CRITICAL CARE NURSES' PERCEPTIONS OF SAFETY RELATED TO USING COMPLEX MEDICAL DEVICES IN DAILY NURSING PRACTICE

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DEDICATION

I dedicate this dissertation to my husband Stuart and children Sarah and Samuel. Stuart, your unconditional love, unwavering patience, and continual sacrifices to see me through this incredible experience is beyond any words of gratitude. I am blessed to have you as my soulmate, my anchor, and my faithful supporter. Sarah and Samuel, thank you for your love and understanding throughout this journey. I hope that my passion for lifelong learning will inspire you always to pursue your dreams and never give up.

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TABLE OF CONTENTS

LIST OF TABLES

Table Page

ABSTRACT

Background: Medical errors are the third leading cause of death in America. Over 10,000 medical errors occur daily, with an estimated financial impact of preventable mistakes is 20 billion dollars annually. Increasing the use of multifarious sophisticated medical technologies in the Intensive Care Unit (ICU) poses a risk of medical errors and unintentional harm to patients. However, limited empirical evidence exists regarding ICU nurses' perspectives.

Purpose: This study aimed to elucidate ICU nurses' perceptions of their use of complex medical devices.

Framework: The Conceptual Model for Technology, Nursing, and Patient Safety provide the framework for this study.

Sample: Using purposive, convenience, and snowball sampling, 260 ICU nurses throughout the United States participated in this study.

Methods: The study featured an online mixed methods descriptive exploratory research approach. The Hospital Survey on Patient Safety Culture (HSOPSC) survey, opened-ended questions, and demographic data were collected using RedCap©.

Data Analyses: Quantitative data were analyzed using the R (version 4.2.0) statistical package. A two-tailed Pearson's correlation and linear regression models were used to test the hypothesis. The NVivo© for Mac 11.4.3 software was used to analyze the qualitative data.

Results: The results revealed a significant relationship between nurses' safety perceptions and the years of experience, education, and medical device competency.

Conclusion: The findings inform medical device education standards, intervention research, and policy changes.

CHAPTER 1

PROBLEM AND DOMAIN OF INQUIRY

The proliferation of new patient care technology in healthcare has significantly impacted nurses' workflow and nursing practice. Advances in patient care technologies such as computerized features have enhanced and improved patient outcomes. Smart technology has revolutionized healthcare delivery due to its sophistication and complexity. However, the incorporation of automated features within patient care devices may lead to unintentional mistakes due to the constantly changing dynamics between the human-machine interfaces in hospitals (Swayze & Rich, 2012). The National Quality Forum (NQF) reported in 2012 that patients in the American healthcare system are at higher risk of exposure to avoidable medical errors compared to other developed countries.

According to the NQF, over 10,000 medical errors occur daily within the United States (U.S.) healthcare system, resulting in approximately 44,000 to 98,000 injuries and death every year. The annual financial impact of preventable mistakes is estimated at 20 billion dollars, inclusive of healthcare expenses, disability, and lost productivity. Healthcare expenses continue to rise at a rate of seven percent annually in contrast to a one percent increase in patient safety (National Quality Forum, 2012). Nurses are the largest healthcare providers in hospital settings, and they must be able to use a variety of patient care technologies, such as electronic beds, IV pumps, telemetry monitors, and ventilators. Internationally, there are over 1.5 million medical devices and healthcare technologies available that are utilized for care delivery. Medical devices are essential healthcare technologies for delivering care in intensive care units (ICUs) (Ruppel & Funk, 2018). However, the increase of cutting-edge technology has not sufficiently improved the quality and safety of patient care. Although some medical devices may seem simple and easy to

use, they can still pose a risk for error related to a manufacturers' design flaw and clinician misuse (Mattox, 2012; Swayze & Rich, 2012).

National Academy of Medicine, known as the Institute of Medicine (IOM), reports have conveyed serious concerns about the quality and safety of the American healthcare system. The IOM identified three key assertions associated with gaps and practice barriers to excellent care: (a) medical errors occur frequently resulting in severe harm and are avoidable; (b) most medical errors are associated with system failures versus human failures; (c) the role of the nurse in identifying potential errors is vital to patient safety. Nurses are considered paramount to the safety process from a system and a human factor viewpoint (Henneman, 2017).

Sowan et al. (2017) assessed ICU nurses' competence and perceptions on physiologic monitor alarm management as a response to the Joint Commission enactment of the National Patient Safety Goal on clinical alarm systems safety in 2014. Medical devices have safety alarms, but some have security features that activate a maneuver to address the alarm after a certain amount of time has elapsed. Safety designs on other devices may address physiological trends and make necessary changes. These nuances, installed inside medical equipment, present additional challenges for nurses in their daily practice. Some of the complexity of device alarms, such as similar-sounding alarms or alarms that require no intervention, can influence nurses' sensitivity to responding (Sowan et al., 2017). Medical device alarm safety studies elucidate multiple factors associated with persistent technology-related errors, including the incorrect use of monitors, environmental logistics, and the absence of alarm management policies, procedures, and standardized practices. For example, Sowan et al.'s (2017) descriptive study revealed that 27% of ICU nurses described a lack of confidence to manage physiologic monitor alarms. Furthermore, 40% of the participants conveyed a lack of knowledge related to the various alarm

features and device capabilities. However, the most significant finding was the lack of nursing competence on how to use physiologic monitors (Sowan et al., 2017).

Regardless of the machines' technological purposes and utilities, nurses must be able to provide safe, high quality, and seamless patient care. However, this essential quest is challenged by the fact that even the definition of technology among nurses is nebulous. For example, Tunlind et al. (2015), described technology as machinery that provides knowledge and is utilized to increase efficiency. However, Swayze and Rich (2012) presented a broader definition of technology that ranges from tongue depressors to complex extracorporeal membrane oxygenation (ECMO) machines. Other sophisticated technologies, such as ventricular assistive devices (VADs), mechanical ventilators, electronic health records, intracranial monitoring devices, and smart IV pumps, are examples of medical technologies commonly used in ICUs. Therefore, a crucial first step in investigating related nursing competence and self-efficacy is the development of a cogent definition of nursing-related technology. Due to the vast amount of technology used by clinicians, it is essential to distinguish the technology that is specific to this study. The focus of this study was exclusively on complex medical devices that nurses use in ICUs as an adjunct to patient care delivery. These patient care technologies are devices and machines used to monitor and provide therapeutic interventions that are critical to maintaining patients' biological and physiological body functions. Examples of these machines include ventilators, physiologic monitors, infusion pumps, ICU beds, continuous renal replacement therapy systems, and temperature management systems. Critical care nurses routinely use these devices to maximize patient care and recuperation. Patients may need several sophisticated medical devices to support their care and recovery.

