study. At Phase III (Evaluation of Retention) the total number of participants was *N* = 32 (Control = 15; Intervention = 17). Attrition accounted for the loss of 4 participants with 2 withdrawing and 2 unavailable to complete Phase III due to personal health reasons.

The age range of RN participants in this study were age 22 to 65. All participants in this study were female RNs that held the employment status of full-time (*N* = 21), part-time (*N* = 8), or optional work time (*N* = 3). The participants had varying levels of education preparation, perinatal area of practice, and NRP experience, as identified by the Participant Survey (Appendix C). Of the 32 participants who completed the study, 25% (*N* = 8) identified their level of education as Associate Degree (ADN or equivalent); 65.6% (*N* = 21) identified their level of education as Bachelors of Science in Nursing (BSN); and 9.3% (*N* = 3) identified their level of education at graduate level with a Masters of Science in Nursing (MSN) degree as noted in Table 2.

The model of nursing care at the study site is structured in a manner that permits RNs to practice across the various units of the Family Birth Center. Based upon the study site's nursing care model, participants are trained to work at minimum in one area of practice, while other participants are trained to care for patients across two, and in some instances, three areas of perinatal nursing practice (Labor and Delivery (L&D), Mom/Baby, Special Care Nursery (SCN)). Participants identified their area(s) of nursing practice in the Participant Survey as L&D, Mom/Baby, and/or SCN (Appendix C). Within this study's sample population, 75% (*N* = 24) identified at least one of their areas of practice to be L&D; 68.8% (*N* = 22) identified at least one of their areas of practice to be Mom/Baby; and 43.8% (*N* = 14) identified at least one of their areas of practice to be SCN/Level II NICU. This demographic characteristic was obtained in order to understand the participant background level of workplace experience in resuscitation of a neonate and is noted in Table 2.

As a study requirement, all participants in the study had previously completed the NRP at a minimum of one time within the last two years. In the hospital setting, the NRP course is an employment requirement in which training occurs at time of new hire, if needed, followed by a bi-annual basis for individuals involved in neonatal care. In efforts to assess participant level of exposure, training, and experience to the NRP course content and the application into practice, participants identified the number of times the NRP course had been taken in their career and resuscitation exposure in their clinical practice. A majority of participants, 65.6% (*N* = 21) identified that that they had taken the

NRP course more than 5 times in their career (indicating approximately 10 years or more experience in this nursing specialty area). In addition, 50% indicated they had performed 5-10 resuscitations and 21.9% indicated they had participated in greater than 10 resuscitations in the last 24 months.

Participant demographics data and group distribution demonstrated below in Table 2.

Table 2. Baseline Characteristics of Participants (N = 32)				
Characteristics	**Category**	**No. (%)**	**Control No. (%)**	**Intervention No. (%)**
Level of Education	ADN	8 (25%)	4 (12.5%)	4 (12.5%)
	BSN	21 (65.6%)	9 (28.1%)	12 (37.5%)
	MSN	3 (9.3%)	2 (6.3%)	1 (3.1%)
Practice Area	L&D RN	24 (75%)	12 (37.5%)	12 (37.5%)
	Mom/Baby RN	22 (68.8%)	10 (31.3%)	12 (37.5%)
	SCN	14 (43.8%)	7 (21.9%)	7 (21.9%)
NRP Experience	1-3 times	6 (18.8%)	2 (6.3%)	4 (12.5%)
	3-5 times	5 (15.6%)	3 (9.4%)	2 (6.3%)
	≥ 5 times	21 (65.6%)	10 (31.3%)	11 (34.4%)
Resuscitations (last 24 months)	None	1 (3.1%)	0 (0%)	1 (3.1%)
	0-4	8 (25%)	3 (9.4%)	5 (15.6%)
	5-10	16 (50%)	6 (18.8%)	10 (31.3%)
	≥ 10	7 (21.9%)	6 (18.8%)	1 (3.1%)
ADN = Associate Degree; BSN = Bachelors Degree; MSN = Masters Degree				
Practice Area totals are greater than 100% due to RNs practicing in 1-3 areas				

Organization of Data Analysis

Data obtained during this study included a participant survey (Appendix C), and Phase I Baseline Simulation score followed by Phase III Evaluation of Retention Simulation score using a modified version of the *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, et al., 2006) (Appendix D). The participant survey data were coded, securely stored, and entered into SPSS statistical software package (SPSS, Chicago, IL.). This process allowed for analysis of the descriptive characteristics of the RN convenience sample.

Instrument

An adapted version of the *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, et al., 2006) was used in the evaluation of participant simulation performance. Prior to being used in the scoring of this study's simulations, the adapted tool was reviewed by 4 NRP experts for content validity, (Appendix A). Evaluation of these findings found a mean I-CVI of 1.0 for the modified tool, indicating that the items within the tool are highly relevant to the evaluation of neonatal resuscitation performance (Polit & Beck, 2006). These findings are consistent with the psychometrics of the original tool reported as follows: face/content validity; ICC of 0.95 and 0.77 for intra- and inter-rater reliability; median percentage of intra-rater agreement was 100%; inter-rater agreement 78.6-84.0%; median kappa was 0.85 for intra-rater reliability; and 0.42-0.59 for inter-rater reliability (Heide et al, 2006; Clary-Muronda & Pope, 2017).

Simulation Data and Analysis

Simulation videos were uploaded to a secure, password protected, University of Cincinnati BOX account research folder. Two NRP expert reviewers, who are perinatal nurse educators and NRP instructors, were identified to perform the simulation evaluations. The reviewers were from across the state and identified through a nursing professional practice organization, the Association of Women's Health, Obstetrics, and Neonatal Nurses (AWHONN), and are perinatal nurse colleagues. The expert reviewers had no affiliation (personal or workplace) with the study participants. The identified expert reviewers were enrolled as users of the secure BOX account file where the videos were stored and the link to the file was provided to the reviewers at the time of training. The training was conducted via Internet based meeting software between the experts and the researcher in a 1:1 live training format. The experts received training on tool application and use by this researcher. Video reviewer comprehension of application and interpretation of the tool was validated via three video reviews conducted with this researcher and the expert for corresponding interpretation. Education on tool application included the identification of key behaviors to assess for during the simulation, tool constructs and language. Training included viewing and scoring of three simulations by the experts simultaneously with the researcher. During the simulation scoring training sessions, opportunities for questions and feedback related to the application of the tool was provided. Each NRP expert was provided with the researcher's contact information (email and phone number) to use as needed in the event of questions.

The adapted tool, resulting from this review and refinement, includes the concepts of group function, preparation and initial steps, communication, oxygen administration, ventilation, chest compressions, and a total score. The data obtained using the modified *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, et al., 2006) was aligned with the appropriate participant identification number and transferred into an excel spreadsheet. The excel spreadsheet included participant identification number, study group, simulation group number, and the each reviewer's participant score on the concepts of group function, preparation and initial steps, communication, oxygen administration, ventilation, chest compressions, and a total score as calculated by each of the expert reviewers. This data organization process allowed for information to be uploaded into SPSS statistical software (SPSS, Chicago, IL) for data analysis.

The data analysis outcomes to be presented compare the control group to the intervention group at Phase I Baseline Simulation and Phase III Evaluation of Retention Simulation time points of this study. The tool identified simulation performance total score and scores on the concepts of group function, preparation and initial steps, communication, oxygen administration, ventilation, and chest compressions, used to answer the research questions.