The complexity and intensity of the ICU environment and the condition of critically ill

patients can be overwhelming and a source of stress and anxiety of nurses. Elements of the physical environment include light, noise, and human factors such as malfunctioning technology that can contribute to work stress (Donchin & Seagull, 2002; Wung, 2018). Some of the challenges nurses in the ICU encounter are error-prone complicated equipment. The nurse can make a mistake when using a device if it is not designed to incorporate how the nurse will interact with and understand the machine's interface. For example, the smart IV pump is a complex medical device prevalent in ICUs. Nurses use the IV pumps to titrate life-threatening medications such as norepinephrine. A case study report described the accidental over infusion of norepinephrine associated with a programming error that resulted in an adverse event and harm to a patient. The patient suffered a cardiac arrest after receiving a loading dose of the drug instead of an infusion dose (Ibey et al., 2015). Despite improvements in safety features, such as dose error-reduction, the risk for mistakes still exists (Giuliano, 2018). Medical device training may be insufficient for nurses to understand the safety functions and gain competence with its utilization (Wung, 2018). Therefore, this study seeks to assess and describe the experiences of critical care nurses' practice and explore nurses' perceptions regarding the safe use of complex medical devices.

Technology and medical devices are the essentials of critical care nursing practice, expertise, and professional status. The ICU is a complex and high-stress environment where patients are sickest and require high-quality care, which includes the use of complicated devices. The American Nurses Association's (ANA, 2015) scope of practice outlines the duty of nurses to maintain competence in practice. Nurses must be skilled in operating these cutting-edge technologies to provide safe nursing care. Critical care nurses must manage multiple intricate devices, such as physiologic monitors, mechanical ventilators, and infusion pumps, concurrently.

In a study of Iranian critical care nurses' attitudes associated with technology conducted by Sabzevari et al. (2015) reported that while nurses felt medical technology has some benefits, there were many disadvantages related to its use. Nurses expressed that technology negatively affected nurse-patient communication and the personalization of patient care. They reported that technology was difficult to handle and caused moral distress due to the ethical situations as a result of advanced technology and procedures used to prolong patients' lives. However, the nurses acknowledged that technology facilitates patient care in the ICU and elevates nursing practice (Sabzevari et al., 2015). Exploring innovative ways to integrate new technology into nursing practice is significant in advancing the nursing profession. Creating a balance between technologic influence and human concepts of nursing care is obligatory (Ruppel & Funk, 2018). Understanding the American critical care nurses' viewpoint of how technology can improve the quality, safety, and efficiency of patient care is crucial to advance nursing practice.

Education in technical skills should prepare ICU nurses to manage multiple technological devices and understand the aspects of technological care, thus assisting nurses with integrating technology into daily practice to improve the quality and safety of patient care (Sabzevari et al., 2015). Engaging nurses in technology design, adequate support, resources, mentors, and training guides can contribute to the safe use of technology. Educational strategies should incorporate simulation in a clinical skill laboratory, discussions on medical device application principles, and review of device-related incidents, and how to prevent clinical errors (De Veer et al., 2011; Ewertsson et al., 2015; Weckman & Janzen, 2009).

Nurses' perceptions of medical devices involve several aspects. While some nurses view medical technology as an asset to improving patient outcomes, others feel it creates stress, is time-consuming, and infringes on nursing autonomy (Zhang et al., 2014). Qualitative

international studies exploring critical care nurses' experiences and perceptions uncovered that nurses have both positive and negative experiences when using technology in nursing practice. Sabzevari et al. (2015) found that Iranian critical care nurses expressed both positive and negative opinions about the technological influences on their practice. Younger ICU nurses had higher scores reflecting the negative aspects of technology.

Kiekkas (2014) examined the safety concerns of critical care nurses associated with the rapid introduction of complex new medical devices with limited training and time to master the needed technical skills. Kiekkas's results showed the stress that nurses experience when dealing with the barriers to new technology and the risks that they will develop a fear of using it. Sowan et al. (2017), meanwhile, pioneered a study of critical care nurses' competence and perceptions related to physiologic monitor alarm management, with results that unearthed a significant lack of competence when operating physiologic monitors. Forty percent of the ICU nurses reported never using 27 device-monitoring functions and were unsure of how to operate the monitors completely. According to Ewertsson et al. (2015), only 19% of nurses always avowed device-related incidents, and 22% did not report such incidents. Patient safety is contingent on nurses being prepared with the knowledge, skills, and attitude to manage sophisticated medical technology competently. Understanding how ICU nurses utilize medical devices to plan and implement care is imperative to avert the threat of possible aforementioned adverse outcomes.

There is substantial international nursing literature and studies on the experiences of ICU nurses and the use of technology. However, the literature indicates a gap and insufficient evidence of American nurses' perceptions about the increased use of complex technology and its impact on nursing practice. No current research is available that describes and explains how critical care nurses attain technical competence to use complex equipment and safely apply their

knowledge and technical skills to patient care. Evidence is needed to understand how nurses learn to perform technical skills and safely use complex medical devices (Ewertsson et al., 2015). Research is required to explore the current state of this phenomenon from the American critical care nurses' perspective.

Problem Statement

Medical errors are the third leading cause of death in America. Medical errors are numerous, expensive, and frequently preventable. One in 10 deaths is associated with a medical error amounting to an estimated 400,000 premature deaths annually (Makary & Daniel, 2016). Preventable medical errors amount to an estimated $38 billion annually (Padgett et al., 2017). An estimated annual cost of $17.1 billion is attributed to device-related errors (Van Den Bos et al., 2011). Factors influencing device-related medical errors include (a) inadequate implementation plans, (b) poor user education programs, (c) data overload, and (d) human factors. The rapid increase of new technology, coupled with poor implementation strategies, is contributing to the surge of medical error-related mortality since the 1999 IOM Report (Gurses & Doyle, 2014; James, 2013; Makary & Daniel, 2016).

Purpose of the Study

The purpose of this study is to explore the experiences and perceptions of critical care nurses' practice when using complex patient care technology in an ICU setting.

Research Questions and Hypotheses

Research Question 1

RQ1. What are the experiences of critical care nurses working with complex patient care technology in daily practice?

Research Question 2 and Hypothesis 1

RQ2. What are the facilitators and barriers to using complex patient care technology to provide nursing care?

H_{01}: There is no relationship between the safety perceptions of critical care nurses' and the level of education and years of experience using complex medical devices to provide patient care.

H_{a1}: There is a relationship between the safety perceptions of critical care nurses' and the level of education and years of experience using complex medical devices to provide patient care.

Research Question 3 and Hypothesis 2

RQ3. What are the perceptions of nurses of the clinical education that they received to use complex patient care technology?

H_{02}. There is no relationship between organizational learning education and continuous improvement processes and critical care nurses' perceptions of technological competence.

H_{a2}. There is a relationship between organizational learning education and continuous improvement processes and critical care nurses' perceptions of technological competence.

Research Questions 4 and 5

RQ4. Which educational strategies are most effective in facilitating patient care technological competence?

RQ5. What are the challenges encountered when using complex patient care technology to facilitate clinical decision making and providing patient care?

Significance of the Study

The increasing use of multifarious patient care technologies in the ICU influences the best practices for safe patient care. There is a dearth of empirical research regarding nursing knowledge, practices, and perceptions of using complex medical technology in daily practice. Therefore, more evidence is needed to understand how nurses use technology and why technology-related errors occur. Due to the increased risk of adverse events in the ICUs, it is also necessary to comprehend how critical care nurses adapt and incorporate complex technology into patient care delivery and what effects it has on their practice (Ribeiro et al., 2016).

Nursing Education

Nurses cannot deliver safe patient care without accurate information to make precise clinical decisions. As a knowledge-based profession, nurses depend on technology as an adjunct to convey vital information to develop individualized patient care delivery. Nursing practice and patient safety are compromised when nurses are inadequately trained to use technological devices. Some of the contributing factors to errors include device failure, improper use, inadequate staff training, and insufficient maintenance (Ewertsson et al., 2015; Powell-Cope et al., 2008). Understanding the impact of a high-technology work environment on nursing practice can provide valuable information for preparing nurses for innovations in practice. Technological competence is imperative for nurses to identify device errors or malfunctions and report safety concerns. New technologies in healthcare are proliferating at a rapid pace, and many are replacing current technology. This constant change demands that nurses change their practice and maintain technological competency (Kiekkas et al., 2013; Sabzevari et al., 2015).

The need for experts who can lead the change and be the vital viaduct between nurses and technology is imperative (Huston, 2013). Benner et al. (2010) call for nursing education to focus

on the specific nursing learning necessities using educational strategies that will decrease the current gap between clinical practice and nursing education. Nurse educators and healthcare administrators have a shared responsibility to provide learning opportunities for nurses to enhance their technical competence. Continuing clinical education should offer nurses time to practice technical skills in a safe learning environment. Nurses also have a responsibility to foster a culture of life-long learning that includes the use of reflective, evidence-based practice to ensure their technical proficiency (Benner, 2012; Ewertsson et al., 2015).

Ewertsson et al. (2015) reported that no study exists in the literature that has investigated the number of medical devices new nurses utilize in their daily practice or the required technical skills they need to care for patients safely. According to Ewertsson et al. (2015), 43% of new nurses reported that they were involved in device-related incidents, and these errors pose a risk to patient safety. Less than 50% of the nurses received training that could strengthen their technical skills. In the ICU, highly specialized skills are required for safe practice. Simulation is a tool that can verify competency in a vast range of skills, from simple to complex. Since simulation is an instructional technique that mimics reality, it is considered a suitable teaching strategy for practicing complex technical skills (Burnette & Thibodeau-Jarry, 2016). Gaining insight into nurses' perceptions of complex technology can provide meaningful information for designing clinical education programs to improve technical competence and practice safety. Promoting nurses' technological competence can improve both practice and patient safety.

Nursing Practice

The Federal Drug Association (FDA) patient safety concerns specifically related to medical devices have led to several recommendations for professional nursing organizations (PNO). One proposal was aimed at PNO developing position statements to promote the safe use

of medical devices and improved patient outcomes. The position statements are designed to outline professional nursing standards, policies, and procedures. The FDA also suggested that the PNO partner with staff nurses to increase their training in medical device safety and its application in patient care delivery. Furthermore, the FDA has offered to provide information about defective medical devices that were sequestered as a result of adverse event reporting, which will assist the PNO in crafting position statements that are intended to improve device safety and patient outcomes (Swayze & Rich, 2012).

Creating a balance between the technological and humanistic aspects of nursing care is needed to provide effective, high-quality patient care. Bridging the gap between education and practice requires educators, nurses in clinical practice, nurse executives, and students. Sabzevari et al. (2015) recommend that all ICU nurses have appropriate training on how to operate and interpret the information on technological devices to act on current changes that impact the nursing profession collectively. A joint effort among all nurses is needed to understand the growing professional needs of nurses to advance and transform the practice environment (Benner, 2012). An innovative approach to strengthening the quality of care and nursing practice in a Brazilian ICU implemented a nursing care systematization program as a conceptual structure to promote continuity and quality patient care. The nurses recognized the need to advance their technologic skills and knowledge to sustain safe nursing practice as well as gain the respect and recognition of the healthcare team (Massaroli et al., 2015).

Nursing Research

Currently, nursing education for patient care technology lacks consistency and proficiency standards for fundamental educational requirements. Increasing technology complexity creates challenges for nurses to become competent in a high-stress environment with

limited time to learn. Healthcare leaders and clinicians have initiated a partnership with the Association for the Advancement of Medical Instrumentation Foundation (AAMI, 2016). The main goal of this national coalition is to promote the safe use of multifarious technology. Research can generate recommendations for further exploration to advance nursing training. An innovative approach to the problem could be developing a manufacturer-healthcare partnership involving nurses in technology design and continuous education to promote competency and safe care delivery. Further research is needed to develop cost-effective continuing clinical education and standardized technological competency for nurses.