Analysis of Data

The purpose of this study was to examine the examine the effects of adding independent computer-based neonatal resuscitation simulation to NRP simulations when examining participant performance of required NRP behaviors which are used by perinatal nurses in lifesaving neonatal care.

An evaluation of differences between the control group and the intervention group on the concepts identified in the research questions below have been analyzed using SPSS statistical software, Version 23 (SPSS, Chicago, IL). A Comparison of Means, Independent Samples T-test were calculated using the data sets obtained from two NRP expert reviewers on participant simulation performance conducted during Phase I (Baseline) and Phase III (Evaluation of Retention).

Results

Each required NRP behavior of the participants was evaluated with a total performance score and separate NRP construct scores. These values were obtained during the simulations at Phase I and Phase III of this study. The data has been evaluated among and between the control and intervention groups for variances and statistical significance.

Research question 1, corresponding hypothesis, and the findings are as follows:

Research Question 1: Are there differences in the three-month retention and performance of NRP concepts of airway, chest compressions, pulse oximetry, and communication between participants who receive self-study, live NRP simulations, and a NRP clinical update compared to those who receive self-study, live NRP simulations, and an independent computer-based neonatal resuscitation simulation experience?

Hypothesis 1: RNs who receive the NRP self-study, live simulations, and an independent computer-based neonatal resuscitation simulation experience will have increased retention compared to the control group on the NRP concepts of airway, chest compressions, pulse oximetry, and communication when measured at month 4.

Total Score Performance

The total performance score was used in the evaluation of overall retention of NRP concepts in the control and intervention groups. This score was calculated using the adapted *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, et al., 2006). The total score was analyzed using a mixed effect model to compare means of total performance score cross-sectionally between the control group and the intervention group at Phase I and Phase III respectively; and longitudinally between Phase I and Phase III in each of the groups. Table 3 summarized the results of the statistical analysis for the study groups related to simulation performance total score. Overall interpretation is that the intervention groups showed no sign of significant impact either longitudinally or cross-sectionally.

In the evaluation of neonatal resuscitation total score (100 summative points available), the control group (*N = 15*) showed sample means (*M)* and (standard deviations or SD's) of performance scores 70.94 (13.74), 73.13 (10.93) at Phase I and Phase III respectively. The *M*'s (SD's) of performance score were *M* = 78.94 (9.74) and 78.77 (10.64) respectively in the intervention group (*N = 17*). The differences were not statistically significant in either the cross sectional or longitudinal comparisons (Table 3). The change of the total performance score was (*M* = -1.06, SD = 12.2) in the intervention group and (*M* = -1.73, SD = 13.10) in the control group and the difference was not significant between groups ($p = 0.881$). These results suggest that the addition of the independent computer-based simulation to neonatal resuscitation education does not have a statistically significant effect on overall neonatal resuscitation performance. Although the intervention group findings were not found to be statistically significant, the mean values of the intervention group did not decline and remained constant at the assessment time points of this study.

An independent samples, Mann-Whitney U Test was used as a back-up test to the mixed effects model when cross sectional comparisons were tested. Table 3 showed no difference of conclusion using the mixed effect model and the Mann-Whitney U Test.

Fair to good inter-rater agreement was calculated between raters at both Phase I and Phase III using ICC (95% CI). In particular, the ICC (95% CI) was 74.9% (61.3%, 88.5%) at Phase I and 63.3% (44.2%, 82.5%) at Phase III respectively.

Table 3. Simulation Performance Total Score						
Total Score	**Group**	**Phase I (Mean ± SD)**	**Phase III (Mean ± SD)**	**Change (Mean ± SD)**	***p*-value**
	Control	70.94±13.74	73.13±10.93	-1.73±13.10	0.616
	Intervention	78.94±9.74	78.77±10.64	-1.06±12.25	0.726
	***p*-value	0.052	0.15	0.881	
Mann Whitney p1=0.006/p2=0.105/p3=0.628					
Phase I=Baseline simulation score; Phase III= Follow up simulation score					
**p*-value=Phase I & Phase III comparison of means of each study group					
***p*-value= Comparison of means between study groups					
*All statistical analyses were conducted with CI 95% ($p \leq .05$)					

Research question 2, corresponding hypothesis, and the findings are as follows:

Research Question 2: Are there differences in the application of NRP concepts of airway, chest compressions, pulse oximetry, and communication between participants who receive self-study, live NRP simulations, and a NRP clinical update compared to those who receive self-study, live NRP simulations, and an independent computer-based neonatal resuscitation simulation experience?

Hypothesis 2: RNs who receive the NRP self-study, live simulations, and an independent computer-based neonatal resuscitation simulation experience will have increased performance compared to the control group on the NRP concepts of airway, chest compressions, pulse oximetry, and communication when measured at month 4.

Neonatal Resuscitation Concepts

The adapted *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, et al., 2006) was used in the evaluation of application related to airway, chest compressions, pulse oximetry, and communication. The tool concepts of group function, preparation, communication, oxygen administration, ventilation, and chest compressions are calculated individually and then summarized to obtain a performance total score. Each neonatal resuscitation concept score was analyzed using a mixed effect model, similar to that of the total performance score. Evaluation of each concept showed no sign of significant impact longitudinally or cross-sectionally. Results are summarized in Table 4.

Performance in the concepts of ventilation and chest compressions are vital to resuscitation efforts and integrates each of the concepts being explored in this study. This importance translates into these two concepts being weighted the highest in the identified scoring tool. Related to ventilation (30 points available), the control group (*N = 15*) showed sample means (*M*) (standard deviations or SD's) of 21 (4.72), 24.2 (4.60) at Phase I and Phase III respectively. The *M*'s (SD's) of ventilation were 22.67 (6.33) and 22.94 (5.61) respectively in the intervention group (*N = 17*). The differences were not statistically significant in either the cross sectional or longitudinal comparisons (Table 4). The change in ventilation scores was (*M* = -0.29, SD = 7.36) in the intervention group and (*M* = 2.0, SD = 6.18) in the control group. The difference was not significant between groups ($p = 0.351$).

The highest weighed concept on the tool is chest compressions (36 points available). The *M*'s (SD's) of chest compression performance in the control group were 23.83 (5.77) and 21.6 (11.41) at Phase I and Phase III respectively. In comparison, the intervention group *M*'s (SDs) were 27.83 (4.69) and 28.76 (5.62) respectively. Again, the differences in chest compression performance were not statistically significant in either the cross sectional or longitudinal comparisons (Table 4). The change in chest compression scores was (M = 0.53, SD = 6.81) in the intervention group and (M = -3.80, SD = 12.13) in the control group. The overall difference between the two groups was not statistically significant (p = 0.216).

Table 4. Simulation Performance Concept Scores					
Simulation Performance Concepts	**Group**	**Phase I**	**Phase III**	**Change (Mean ± SD)**	***p*-value**
Group Function	Control	7.61±1.75	7.73±1.22	-0.333±1.59	.430
	Interv.	8.17±0.38	7.41±1.77	-0.77±1.75	.091
	p Value	.198	.560	.473	
Preparation	Control	10.67±2.35	10.93±1.33	-0.40±1.55	.334
	Interv.	11.5±1.54	11.53±0.86	-0.06±1.94	.902
	p Value	.217	.138	.590	
Communication	Control	3.67±0.59	3.53±1.13	-0.27±1.28	.433
	Interv.	3.78±0.43	3.88±0.49	0.12±0.70	.495
	p Value	.524	.254	.292	
Oxygen Administration	Control	4.5±1.43	5.13±0.35	0.27±1.33	.451
	Interv.	5±0.84	4.24±1.3	-0.77±1.20	.018
	p Value	.208	.150	.028	
Ventilation	Control	21±4.72	24.2±4.60	2.0±6.18	.230
	Interv.	22.67±6.33	22.94±5.61	-0.29±7.36	.871
	p Value	.377	.496	.351	
Chest Compressions	Control	23.83±5.77	21.6±11.41	-3.80±12.13	.245
	Interv.	27.83±4.69	28.76±5.62	0.53±6.81	.753
	p Value	.029	.029	.216	
Phase I= Baseline Simulation Score; Phase III=Follow up simulation score					
Interv.= Intervention Group					
*p-value = Phase I & Phase III comparison of means					
*All statistically analyses were conducted with CI 95% ($p \leq .05$)					

Intervention Group Demographics and Performance Scores

Intervention group data were analyzed using a Means test to compare the total score mean change values from Phase I to Phase III to each of their demographic characteristics (CI interval at 95%; $p \leq .05$). This information is demonstrated in Table 5. Based upon the data analysis, there was no statistical significance in Phase III total score performance for intervention group RNs who also have experience with neonatal resuscitation in clinical practice.

Though not statistically significant, experience with the NRP 3-5 times (M = -4.25, SD = 3.89) and NRP greater than 5 times (M = -1.09, SD = 14.02) noted a numerical decrease in overall performance; as did those intervention group participants identified as participating in neonatal resuscitation 5-10 times in recent clinical practice (M = -2.8, SD = 14.31). A trend in decreased numerical performance in the intervention group was also noted in individuals identified as Mom/Baby RNs (*M* = -2.91, SD = 13.68) and not L&D RNs (*M* = -5.5, SD = 19.12). Conversely, intervention group individuals with ADN education background (*N* =4) had an increase in their total performance score (*M* = 5.75, SD = 5.62) and individuals with a BSN education (*N* = 12) had numerical increases as well (*M* = 2.83, SD = 13.65). Though the ADN sample was small, the overall improvement in this demographic of the intervention group on total performance score is notable. Evaluation of intervention group total score performance and demographic data is demonstrated below in Table 5.

Table 5. Intervention Group Characteristics & Total Score Mean Change

Group Characteristics		N	Total Score Mean ± SD	*p*-value
Degree	ADN	4	5.75±5.62	0.133
	BSN	12	2.83±13.65	0.487
	MSN	1	N/A	N/A
L&D RN	No	5	-5.5±19.12	0.555
	Yes	12	0.79±8.53	0.754
Mom/Baby RN	No	5	3.4±7.13	0.346
	Yes	12	-2.91±13.68	0.476
SCN RN	No	10	-1.55±14.99	0.751
	Yes	7	-0.357±7.90	0.909
NRP Experience	1-3 times	4	0.63±11.41	0.919
	3-5 times	2	-4.25±3.89	0.366
	≥ 5 times	11	-1.09±14.02	0.802
Resuscitations (last 24 months)	None	1	N/A	N/A
	0-4	5	0.8±9.57	0.861
	5-10	10	-2.8±14.31	0.551
	≥ 10	1	N/A	N/A

ADN= Associate; BSN= Bachelors; MSN=Masters

L&D= Labor & Delivery; SCN= Special Care Nursery

All statistical analyses were conducted with CI 95% ($p \leq .05$)

Summary

Data analysis was conducted on the participant performance scores in neonatal resuscitation simulations across two time points of this study (Phase I Baseline and Phase III Evaluation). The data obtained provided an approach to evaluate the effect of independent computer-based simulation on participant neonatal resuscitation application of skills, such as airway, chest compressions, pulse oximetry, communication, and retention of neonatal resuscitation skills across this study. In a comparison of control and intervention groups on total score performance, the intervention of independent computer-based simulation demonstrated no statistical significance as evidenced by the total performance scores remaining numerically similar across Phase I baseline (M = 78.94, SD = 9.74) and Phase III evaluation (M = 78.77, SD = 10.64). The intervention group findings on application of the neonatal resuscitation concepts of group function, preparation, communication, oxygen administration, ventilation, and chest compressions yielded similar non-statistically significant results. Based upon the analysis conducted in this study, there was not a measurable effect of the impact of independent computer-based simulation on performance or retention of neonatal resuscitation within the study participants.

Interpretation of the data analysis presented in this chapter will be presented in the following chapter. Chapter 5 will provide a discussion related to the findings, conclusions, implications, and recommendations for future research.

CHAPTER V

Findings, Conclusions, and Implications

On an annual basis almost 1 million babies die across the world due to birth asphyxia (American Academy of Pediatrics, 2011; World Health Organization 2015). In the United States, 400,000 infants will require assistance with breathing and approximately 40,000 infants will require extensive resuscitative measures (Centers for Disease Control, 2011). Performing neonatal resuscitation accurately and efficiently is critical to saving these infants' lives. Integrating various simulation-based opportunities, including independent computer based simulation, into the adult learning environment provides an approach to assist nurses and other neonatal health care professionals become an active participant with the experiential development, application, and maintenance of their neonatal resuscitation knowledge, skills, and behaviors (American Academy of Pediatrics, 2016; American Academy of Pediatrics, 2011; Jefferies, 2007; Yaeger & Arafeh, 2008). Repeated education on the neonatal skills of airway, chest compressions, pulse oximetry, and communication can assist in providing care for neonates in resuscitation situations. The perinatal nurse and health care delivery team must continually maintain competence in order to rapidly and accurately assess, recollect, act, and analyze the lifesaving interventions needed for the significantly compromised neonatal patient. In efforts to address this education training need, the purpose of this study was to examine the effects of adding independent computer-based neonatal resuscitation simulation to current NRP live simulations when examining participant knowledge and performance of required NRP behaviors which are used by perinatal nurses in lifesaving neonatal patient care.

Methodology

A quasi-experimental longitudinal pre-test post-test design was used to test the effect of independent computer based simulation on neonatal resuscitation skills in a convenience sample of 32 perinatal RNs. The RN participants were randomly assigned by computer software to either the control or intervention group. The hypotheses were as follows:

1. RNs who receive the NRP self study, live simulations, and an independent computer based neonatal resuscitation simulation experience will have increased retention compared to the control group on the NRP concepts of airway, chest compressions, pulse oximetry, and communication when measured at month 4.
2. RNs who receive the NRP self study, live simulations, and an independent computer based neonatal resuscitation simulation experience will have increased performance compared to the control group on the NRP concepts of airway, chest compressions, pulse oximetry, and communication when measured at month 4.