Public Policy

Critical care nurses are the primary operators of patient care equipment to monitor, make clinical decisions, provide therapeutic interventions, and considerably more (Smallheer, 2015). Therefore, their level of technological competence can have a significant impact on patient outcomes. It is essential to introduce continuing education programs designed to train nurses on how to safely operate medical devices is necessary (Bagherian et al., 2016). Training should include (a) the purpose of the device, (b) manufacturers' safety instructions, (c) possible complications, warnings, and contraindications. Troubleshooting the equipment should be part of the training. Reporting equipment problems and following the organization's safety policies and procedures is imperative. Nurses should be trained to check the expiration date and preventive maintenance date of all medical equipment before use (Konecny, 2003; Robeznieks, 2014; Sowan et al., 2017; Swayze & Rich, 2012).

Mattox (2012) promoted awareness of device-related errors to critical care nurses and proposed strategies for improving the quality and safety of nursing care. Fundamentally, there are two types of device-related problems—design flaws and user errors. It can be challenging to

identify the difference between them (Mattox, 2012). Nurses should be prepared to promptly intervene, replace the flawed device, secure the device, and report the incident. Nurses should be aware of human factors engineering principles and how to identify medical device failures. Nurses are in a unique position to prevent errors and near-miss events and evaluate the failure from their perspective. Mattox (2012) suggested several strategies for decreasing device-related errors, starting with acknowledging that mistakes happen. Secondly, removing the culture of blame and promote and encourage awareness and incident reporting. The third approach is to mandate that devices meet the standards of human factor engineering, which requires that the design addresses the care needs. For example, Giuliano (2018) proposed that devices be designed to incorporate and interface with patient-specific information, such as laboratory and physiologic parameters, to enhance care management. Devices screens should be light, bright, and easy to read. Using auto-programming instead of manual programming may decrease the safety risks associated with manually navigating through several complicated and time-consuming steps. Wolf (2018) recommended that smart IV pumps include drug libraries to promote patient safety. Other recommendations suggest involving clinical nurses in the evaluation of the new equipment before purchasing and listen to their feedback (Mattox, 2012). Education and skills training on managing medical devices can promote safe patient care. Continuing education of new medical technology for student nurses and practicing nurses is needed (Ewertsson et al., 2015). Bagherian et al. (2017) recommended initiatives to promote life-long learning that supports patient-centered care and safe patient outcomes in a technology-pervasive environment.

Philosophical Underpinnings

Nurse researchers can explore various phenomena using the qualitative inquiry approach to uncover rich details of the problem; in contrast, the quantitative approach provides numerical

measures and the statistical significance of the relationship among the variables. Thus, offering the researchers a greater understanding of behaviors and interpretation of the meaning associated with significant problems in nursing practice. An advantage of mixed methods is that it allows for more reliable inferences and fewer chances of researcher bias. Using different methodologies may provide information that may not be captured by using one method (Creswell, 2014; Ingham-Broomfield, 2016; Shorten & Smith, 2017).

Post-Positivism

The underpinnings of quantitative research are post-positivist assumptions. Post-positivist assumptions are grounded in the scientific method that follows a logical step-by-step process of inquiry to produce empirical data. The post-positivistic approach to examining truth and knowledge is based on observations of reality from an objective perspective. Information gathered through a systematic approach using deductive reasoning and hypothesis testing to explain and describe a phenomenon provides an understanding of the real world (Crotty, 1998).

Crotty (1998) further explains positivism as having an epistemological posture of objectivity. The aim is to ensure factual information of reality free of ambiguity. Ontologically, the post-positivist perspective postulates that reality is unrelated to the researcher's beliefs and can be observed and understood independently. Creswell (2014) described post-positivism as experimental, with data collected using analytical tools that can measure the information and provide numerical value. Researchers use statistical analysis to make correlations among variables to determine whether to accept or reject the null hypothesis. The researcher gains insight into the problem as a result of the evidence and can objectively describe or confirm a theory (Creswell, 2014).

Social Constructivism

The qualitative research design used for this study is based on social constructivist philosophical assumptions. The social constructivist worldview posits that personal knowledge and meaning are constructed from one's experiences as a result of social interactions within one's world. A researcher's paradigm refers to the knowledge and belief assertions brought to the research (Crotty, 1998). Creswell (2014) referred to this paradigm as a persuasive stance used to maintain and uphold the researcher's position. Philosophical assumptions, ontology, and epistemology are ways of knowing. Creswell (2014) describes ontology as the perception and interpretation of one's world and reality. Epistemology is the subjective data that is the evidence supporting the knowledge claim.

A philosophical worldview refers to personal beliefs formed as a result of prior influences, experiences, and knowledge. When researchers observe and interpret the world to gain an understanding of ways of knowing, it is referred to as a philosophical underpinning (Creswell, 2014). Social constructivism is a philosophical underpinning that consists of assumptions stating that individuals search for the meaning of their world based on their interactions with their environment, objects, and things. Individuals create subjective interpretations of their experiences that can be complex and may vary contextually. The interpretive method aims to reveal unseen social dynamics and makeup. The phenomenological approach examines the participants' experiences without preexisting inferences and perceptions. Hermeneutics refers to the researcher interpreting the meaning of human behaviors in their social environments. Ethnography is the descriptive study of specific human culture (Cohen et al., 2007; Creswell, 2014).

The Interpretive Phenomenological Analysis (IPA) approach will be used for this research because the assumptions support the qualitative research method and are congruent with research questions. This study aimed to uncover and interpret ICU nurses' experiences when using complex medical technology. The researcher gains an understanding of the nurses' reality and their world by asking them to share their experiences of working with complex medical devices. The IPA is an innovative way of conducting phenomenological research whereby to explore, describe, interpret, and make sense of the participants' experiences. The foundations of the IPA are phenomenology, hermeneutics, and idiography (Tuffour, 2017).

Edmund Husserl originated phenomenology, a qualitative inquiry approach that was further advanced by Martin Heidegger and continues to evolve as a recognized qualitative research method. There is increasing interest in this design among nurses, social workers, and public professionals due to their focus on daily experiences and more of an inductive research approach. The IPA approach incorporates more of hermeneutic underpinnings and Heidegger's philosophy and other philosophers. Merleau-Ponty and Sartre are philosophers whose work complimented Heidegger's focus on exploring and interpreting participants' individual lived experiences. Together these philosophers contributed to the refinement and universal phenomenological approach. From the existential-phenomenological perspective, human nature is about becoming rather than being. It is about the self-determination to choose and taking responsibility for those choices. The complexities of an individual's biographical history and social situations may influence their decisions and actions. Hence, these aspects of experience are included in the phenomenological analysis (Smith & Osborn, 2007; Tuffour, 2017).

Hermeneutics, the main theoretical underpinning of IPA, emphasizes the interpretation of meaning as continually flowing and subject to reinterpretation and revisions. The IPA researcher

performs a dual interpretation by creating meaning based on the participants' meanings. The key role of the researcher is to analyze and interpret participants' experiences using a holistic approach. The third aspect of IPA is its idiographic basis, which ensures that each case is individually and judiciously examined before participants' experiences are merged or separated (Hefferon & Gil-Rodriguez, 2011; Tuffour, 2017). Due to the originality and complexity of this research topic, IPA was an appropriate method for inquiring into how ICU nurses perceive their clinical situations and how they assign meaning to their personal experiences and work environment.

Conceptual Framework

Technology is a fundamental part of critical care nursing practice. Critical care nursing practice is reliant on patient care technologies to make clinical decisions, provide therapeutic interventions, and monitor patients' responses and clinical outcomes. (Ruppel & Funk, 2018; Sabzevari et al., 2015). The conceptual framework chosen for this research study is the Conceptual Model for Technology, Nursing, and Patient Safety. Powell-Cope et al. (2008) created this model to illustrate the relationship among nurses' use of medical devices, factors affecting usage, and the possible nurse, patient and organizational outcomes. Currently, this model is the only conceptual model in the literature that depicts the relationship between nurses' use of patient care technology to deliver care, restraining and facilitating factors, and the patient safety outcomes associated with the devices. The model situates the use of technology contextually within nursing practice, hence allowing the evaluation of patients, nurses, and organizational outcomes related to the use of technology (Powell-Cope et al., 2008).

Fuhrer et al. (2003) designed a conceptual framework that was specific to assistive devices and associated expected outcomes. The three key concepts of the conceptual framework

are technology, nursing processes, and outcomes. Powell-Cope et al. (2008) crafted the distinctive Conceptual Model for Technology, Nursing, and Patient Safety by incorporating fundamental concepts related to nurses, patients, and organizational outcomes. The model portrays the importance of technology in nursing practice and averting harmful consequences.

Since no previous model exists that depicts nurses' relationship with medical devices, Powell-Cope et al. (2008) borrowed ideas from Fuhrer and colleagues' conceptual framework of the assistive technology device model to develop a new model. The new model integrates the nursing process and outcomes with nurses' use of technology to deliver safe patient care. This unique framework embeds the use of technology within the setting of nursing practice, and it provides a structure to examine the short- and long-term outcomes on the patient, nurse, and organization (Powell-Cope et al., 2008).

Fuhrer's model concentrates on assistive technology devices that are patient-centered and allows for a variety of interventions that involve structural and temporary modifications of the physical environment (Fuhrer et al., 2003). To develop this framework into a nursing model Powell-Cope et al. (2008) expanded the concept to incorporate a wide variety of patient care technologies used by nurses to deliver nursing care. One of the assumptions of this conceptual model is that properly manufactured devices allow nurses to concentrate on providing safe patient care. There are multiple descriptions of patient care technologies within this framework; they are classified according to everyday nursing activities. These activities are categorized by (a) direct nursing care delivery technology, (b) indirect nursing care delivery technology, (c) communication technology, (d) nurse protective devices, (e) patient and nurse protective devices, (f) patient assessment, monitoring, and surveillance, and (g) patient assistive devices, remote monitoring, pattern identification, and continued learning (Powell-Cope et al., 2008). This study

focused on two categories: the IV pumps, hypothermia machines, and mechanical ventilators classified as direct nursing care delivery technology; and the physiologic monitors, pulse oximetry, intracranial monitors classified as patient assessment, monitoring, and surveillance technology. The research was designed to assess critical care nurses' experiences with using complex devices. The research aimed at uncovering nurses' perceptions of the facilitators and barriers of using technology in daily practice.

Another theoretical assumption of this framework was that four workplace dimensions influence nurses' use of technology (Stone & Wiener, 2001). The four-workplace dimensions include organizational arrangement, social aspects, the physical environment, and technology. Organizational arrangement refers to the structure, policies, goals, and rewards of the institution. The social elements are the organization's philosophy and values and the management style it uses to interact with its patients and employees. The third dimension is the physical environment that defines the atmosphere, physical layout, and ergonomics of the organization. The fourth is the technology's interface, ergonomic design, reliability, and compatibility with other devices. These are the four fundamental workplace dimensions used to facilitate and enhance patient care delivery (Pascale et al., 2014). The System Engineering Initiative for Patient Safety (SEIPS) model of work is used to improve the quality and safety of patient care. Improvement initiatives involve employees to actively engage in adapting the fundamental principles of quality and safety (Pascale et al., 2014; Powell-Cope et al., 2008; Stone & Wiener, 2001). These four dimensions may be facilitators or barriers to nurses' safe and effective use of patient care technologies. The study will examine the relationship between critical care nurses' safety perceptions, attitudes, and competence related to the use of complex technological factors that facilitate or impede their experiences.

Definition of Terms

The concepts within the Model for Technology, Nursing, and Patient Safety are technology, organizational factors, social factors, and the physical environment (Powell-Cope et al., 2008; Stone, 2001; Stone & Wiener, 2001). These elements will be defined conceptually and operationally.