The intervention group of 17 perinatal RNs participated in simulation based neonatal resuscitation interventions, including live high fidelity simulation at two time points in this study and the delivery of an independent computer based simulation (eSim® practice case). The control group contained 15 perinatal RNs that received live high fidelity simulations at two time points in this study and a NRP clinical update flyer. Administration of live high fidelity simulations occurred during Phase I (Baseline) and Phase III (Evaluation) in both the control and intervention group. The simulations occurred in a labor and delivery room at the study site. The live simulations were conducted with the use of Laderal developed SimNewB® manikin. This high fidelity newborn simulator was developed for the American Academy of Pediatrics to meet the resuscitation training needs of neonatal emergencies (www.laderal.com). The SimNewB® simulated color change, chest rise, heart rate and respirations for auscultation, vital signs including pulse oximeter readings (which were visible on the bedside monitor when its use was initiated by simulation participants), neonatal movement, and respiratory sounds such as grunting and crying. The SimNewB® response progressed in coordination with participant simulation performance. The simulation scenario (Appendix E) was read to participants at the initiation of the live simulations during Phase I and Phase III. Each of the live simulations lasted approximately 10 minutes and was followed by debriefing. Debriefing included participant self directed discussion and personal reflection about skills and behaviors completed correctly in the simulation and opportunities for improvement. This researcher facilitated the debriefing further to include participant personal reflection and group discussion related to each of the concepts evaluated in the performance scoring tool (Appendix D). In the majority of the debriefing sessions the content discussed included ventilation assessment of chest rise and corrective steps including mask adjustment, repositioning of the airway, suctioning, peak inspiratory pressure (PIP) increase, and alternate airway placement (laryngeal mask). Other content frequently discussed during debriefing included ventilation ratio with and without chest compressions, the need to increase the FiO2 to 100% with the initiation of chest compressions, and the use of the pulse oximeter reading to guide ventilation clinical decisions.

The simulations were videoed and scored using the adapted *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006). The tool has psychometrics described in the literature as having face and content validity; ICC of 0.95 and 0.77 for intra- and inter-rater reliability; median percentage of intra-rater agreement was 100%; inter-rater agreement 78.6-84.0%; median kappa was 0.85 for intra-rater reliability; and 0.42-0.59 for inter-rater reliability (Heide et al, 2006; Clary-Muronda & Pope, 2017). Four NRP instructors reviewed the adapted tool used in this study with universal agreement (I-CVI = 1.0) related to content validity and applicability of this tool in the evaluation of simulation performance (Appendix A). Reliability findings of this study indicated fair to good inter-rater agreement calculated between raters at both Phase I and Phase III using ICC (95% CI). In particular, the ICC (95% CI) was 74.9% (61.3%, 88.5%) at Phase I and 63.3% (44.2%, 82.5%) at Phase III respectively.

Findings

The two hypotheses from this study were rejected using mixed effect models to compare means. Total neonatal resuscitation performance scores were found to not be statistically significantly among and between study groups in the evaluation of simulation performance with the mean performance scores remaining relatively unchanged between Phase I and Phase III. The mean total performance scores following Phase III of this study were 73% for the control group and 78% for the intervention group, which is comparable to the error rate of 23% reported by Yamada et al. (2015). The findings did show that performance scores remained relatively constant with knowledge and skill performance retained between both simulation assessment points without additional decline leading to the interpretation that the additional simulation experiences (live simulations and computer based) did not negatively impact resuscitation performance. These findings are complimentary to the literature which has found that knowledge and skills deteriorate between 3 to 8 months following NRP training, which is noted in the performance scores found in this study (Carbine, Finer, Knodel, & Rich, 2000; Curran, Aziz, Yound, & Bessell, 2004; Kaczorowski, Levitt, Hammond, Outerbridge, Grad, & Rothman, 1998; Patel, Posencheg, & Ades, 2012; Weiner, Menghini, Zaichkin, Caid, Jacoby, & Simon, 2011).

Similar findings, all of which were not statistically significant, were found in the evaluation of participant performance on the concepts of group function, preparation, communication, oxygen administration, ventilation, and chest compressions. Based upon these statistical analyses, the independent computer based simulation was not a strong enough intervention to increase neonatal resuscitation performance in the simulated environment among the RN intervention group. While the use of computer-based simulations does provide an opportunity to augment the delivery of training, its overall impact on knowledge and retention has outcomes ranging from equivalent to significantly higher reported in the literature (Cant & Cooper, 2014).

Errors in the ability to accurately assess heart rate, delays and ineffective airway management, irregular adherence to NRP algorithm, and situational time awareness are examples of training improvement needs in the majority of subjects. These concepts were not impacted by the independent computer-based simulation and are representative of the most common skills not effectively administered during a neonatal resuscitation (Chitkara, Rajani, Oehlert, Lee, Epi, Halamek, 2013; Fuerch et al, 2015; Mitchell, Niday, Boulton, Chance, Dulberg, 2002; Yamada et al., 2015).

Application of ELT

The application of Experiential Learning Theory (ELT) was well conceptualized within this study through the delivery of high fidelity of simulation providing participants with tangible qualities involving the initial application of resuscitation skills (Concrete Experience), reflecting upon other participant performance in the simulation experience (Reflective Observation), followed by debriefing about individual and group performance (Abstract Conceptualization), and a subsequent delivery of a high fidelity simulation across the identified time points of this study (Active Experimentation) (Kolb, 1984). The intervention group received an additional dose of experiential learning through participation and completion of the independent computer based simulation, providing a supplemental opportunity for engagement through the experiential learning process. Despite participation in this study's experiential learning simulation activities of live simulations and the independent computer based simulation; the results did not show a performance difference between the control and intervention groups.

Interpretation of these findings related to ELT should be considered from a different perspective. The RN participants had previous experience with the NRP throughout their careers, therefore experiences and application of the prior NRP guidelines may have been more readily available for retrieval in their cognitive processing during the simulated emergent situation. These individuals have moved through the experiential learning cycle repetitively over their years in practice as a perinatal nurse. Movement through the four ELT concepts across time has lead the learner toward a deeper level of analysis and synthesis (Kolb, 1984); thus requiring new and updated experiential learning opportunities to be strong and perceived as meaningful to the participant in order to achieve an impact. This perspective signals the importance to develop repetitive and valuable learning experiences from which the advanced learner is able to re-learn needed skills for application and the novice gain the required knowledge, skills, and behaviors for application into clinical practice. Providing repetitive, valuable, and situation applicable learning opportunities will engage the emotions of the learner, fostering integration of the new information into their existing knowledge (Bell et al., 2008). Examination of workflow processes for areas of communication and performance breakdown will immerse the learner in the new knowledge application from the problem-solving perspective. The problem solving approach to learning can promote deeper learning through the development of revised workflow processes and may be perceived as extremely valuable to their current clinical practice.

Validity and Threats

Validity of the adapted *Scoring Tool for Adherence to Neonatal Resuscitation Guidelines* (Heide, Toledo-Eppinga, Heide, & Lee, 2006) should be considered for its potential threat to simulation performance scores. During expert training for data analysis, it was discovered that the tool's language needed clarification with expert reviewers. The tool contained three items for evaluation that started with the term "appropriate decision making". Concept definitions and directions for interpretation and evaluation of "appropriate decision making" in scoring simulation performance were provided to each reviewer during training. For example, "appropriate decision making" related to oxygenation was defined as the integration of pulse oximeter readings into the delivery of FiO2 oxygen percentages related to the neonate's minutes of life following birth; ventilation was defined as the application of corrective ventilation steps that included the concepts listed on the tool, correct assessment, and application of corrective steps "MR SOPA": mask adjustment, reposition head, suction mouth and nose, open mouth, increase pressure, consider alternative airway (Appendix E, No. 6); and for chest compressions appropriate decision making included HR < 60 and increasing the FiO2 percentage to 100% at the initiation of chest compressions. These concept definitions and frequent questions surrounding how to score and evaluate for these tasks in the simulations highlighted the need for the tool to be updated related to 7th edition NRP recommendations (Clary-Muronda & Pope, 2016). The expert reviewers individual observations and application of the tool constructs in their assessment of neonatal resuscitation skills may have also impacted participant evaluation scores, along with infrequent issues in video review such as the occasional difficulty in viewing the delivery of skills in the video simulations.