Theoretical Definitions

There are four dimensions to the workplace. The first dimension is organizational structure and operations (Stone & Weiner, 2001). Organizational factors refer to policies, resources, culture, social norms, management commitment, training programs, employee participation/empowerment, and ethical environment. Social factors exemplify organizational core values and communication with employees and patients. Social factors are defined separately and specifically for nurses and for patients. For nurses, social factors include the characteristics of the nurse; the nurse's age, experience, mindset about technology/attitudes, self-efficacy, attention, fatigue, sensory input, perception, goals, intention to use, knowledge. Similarly, Powell-Cope et al. characterized these patient factors as age, co-morbidities, attitudes, receptivity, and sensory capabilities (Powell-Cope et al., 2008, p. 208).

The third dimension is the physical space, situation, and ergonomics. The physical environment is defined as lighting, noise, and architectural features (Powell-Cope et al., 2008, p. 208). The fourth and final dimension is technology. The characteristics of the technology are its reliability, validity, ergonomic design, output display, input mechanism, interface, and compatibility with other technologies (Powell-Cope et al., 2008, p. 208). Collectively, these four dimensions have a significant impact on nurses' initial and ongoing use of patient care technology in their daily practice (Stone & Weiner, 2001).

Operational Definitions

Organizational factors include the hospital and ICU environment and the safety culture, the management style and means of communicating safety concerns, and patient safety policies. Institutional factors are related to working conditions, teamwork, job stress, and satisfaction (Luiz et al., 2015). The operational definitions of social factors are specific to nurses and patients. Social factors for nurses include age, number of years of nursing experience, number of years working in the ICU, level of nursing education, critical care nursing certification, perceptions about complex medical technologies, and technological competence (Sabzevari et al., 2015). Social factors for the patients are their co-morbidities, clinical conditions, their need for multiple complex technologies to deliver care, and their responses to treatment (Buehler et al., 2018)

Operationally, the physical environment encompasses the physical workload and how people work together to accomplish the job, whether there are adequate resources for people to complete the work safely and effectively, the nurse-to-patient ratio, and the accessibility of necessary equipment and supplies (Pascale et al., 2014). The work environment promotes staff speaking up when situations may negatively impact patient care (Applebaum et al., 2010; Armellino et al., 2010). Tunlind et al. (2015) define technology resources such as equipment and devices that unite information and promote increase work effectiveness and productivity. Technology in ICUs includes medical devices that can monitor, detect, treat, and counteract harm while improving patients' clinical conditions.

The operational definition of technological competence is the nurse's ability to use the technology to monitor, assess, and evaluate patients safely. It also refers to how able the nurse is to use the information correctly to make clinical decisions, provide nursing care, and identify and

report equipment malfunctions or mistakes (Tunlind et al., 2015). ANA defines competence as the level of expected nursing performance that is measurable and incorporates knowledge, skills, and judgment grounded in scientific data and standards of nursing practice (Harding et al., 2013).

Chapter Summary

This chapter illuminates the need to explore and describe the experiences and perceptions of critical care nurses using cutting-edge technology in their daily work. This research used a mixed-methods design that captured both qualitative and quantitative data aimed at answering the research questions. The IPA approach uncovered rich descriptive narratives of the participant lived experiences using complex technology and accounts of how they develop mastery when using these complex devices. Nurses viewed technology as both a benefit and a hindrance to their practice. ICU nurses have voiced insufficient knowledge and skills to use new technology safely, and nurses are asking for continuous training to promote the safe use of patient care technology (Tunlind et al., 2015). For this research, a mixed-methods approach was used to gather information about the nurses' perceptions of their work environment, use of technology, and safe patient care.

The theoretical assumptions of the Conceptual Model for Technology, Nursing, and Patient Safety were to guide an examination of the research questions. Powell-Cope et al. (2008) created this model with adaptations from Fuhrer and colleague's Model of Assistive Technology Device (Fuhrer et al., 2001). Its constructs derive from Stone and Weiner's (2001) four workplace dimensions, which include organizational, social, physical, and technological factors. These concepts play an essential role in nursing practice, and they have a significant impact on how nurses perceive their delivery of patient care (Pascale et al., 2014; Powell-Cope et al., 2008). The main theoretical assumptions of the model are (a) when medical devices are correctly

designed, nurses can concentrate on safe patient care and quantity outcomes, and (b) the four workplace dimensions can directly influence nurses' use of patient care devices. In the ICU, nurses are the primary users of patient care technologies. Therefore, the quality and safety of patient care depend on the nurses' interaction with the technology (Ruppel & Funk, 2018).

This study will provide information that may be beneficial to nursing practice, education, and future research. Recommendations for nursing practice include developing clinical education programs to facilitate nurses' technological competency for safer patient care delivery. Findings may provide information for improving the nurses' work environment by developing medical device safety policies. Chapter 2 provides a literature review and a discussion of the research gaps in understanding the problem.

CHAPTER 2

LITERATURE REVIEW

The purpose of this research is to uncover the perceptions and practices of ICU nurses in a highly technologically advanced environment. The aim is to understand the challenges, including both barriers and facilitators, that nurses encounter when providing nursing care. Additionally, the study will explore educational strategies for improving nurses' technological competence and safe nursing practice. First, the researcher will present a historical perspective of how ICUs emerged and the relationship between technology and the critical care nurse. This historical overview will then transition into the current state of new and complex medical devices in the ICUs. Chapter 2 will present the Conceptual Model for Technology, Nursing, and Patient Safety Powell-Cope et al. (2008) and discuss the relationship between nurses and technology. The researcher will also discuss the viewpoints, perspectives, and research findings in the literature focusing on the strengths, limitations, and opportunities to support this research study.

Databases, Keywords, and Resources

Articles published in English between 1980 and 2018 indexed in PubMed, Cumulative Index to Nursing and Allied Health Literature, Scopus, Cochrane Library, Google Scholar, and ClinicalTrials.gov were selected for this review. The Boolean keywords " patient safety AND medical devices, AND critical care nurses, OR technology" were used to conduct the article search. Boolean logic is a system of showing relationships between sets by using the words AND, OR, and NOT. The term comes from George Boole, the man who invented this system (Rasmuson, 2016).

For inclusion, the articles had to be published internationally or in the U.S. They included editorials, qualitative and quantitative health science research on medical technology, critical

care nurses' using medical devices, and patient safety concerns. The search yielded 300 articles from CINAHL, 50 from PubMed, 24 from Direct Science, and 70 from OVID. A further review of PubMed and CINAHL using medical subject headings was done to ensure that no relevant content was missed. There was redundancy in the literature abstracts and titles among the databases. Approximately 140 articles were selected and thoroughly reviewed for supportive data.

Medical Devices in the ICU

Technology dominates the ICU environment. ICUs designed with technological devices and systems to care for patients with critical illnesses emerged in the 1950s. However, nursing care was not studied, despite nursing care being the primary purpose of the ICU. Instead, the focus was on medical devices and doctors. With the evolution of ICU nursing practice, a model to improve the care of ICU patients laid the foundation for patient-centered care (Fairman, 1992). In the 1960s and 1970s, there was an increase in ICUs, and technology became the mainstay of practice. Nurses practiced with data from medical devices paired with observational skills and expertise. The nursing profession began to understand nurses' influence in the ICU environment and the need to define the critical care nurse's role. Nursing care successfully impacted patient outcomes, hence validating the role of ICU nurses (Fairman, 1992).

There is an intertwining of nursing care and technology in the ICU. Cooper links technology, competence, and care as the three elements that ICU nurses equate to saving patients' lives. However, she also states that technological capabilities and taking care of patients' needs did not blend with nursing practice. Some nurses seem distracted by technology due to their lack of experience with devices, while others were skilled at delivering competent care using technology. Technological influence in ICU has a significant impact on patient care

and nursing practice (Cooper, 1993). Over the last 30 years, technological advances have steadily increased, hence transforming nursing practice. According to Powell-Cope et al. (2008), nurses and healthcare professionals utilize over 5,000 technological medical devices. Crocker and Timmons (2008) pointed out that the literature lacks sufficient evidence to describe nursing contributions using technology adequately. Critical care nurses are encouraged to examine the relationship between nursing and technology by refining and adapting technology to impact better patient outcomes. Little (2000) discussed the contradictions in the literature regarding technology and the nursing practice relationship. She argued that technology is a supportive aspect of nursing practice and that technological proficiencies are needed to practice competently. However, the insurgence of complex healthcare technology has also drastically affected critical care nurses' practice (Barnard, 2007; Sandelowski, 2000).

Critical Care Nursing and Complex Patient Care Technology

The nurse-technology relationship is one of the most emerging topics of discussion in the literature. All nurses use technology to deliver patient care. Complex patient care technology—such as ventilators, physiologic monitors, ICU beds, and smart infusion pumps—are among the numerous devices with which ICU nurses interact to make clinical decisions about patient care. Medical technology defines the complexity of the critical care environment. The ICU nurse manages almost a dozen different devices attached to a critically ill patient, each of which is equipped with a vital, life-saving function. It is essential that the end-users of these devices understand how ICU nurses interact with technology and the impact they have on safe patient care. Nonetheless, only a few research studies emphasize the ICU nurse's interactions with technology.

Meanwhile, new machines are introduced to bedside nurses with the expectation that they will adapt to using these devices with minimal support or clinical education. Lack of training and technical and clinical support can result in ineffective and incompetent use of the equipment. Nurses create workarounds when they are unprepared to use complex devices safely, and that behavior can also affect the quality and safety of patient care. Underreporting device-related problems is another behavior that can potentially harm both patients and nurses. Medical device errors are not only preventable but are also extremely costly. An estimated $17.1 billion has been reported as the cost of medical errors, with device-related errors as one of the main contributors. While many experts offer suggestions to this complicated problem, few solutions involve the ICU nurses' perspectives (Gurses & Doyle, 2014; Ruppel & Funk, 2018; Swayze & Rich, 2012).

As the rapid pace of healthcare transformations continue to evolve with technology being the catalyst, nurses remain the primary consumer of care technology. Nurses are committed to providing safe care. However, there are multifactorial barriers that impede the effective use of new medical technology. For example, the number of resources allotted to implementing new technology may be inadequate to supporting safe, high-quality care. The literature suggests that technology implementation decisions are more financially incline rather than emphasizing practice development. Since healthcare organizations face the financial challenges of implementing and integrating new medical devices, business managers and executives make healthcare technology decisions without engaging frontline nurses who can offer a care setting perspective. Subsequently, the result of not involving the bedside nurse can lead to overlooking key elements to safe care delivery. Providing adequate education, resources, and soliciting real-time feedback from nurses are among the top requirements to support nurses' adaptation of new technology (Gurses & Doyle, 2014; Hamer & Cipriano, 2013; Ruppel & Funk, 2018).

Currently, there is no theoretical framework that is associated with nursing and the use of medical devices. Powell-Cope et al. (2008) created a Conceptual Model for Technology, Nursing, and Patient Safety to illustrate the relationship among nurses' use of technologies using adaptations from Fuhrer et al. (2003) Conceptual Framework of Outcomes for Caregivers of Assistive Technology. The Fuhrer's framework concentrates on interventions of assistive technologies and devices ascribed to the physical environment to promote a disabled person's functional independence. In contrast, the nursing model includes a wide variety of patient care technologies used to provide nursing care. The categories of these devices include (a) direct patient care; (b) indirect nursing care; (c) communication; (d) patient protective; (e) nurse protective; (f) patient assessment, monitoring, and surveillance with patient assistive devices; (g) remote patient monitoring; (h) pattern identification; and (i) continuous learning. Devices designed to meet the needs of nursing care delivery effectively can promote safe patient care. Within the model are essential factors that play a vital role in nursing practice and patient outcomes.

The facilitating and restraining factors identified in this model are four workplace dimensions: organizational, social, environmental, and technological. Mutually, these four dimensions have a significant impact on nurses' use of patient care technology in their daily practice. This model provides a framework that shows the interconnections of the nurse-technology relationship. There is a need to develop the nurse-technology concept and theoretical framework further (Powell et al., 2008; Stone &Weiner, 2001; Swayze & Rich, 2012).