Across the time span of this study, other confounding variables emerged such as availability of RNs on work time to complete and participate in the study. These issues included a higher than expected level of RNs being cancelled/placed on call during their scheduled workday due to low obstetric/neonatal patient census levels. Another consideration is that obstetric and neonatal emergent situations arose, above those that historically occur, during the same time frame of this study, potentially resulting in elevated levels of moral distress and fatigue in the RN participants of the study related to resuscitation care.

Strengths and Limitations

Strengths of this study include the longitudinal design allowing for prospective analysis of findings. The design provided consistent delivery of the assessments and interventions (live and computer based simulations) and researcher control over the type of data obtained for evaluation. In addition, this study a provided a quantitative analysis of neonatal resuscitation performance in the simulated setting. From this process and data analysis, improvements to the delivery of emergent neonatal resuscitation care and future training on neonatal resuscitation can be made.

There were several possible limitations to the study findings. The most significant limitation was a small sample size that precludes any statistical analysis of the results. At the onset of this study, a sample size of 80 participants (40 in each study group) was predicted which would have provided a moderate effect size of 0.5. The actual participant enrollment in this study was N = 32. The higher than predicted level of RNs declining to participate in the study diminished statistical power and generalizability of findings to other settings.

Simulation group size of three RN participants per simulation may be a limitation of the study. During the simulations participants would initiate the organization specific verbal prompt for additional members of a neonatal code team to attend and request for a neonatologist to be called to the bedside or available by phone. The non-interdisciplinary dynamic may have impacted the overall performance scores. The RN participants were limited in their available airway management resources to those within their scope of practice. These resources included positive pressure ventilation with facemask and a laryngeal mask airway as opposed to endotracheal tube placement for intubation that is a skill provided by a physician or neonatal nurse practitioner. Despite being non-interdisciplinary, the simulations were successful in requiring the study participants to engage in focused neonatal resuscitation clinical decision-making and management of the neonatal airway.

Implications

In the process of delivering the independent computer based simulation (eSim® practice case) it was recognized that the initiation of this computer simulation created a sense of hesitancy in the RN participants. The hesitancy was related to their personal ability to effectively navigate and use the computer-based simulation (eSim® practice case). Participants consistently stated they were not acclimated to completing neonatal resuscitation skills (or any other skills) in the computer-based format. Other hesitancies expressed from a small majority of participants included verbalization of a recent negative learning experience and prior barriers to completing a similar computer-based resuscitation simulation program. These become antecedents to the ability to have future positive experiences with computer-based simulation activities. Participant engagement in the intervention activity became focused on the technology and prior negative experiences with completing tasks on a computer or tablet. In efforts to deflect these emotions and prior experiences, collaborative learning opportunities need to be provided. For optimal learning to evolve during the computer-based simulation process, individuals need to have the opportunity to communicate, mentor, and assist one another in the learning process. This can be achieved through face-to-face feedback on performance (i.e. software navigation techniques and skill performance), providing support for learners as they navigate through potential Internet operational barriers (i.e. accessing the Internet site and required Internet speed), and by ensuring that a resource person (proficient with the required computer simulation technology) is present to facilitate the forum. Through collaborative learning opportunities, individuals are given the opportunity to develop positive experiences and emotions related to the computer simulation education modality; thus facilitating engagement of the adult learner through the social interaction perspective of the experiential learning processes. Social interaction and group learning have favorable outcomes of improved process skill development and satisfaction recognized within the literature (Bell et al., 2008; Mundell et al., 2013); therefore collaborative opportunities need to be provided as an option for individuals in their navigation and completion of independent computer-based simulations, especially those that are required for employment.

While this study did not demonstrate a statistically significant increase in participant improvement from the simulation opportunities provided in this study, it did provide a depiction of the skills which were performed well; and inversely the pivotal concepts of ventilation and chest compressions which require improvement related to the delivery of care in neonatal resuscitation. This is a valuable contribution to this area of practice, as healthcare has a limited understanding of the types of errors that occur during neonatal resuscitation (Yamada et al., 2015). The identification of specific concepts requiring educational reinforcement can result in tailored skill and simulation programs (hands on and independent computer based) to promote the effective delivery of neonatal resuscitation based care. Optimal spacing intervals for the delivery of educational reinforcement to keep concepts in the working memory for retrieval has yet to be identified within the literature. Individuals vary in their learning needs and are dependent on exposure within their clinical practice settings. What has been established is that knowledge deterioration has been shown to begin to deteriorate immediately following training with measureable effects in the 3 to 8 months following the completion of a NRP course (Patel, et al., 2012; Weiner, et al. 2011). Providing education and training opportunities to address knowledge deterioration should continually focus upon the delivery of effective ventilation, corrective steps, and timely determination to transition to an alternate airway (according to the NRP algorithm), as these are the first parts in the establishment of improved outcomes.

Developing code team roles and responsibilities that includes the skills, behaviors, and workflow processes required during neonatal resuscitations will improve adherence to the NRP algorithm of resuscitation care. Organizations should use the NRP algorithm as a resource in the identification process, followed by reflection upon how each required component of care is completed and the individual responsible for its achievement. For example, the initiation of chest compressions requires the FiO_2 to be increased to 100%; the individuals managing the airway and providing chest compressions are focused in their cognitive processing of patient status and physically using both of their hands to provide coordinated chest compressions to ventilation. Thus, assignment of this resuscitation requirement to the airway or chest compression code team members creates an opportunity for error. Other responsibilities to consider assigning to code team members include bringing EKG equipment to the bedside, and the placement of the pulse oximeter, EKG leads, and temperature probe on the neonate with the initiation of continued resuscitation efforts beyond 1 minute of life.

Incorporation of verbal prompts by the code team member (i.e. recorder or other identified person) at identified NRP algorithm time points can help the health care providers in their performance adherence and team based communication of neonatal status and resuscitative care needs. This can be achieved with updates to the neonatal resuscitation code sheet to support the management of care. Revisions and verbal prompts to consider include: MR SOPA (Appendix E) at one minute, placement of monitoring equipment, assessment of chest rise, consider alternate airway (i.e. laryngeal mask or endotracheal tube), and increase FiO2 to 100% with initiation of chest compressions.

Suggestions for Future Research

In future studies, research should include an evaluation of the implementation of 7th edition NRP related to the independent computer based simulation. The addition of (eSim®) provides an opportunity to engage health care providers in frequent dosing of content in efforts to keep neonatal resuscitation skills and algorithmic steps in the working memory. Identification of optimal dosing intervals for maintenance of neonatal resuscitation knowledge and skills has yet to be defined, but the development of training programs with demonstrated outcomes remains a priority for the NRP. Further examination of user experiences (advantages and barriers) should also be identified related to the use of the computer-based simulation with subsequent evaluation of practical approaches to address study findings.

Adoption of error reduction strategies, on the concepts of oxygen administration, ventilation, chest compressions, and team behaviors, should be examined for identification of best practice approaches and ultimately the potential success of the neonatal resuscitation efforts. Studies examining error reduction strategies should focus upon division of code team responsibilities, workflow processes, and an analysis of adherence to resuscitation processes. This resuscitation performance insight could then result in the adoption of strategies to reduce common errors seen in these lifesaving situations. Use of the NRP algorithm of resuscitation care could be used as the framework in the analysis of adherence rates and errors.

Moreover, future research on errors related to the high cognitive load (mental work required to act on content knowledge under pressure) or high technical load (mental and physical energy required to complete a technical task) (Yamada et al., 2015), their impact upon neonatal resuscitation performance, and evidence-based resolutions should be explored. High cognitive load issues were identified in this study as contributing factors to neonatal resuscitation performance. Participants were challenged with rapid decision making required during resuscitation and deviated from the NRP algorithm when code team roles did not encompass responsibilities including: increasing FiO2 to 100% with initiation of chest compressions; the application of the pulse oximeter, EKG leads, and temperature probe; EKG monitoring equipment brought to neonate's bedside; and the availability of an alternate airway (LMA or ETT) in the visual field of providers in their delivery of neonatal resuscitation care. The development and adoption of error reducing strategies (i.e. resuscitation kits that include items listed above which are placed in the visual field of care) may reduce high cognitive load effects. This strategy may provide a cognitive prompt for individuals in the use of equipment needed during a neonatal resuscitation thereby improving performance. Exploration of revisions to code team member responsibilities and the impact of the resuscitation kits as error reducing strategies are opportunities for future research currently being explored by this researcher.

Conclusion

The main conclusion is that the effect of independent computer based simulation did not result in a statistically significant change in the performance or retention of neonatal resuscitation skills of airway, chest compressions, pulse oximetry, and communication. The study did identify that mean performance scores remained unchanged across the time points of this study, therefore the integration of computer based simulation had a neutral effect on performance.

Independent computer-based simulations are have become more widespread in the education programs taken by health care providers, including NRP. The effect of computer-based simulations has the benefits of repeatability and accessibility and has also been found to be an equivalent approach when evaluated against comparable teaching strategies. Attention and planning for the computer-based simulation implementation process needs to include training activities (one on one or group based) structured with objectives and support services to assist individuals in the navigation of the technology-based training. These actions will facilitate supported, positive experiences for individuals in their use of this technology and can further promote the benefits of this experiential learning modality. The ability to augment neonatal resuscitation knowledge, repeat the skills, and review performance results provides an accessible learning method to keeping neonatal resuscitation knowledge in the active, working memory for rapid retrieval when needed for these low frequency, high crisis events.

Valuable contributions to nursing and neonatal resuscitation care were able to surmised from this study process. The data obtained provided insight into skill delivery and behaviors that educational training must focus upon for improved adherence to neonatal resuscitation care. Achieving this will require healthcare providers to use the NRP strategies effectively in order to meet the learning needs of the individual. Employing an education based scaffold approach to NRP skill development, maintenance, and simulation based training, will provide an environment conducive to learning.

Effective neonatal resuscitation is dependent on the performance of skills and the ability of the resuscitation team to efficiently coordinate lifesaving care responsibilities. Frameworks such as NRP performance evaluation tools (when updated to current NRP guidelines) and the NRP algorithm can be used to identify the most common errors, in debriefing post simulation to facilitate reflection, and in the evaluation of coordinated care efforts. This evaluation process can further be used to revise resuscitation team roles, responsibilities, and as an error reduction strategy to improve alignment with current NRP guidelines.

The NRP is recognized across the globe as the authority on neonatal resuscitation science and for its training program with over 3 million course participants worldwide. Despite this broad use in clinical practice and training, the program continues to seek strong, evidence-based findings that address the impact of high frequency, low dose training and recommended maintenance intervals that address knowledge and skill deterioration. While independent computer based simulations provide reinforcement of NRP concepts, the translation of its effect in simulation and clinical practice remains undefined. Interdisciplinary studies with statistical power and larger sample sizes are needed to measure the effects of the various NRP training strategies, the cost impact of educational strategies, and overall patient outcomes.

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Appendix A

Evaluation of the Adapted "Scoring Tool for Adherence to Neonatal Resuscitation"

After reviewing the adapted "Scoring Tool for Adherence to Neonatal Resuscitation", please indicate if this tool is relevant and congruent with the NRP concepts to be scored in a live simulation performance. Comments to further refine are appreciated.

<table>
<tr><td>
Content Validity:
Evaluation of the adapted "Scoring Tool for Adherence to Neonatal Resuscitation" for the scoring of live neonatal resuscitation scenarios.

Content of the tool's scoring system is based upon the following NRP objectives:

Live Simulation Learning Objectives:
1. Demonstrate an organized routine for checking presence and function of supplies and equipment necessary for newborn resuscitation, using the NRP flow diagram interventions.
2. Identify any additional preparatory routines for high-risk birth specific to this birth setting.
3. Identify the newborn that requires initial steps of resuscitation.
4. Demonstrate correct technique for performing initial steps.
5. Identify the newborn that requires positive pressure ventilation (PPV).
6. Demonstrate correct technique for PPV, including placement of mask on the newborn's face, rate and pressure, and corrective steps (MR SOPA: mask adjustment, reposition head, suction mouth and nose, open mouth, increase pressure, consider alternative airway).
7. Demonstrate correct placement of oximeter probe and interpretation of pulse oximetry.
8. Recognize improvement during PPV by first assessing heart rate for increasing heart rate and oxygen saturation; if those are not improving, recognize the need to perform ventilation corrective steps and achieve audible breath sounds and chest movement with ventilation.
9. Identify the newborn who requires chest compressions
10. Demonstrate correct technique for performing chest compressions (including the increase in FiO2 to 100%).
11. Identify the sign that chest compressions should be discontinued.
12. Identify the signs that PPV may be discontinued.
13. Demonstrate behavioral skills to ensure clear communication and teamwork during this critical component of newborn resuscitation.
</td></tr>
<tr><td>
• Live Simulation objective(s)
• Adapted scoring tool concepts/sub-concepts for evaluation of performance of live simulation objectives
</td></tr>
<tr><td>
Simulation Objectives:
(#1) Demonstrate an organized routine for checking presence and function of supplies and equipment necessary for newborn resuscitation, using the NRP
</td></tr>
</table>

flow diagram interventions. **(#2) Identify any additional preparatory routines for high-risk birth specific to this birth setting.** **Scoring Tool Components:** **(#1) Group Function** **(#2) Preparation & Initial Steps**					
Please rate this item	**Very Relevant**	**Quite relevant**	**Somewhat relevant**	**Not relevant**	
The items are relevant to the content domain.					
Please rate each category	**Disagree**		**Agree**		**Comments**
The scoring tool component(s) are congruent with the simulation objective.					
Simulation Objectives: **(#3) Identify the newborn that requires initial steps of resuscitation.** **(#4) Demonstrate correct technique for performing initial steps.** **Scoring Tool Components:** **(#2) Preparation & Initial Steps** **(#3) Communication of Heart Rate to Lead Resuscitator**					
Please rate this item	**Very Relevant**	**Quite relevant**	**Somewhat relevant**	**Not relevant**	
The items are relevant to the content domain.					
Please rate each category	**Disagree**		**Agree**		**Comments**
The scoring tool component(s) are congruent with the simulation objective.					
Simulation Objectives: **(#5) Identify the newborn that requires positive pressure ventilation (PPV).** **(#6) Demonstrate correct technique for PPV, including placement of mask on the newborn's face, rate and pressure, and corrective steps (MR SOPA: mask**					

adjustment, reposition head, suction mouth and nose, open mouth, increase pressure, consider alternative airway).
(#7) Demonstrate correct placement of oximeter probe and interpretation of pulse oximetry.
(#8) Recognize improvement during PPV by first assessing heart rate for increasing heart rate and oxygen saturation; if those are not improving, recognize the need to perform ventilation corrective steps and achieve audible breath sounds and chest movement with ventilation.
(#12) Identify the signs that PPV may be discontinued.

Scoring Tool Components:
(#4) Oxygen Administered
(#5) Bag/Mask Ventilation

Please rate this item	**Very Relevant**	**Quite relevant**	**Somewhat relevant**	**Not relevant**	
The items are relevant to the content domain.					
Please rate each category	**Disagree**		**Agree**		**Comments**
The scoring tool component(s) are congruent with the simulation objective.					

Simulation Objectives:
(#9) Identify the newborn who requires chest compressions
(#10) Demonstrate correct technique for performing chest compressions (including the increase in FiO2 to 100%).
(#11) Identify the sign that chest compressions should be discontinued.

Scoring Tool Components:
(#5) Bag/Mask Ventilation
(#6) Chest Compressions

Please rate this item	**Very Relevant**	**Quite relevant**	**Somewhat relevant**	**Not relevant**	
The items are relevant to the content domain.					
Please rate each category	**Disagree**		**Agree**		**Comments**
The scoring tool component(s) are					

congruent with the simulation objective.			

Simulation Objectives:
(#13) Demonstrate behavioral skills to ensure clear communication and teamwork during this critical component of newborn resuscitation.

Scoring Tool Components:
(#1) Group Function

Please rate this item	**Very Relevant**	**Quite relevant**	**Somewhat relevant**	**Not relevan t**	
The items are relevant to the content domain.					
Please rate each category	**Disagree**		**Agree**		**Comments**
The scoring tool component(s) are congruent with the simulation objective.					

Appendix B

IRB #: 2015-6126

Approved: 5/26/2016
Do Not Use After: 5/25/2017

Adult Consent Form for Research
University of Cincinnati
Department: Nursing
Principal Investigator: Donna Green PhD(c), MSN, RNc-EFM
Faculty Advisor: Elaine Miller PhD, RN

Title of Study: The Effect of Independent Computer-Based Simulation on Neonatal Resuscitation Skills

Introduction:
You are being asked to take part in a research study. Please read this paper carefully and ask questions about anything that you do not understand. You are invited to participate in a research study to explore the effect of independent computer-based simulation on Registered Nurse neonatal resuscitation skills and retention. You were selected as a possible subject because you are a perinatal registered nurse (RN) at Mercy Hospital Fairfield who practices and participates in the Neonatal Resuscitation Program as required by your workplace. We ask that you read this form and ask any questions you may have before agreeing to be in this research study.

Who is doing this research study?
The person in charge of this research study is Donna Green PhD(c), MSN, RNc-EFM of the University of Cincinnati (UC) Department of Nursing. She is being guided in this research by Elaine Miller PhD, RN.

What is the purpose of this research study?
The purpose of this research study is to examine the effects of adding independent computer-based neonatal resuscitation simulation to the current Neonatal Resuscitation Program (NRP) and simulations on participant knowledge and performance of required NRP behaviors.

Who will be in this research study?
About 80 people will take part in this study.
You may be in this study if:

1. You are a RN who has completed the NRP within the last two years.
2. You are a RN of any ethnic background, religion, and socioeconomic status.
3. You are a RN who is full time, part time, or optional work time.
4. You are a RN who practices in the perinatal patient care setting.

5. You agree to complete the self-report survey tool.
6. You agree to complete the neonatal resuscitation simulation scenarios.
7. You agree to the video analysis of behaviors in the simulation scenario.

Taking part in this research study is not part of your job. Refusing to be in the study will not affect your job. You will not be offered any special work-related benefits if you take part in this study.

What will you be asked to do in this research study, and how long will it take?
You will be asked to participate in neonatal resuscitation simulations. It will take about 10-20 minutes for each simulation activity. The research will take place at Mercy Fairfield Hospital.
If you agree to be in the study, you will do the following things:

Consent to the videotaping, completion, scoring, and analysis of:

1. Baseline evaluation of neonatal resuscitation simulation performance.

2. The completion of an independent computer-based simulation of neonatal resuscitation, lasting approximately 10 minutes (if placed in this group).

3. A repeated evaluation of neonatal resuscitation simulation performance at approximately 4 months following the initiation of this study.

Each simulation will be approximately 10 minutes in length and will immediately be followed by debriefing which will last approximately 10-20 minutes.

Are there any risks to being in this research study?
There is no anticipated risk to you as a participant in this NRP teaching/learning experience and evaluation. Participation in the study is voluntary. The data collected within this study will be kept confidential and will be reported as aggregate data.

Are there any benefits from being in this research study?
The potential benefit to participating in this study is that your participation may aid in furthering the science of teaching and learning strategies associated with clinical simulation within professional nursing practice.

What will you get because of being in this research study?
There will be no compensation provided to you if you consent to this study.

Do you have choices about taking part in this research study?
If you do not want to take part in this research study you may simply not participate and you will not be treated any differently.

How will your research information be kept confidential?
Information about you will be kept private by the use of a study ID number

instead of your name on research forms. A master list of names and study ID numbers will be kept in a separate location from the research forms and signed consent documents. Research data to be collected will be noted as group data. All research data will be kept on a password-protected computer.

Your information will be kept in a locked cabinet in the researcher's campus office for three years after the study is closed. After that, it will be destroyed by deleting computerized records and the shredding of paper research files.

The data from this research study may be published; but you will not be identified by name.

Agents of the University of Cincinnati may inspect study records for audit or quality assurance purposes.

The researcher will ask people in the simulation group to keep the discussion confidential, but they might talk about it anyway.

The researcher cannot promise that information sent by the internet or email will be private.

What are your legal rights in this research study?
Nothing in this consent form waives any legal rights you may have. This consent form also does not release the investigator, the institution, or its agents from liability for negligence.

What if you have questions about this research study?
If you have any questions or concerns about this research study, you should contact Donna Green at 513-477-4129. Or, you may contact Elaine Miller at 513-558-5298.
The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants are protected. If you have questions about your rights as a participant, complaints and/or suggestions about the study, you may contact the UC IRB at (513) 558-5259. Or, you may call the UC Research Compliance Hotline at (800) 889-1547, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive, Cincinnati, OH 45221-0567, or email the IRB office at irb@ucmail.uc.edu.

Do you HAVE to take part in this research study?
No one has to be in this research study. Refusing to take part will NOT cause any penalty or loss of benefits that you would otherwise have.
You may start and then change your mind and stop at any time. To stop being in the study, you should tell Donna Green at 513-477-4129 or donna.green@uc.edu.

Agreement:
I have read this information and have received answers to any questions I asked. I give my consent to participate in this research study and for my simulation participation to be video taped for review. I will receive a copy of this signed and dated consent form to keep.

Participant Name (please print) ____________________________

Participant Signature ________________________________ Date ______

Signature of Person Obtaining Consent __________________ Date ______

Appendix C

Participant Survey

1. What was your highest level of degree completion at the time of your NRP test and simulation in 2016?
   - Associate degree or equivalent
   - Bachelor's of Science in Nursing (BSN)
   - Master's of Science in Nursing (MSN)
   - Other (please identify_________________)
2. Please identify your current area of perinatal nursing practice. You may choose more than one.
   - Labor & Delivery
   - Mother/Baby
   - Special Care Nursery
3. How many times have you taken the Neonatal Resuscitation Program training in your nursing practice?
   - 1-3 times
   - 3-5 times
   - More than 5 times
4. Approximately, how many neonatal resuscitation events (as defined as infants requiring at least positive pressure ventilation) have you participated in within the last 24 months?
   - None
   - 0-4
   - 5-10
   - Greater than 10

Appendix D

Scoring Tool for Adherence to the Neonatal Resuscitation Guidelines

Date of Review__________________ Key: Y-yes (2 pts) N-no (0 pts)

Subtracted point are multiplied by the factor for that intervention; i.e., x3 for intubation and are subtracted from the total in the section before calculating the score for that section.

Please check box if intervention not administered

Lead Resuscitator____________________________________

Apgar at 1 minute: Observed: __________________________

Assigned:____

Apgar at 5 minutes: Observed: _________________________

Assigned:____

1. **Group Function** **Y** **N**

	Y	N
Clearly defined and functioning lead resuscitator	___	___
Minimal overlap of individual team member functions	___	___
Evidence of team collaboration/cooperation	___	___
Evidence of communication	___	___
Integration of processes (assist with intubation, pulse oximeter, etc)	___	___
Score: Total pts x 1: (total pts possible: 10)	_________	

2. **Preparation and Initial Steps**

	Y	N
Checking of equipment	___	___
Placed correctly on warmer	___	___
Positioned with neck slightly extended	___	___
Suctioned mouth then nose (bulb syringe with head to side)	___	___
Dried infant thoroughly	___	___
Removed wet linen	___	___
Tactile stimulation (score "N" if continued for an apneic infant, or omitted from an initially depressed infant)	___	___

Subtract 2 if continued stimulation interferes with resuscitation: ____________

Deep suction before stable: subtract one for each attempt ____________

Score: Total pts x 1: (total pts possible: 14) ____________

	Y	N
3. Communication of heart rate to lead resuscitator:		
Heart rate checked by approved method (stethoscope, EKG)	___	___
Heart rate communicated to resuscitator (tapped out with finger, verbally communicated)	___	___
Score: Total pts x1: (total pts possible: 4)	__________	

	Y	N
4. Oxygen administered: Administered/Not Administered		
Appropriate decision based on clinical condition of infant (infant is blue, pulse oximeter reading below parameters,)	___	___
Technique:		
Free flow oxygen with approved method	___	___
Evaluated response (slowly withdrawn, continued)	___	___
Score: Total pts x 1: (total pts possible: 6)	__________	

	Y	N
5. Bag/mask ventilation: Administered/Not administered		
Appropriate decision based on clinical condition of infant (apneic/gasping, HR<100 or persistent cyanosis)	___	___
Technique:		
Correct mask size chosen	___	___
Correct rate (40-60 per minute)	___	___
Correct pressure and seal (adequate chest rise & fall)	___	___
Re-evaluated for response (HR and color after 30 sec)	___	___
Score: Total pts x 3: (total pts possible: 30)	__________	

6. Chest compressions: Administered/Not Administered **Y** **N**

Appropriate decision based on clinical condition of infant (HR<60) ___ ___

Technique:

	Y	N
Correct method (either thumb or 2 finger)	___	___
Correct rate and depth of compressions (90 per min)	___	___
Correct rate of ventilation (30 per min)	___	___
Correct coordination with ventilation (3:1 ratio)	___	___
Re-evaluated for response	___	___

Score: Total pts x 3: (total pts possible: 36) __________

Total Cumulative Points of all included sections/Total Possible Points of all included sections (100)= __________% Score

Comments:

[1]

[1] Van der Heide, P.A., van Toledo-Eppinga, L., van der Heide, M., van der Lee, J.H. (2006). Assessment of neonatal resuscitation skills: A reliable and valid scoring system. *Resuscitation, 71* (2). 212-221.

Appendix E

Neonatal Resuscitation Program Simulation Scenarios and Learning Objectives

Simulation Scenario:

You are called to attend a delivery. The obstetric provider tells you that the baby is 33 weeks' gestation. There is 1 baby. The amniotic fluid is clear. There is a category II fetal heart tracing and a suspected placental abruption. A C-Section is anticipated. Complete the equipment check and prepare to resuscitate the baby according to the NRP flow diagram (American Academy of Pediatrics, 2016). As you work, say your thoughts and actions aloud so your team and I will know what you are thinking and doing.

Learning Objectives:

1. Demonstrate an organized routine for checking presence and function of supplies and equipment necessary for newborn resuscitation, using the NRP flow diagram interventions.
2. Identify any additional preparatory routines for high-risk birth specific to this birth setting.
3. Identify the newborn that requires initial steps of resuscitation.
4. Demonstrate correct technique for performing initial steps.
5. Identify the newborn that requires positive pressure ventilation (PPV).
6. Demonstrate correct technique for PPV, including placement of mask on the newborn's face, rate and pressure, and corrective steps (MR SOPA: mask adjustment, reposition head, suction mouth and nose, open mouth, increase pressure, consider alternative airway).
7. Demonstrate correct placement of oximeter probe and interpretation of pulse oximetry.

8. Recognize improvement during PPV by first assessing heart rate for increasing heart rate and oxygen saturation; if those are not improving, recognize the need to perform ventilation corrective steps and achieve audible breath sounds and chest movement with ventilation.
9. Identify the newborn who requires chest compressions
10. Demonstrate correct technique for performing chest compressions (including the increase in FiO2 to 100%).
11. Identify the sign that chest compressions should be discontinued.
12. Identify the signs that PPV may be discontinued.
13. Demonstrate behavioral skills to ensure clear communication and teamwork during this critical component of newborn resuscitation.

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[2] American Academy of Pediatrics (Zaichkin, Weiner, & Major, 2011, pgs. 253-267).

Appendix F

NRP Key Behavior Skills in Action

NRP Key Behavior Skills	**Examples in Action**
Know your environment	Learners perform equipment check before newborn arrives Know location of and how to access crash cart Know to call for help & who is available
Anticipate & plan	All learners listen to circumstances of scenario Resuscitation team "huddles" & assigns roles/responsibilities Team discusses action plan in event of potential complications
Assume the leadership role	Learners "huddle" & assigns role(s) Leader will: • Clearly articulate goals • Effectively use resources • Delegates tasks, as appropriate • Uses call-outs to communicate critical information • Asks for input from team members • Enables team members to challenge the plan when appropriate • Promotes teamwork & resolves conflict • Includes family in communication
Communicate effectively	Team members: • Call each other by name • Actively share information • Verify information that is communicated • Ensure that changes in information are shared with all team members
Delegate workload optimally	Team members: • Do not duplicate work or use more resources than necessary.

	• Agree to change task assignments depending on skill sets & what is required at the moment • Protect each other from work overload
Allocate attention wisely	Team members: • Maintain situation awareness by scanning & assessing at all times • Monitor one another's actions in context of patient safety
Use all available information	Team members: • Ask about prenatal & intrapartum history, including presence of meconium-stained amniotic fluid prior to birth • Ask about newborn history, if newborn is being resuscitated after five minutes of life
Use all available resources	Know human resources available Know supplies & equipment available
Call for help when needed	Team members: • Call for help in a timely manner • Know process for getting assistance of the right kind
Maintain professional behavior	Team members: • Use respectful verbal & nonverbal behaviors • Actively seek & offer assistance • Support & promote teamwork • All are equally valued & respected

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[3] American Academy of Pediatrics (Zaichkin, Weiner, & Major, 2011, p. 102).
*NRP Key Behavioral Skills are from the Center for Advanced Pediatric and Perinatal Education (CAPE), Lucile Packard Children's Hospital at Stanford University. Available at http://cape.lpch.org/courses/logistics/skills.html