Facilitators and Barriers to Safe Use of Medical Devices

The structure and operations of organizations are evident within their culture, social norms, and the ethical environment they promote. Leadership's commitment to policies, training

programs, resources, and employee engagement define organizations. One example of an organizational factor is designing policies that focus on the Safe Medical Devices Act of 1990. Organizations must have policies and reporting structures in place that allow reporting of equipment safety issues. Organizations use these reporting systems to monitor and examine events to improve safer patient care delivery systems. The law requires mandatory reporting of device and user error related injury or deaths. However, despite regulations and mammoth evidence to support the need to increase safety practices in the healthcare business, there are insufficient initiatives to change the culture. The literature suggests that the lack of engagement among healthcare professionals is a contributing factor that is impeding the advances of the safety culture (Hignett et al., 2018; Powell-Cope et al., 2008; Swayze & Rich, 2012).

Furthermore, the Food and Drug Administration Reauthorization Act requires the Secretary of Health and Human Services to report the continued servicing of medical devices while focusing on quality and safety. However, healthcare organizations struggle with maintaining optimum patient safety for multiple reasons, including inadequate staffing and lack of appropriate medical technology. It is challenging for hospital administrators to provide continuing clinical education and the proper integration of new devices. Despite laws, regulations, and advances in technology, studies show that there has been an increase in device-related medical errors (ECRI Institute, 2018; James, 2013; Powell-Cope et al., 2008; Stone & Weiner, 2001).

The literature revealed that hospital systems rely on incident reporting systems that only capture about 14% of adverse events. Recent national studies of both physicians and nurses uncovered that two-thirds of physicians confessed to not reporting a serious incident to an administrator, nor was the documentation entered in the medical records (James, 2013; Levinson,

2012). Hignett et al.'s (2018) questionnaire survey of 330 English healthcare professionals reported a total of 760 issues that affect the delivery of quality and safety of care. Organizational culture was among the top challenges along with workload, ergonomics, and human factors issues. A common coping strategy for workplace difficulties is modifying work practices. While this strategy can provide equilibrium and efficiency, it can lead to unsafe practices that can result in harmful events. The literature discusses conflicts among professionals regarding the cost-effectiveness compared to the clinical effectiveness of medical technology. These are not new problems. However, the mounting concerns and lack of improvement and resolution must be addressed (Hignett et al., 2018).

A comprehensive literature review concluded that the safety culture in American hospitals is a complicated concept and difficult to comprehend. Thus, it presents an operational challenge to hospital leadership. Another factor that added to the complexity of hospital safety culture is the increasing expectations of healthcare consumers and external regulatory agencies to assure the prevention of medical error and delivering safe patient care. Healthcare organizations are financially challenged to provide sufficient resources and training programs to maintain clinicians' technological competence. Additionally, administrators are sometimes not well informed on the safety implications and unintended consequences of their decisions when purchasing technology without input from the end-users (Gurses & Doyle, 2014; Ruppel & Funk, 2018; Sammer et al., 2010).

The literature identifies trust issues among administrators and bedside nurses as a concern for device-related safety problems. Administrators and amateurs viewed nurses' attitudes and behaviors about technology and patient safety as apathetic, complacent, overwhelmed, and negligent. Leaderships' perception is that nurses are ignoring alarms and abandoning their

patients. These implications of leadership suggest that there may be trust issues or a lack of understanding of the nurses' experiences related to medical device alarms. Leaders may benefit from gaining an understanding of equipment alarms and nurses' responses. Instead, the recommendation was to develop escalation procedures and policies requiring everyone to respond to clinical alarms. While there may be a need for an escalation policy for responding to alarms, the outcomes of nurses adopting new technology in practice should be considered. Technology is a valuable adjunct to providing safe care, depending on whether it is helpful or harmful to the patient. There are safety risks associated with nurses' level of reliance and trust in technology, hence overshadowing their awareness of potential errors. The research shows that automation contributes to a high degree of trust and reliability, resulting in less diligence when nurses are monitoring performance. Complacency has been proposed as a cause of not identifying equipment failures (Browne & Cook, 2011; Hamer & Cipriano, 2013; Lukasewicz & Mattox, 2015).

Nurses' levels of trust are associated with their perceptions of leadership and organizational support. Trust and empowerment between leadership and staff influence safety culture and behaviors. A descriptive study suggests that there may be a correlation between ICU nurses' structural empowerment and patient safety culture. The survey response rate implied that participants might have issues with trust in the organization. The literature reveals a link between medical errors and nurses' work environment. Studies also indicate that a non-punitive organizational culture promotes medical error reporting and opportunities to improve patient safety. Implications for nursing leaders are to develop system practices to enhance the structural empowerment of nurses, improve patient safety, and foster trust within the organization. Nurses perceived a decrease in opportunities the more years they worked of the organization, which may

imply a need for an organizational structure that offers resources, support, and opportunities to staff (Armellino et al., 2010).

One of the key initiatives of the IOM 2004 report was to maintain patient safety by transforming the nurses' work environment. This recommendation was based on the IOM findings, which suggested taking multiple approaches to improve the quality and safety of patient care: (a) fostering trust between nurses and institutional leadership, (b) involving nurses in executive decision-making, and (c) providing learning opportunities for novice and experienced nurses. (Sherwood & Barnsteiner, 2017). Implementing the IOM recommendations requires effective leadership at all levels of healthcare organizations, especially at the unit level. A concept analysis of the frontline managers' role revealed that there is a need for clarity of managerial competency and how their performance impacts nurse retention, nurses' job satisfaction, patient satisfaction, and quality outcomes. The literature suggests that further research is warranted to develop managerial competencies and evaluation (Gunawan & Aungsroch, 2017).

Cooper (1993) described ICU technology as invincible, predictable, inhuman, and objective in contrast to nursing care being vulnerable and humanistic. Technology dominates the ICU environment and defines critical care nursing. Despite the safety benefits of new technology, there continue to be technology-related errors and patient harm. The UK National Patient Safety Agency found 1,021 device-related patient safety events within 7 months. The reported incidents were due to device failure, improper use, inadequate staff training, and maintenance. The complexity of technology and medical devices requires nurses to cultivate astute error recognition skills. Given the continuous development of medical devices, nurses

need ongoing and updated clinical education to maintain their technical competence (Ewertsson et al., 2015; Polisena et al., 2015; Sowan et al., 2017).

To improve the culture of safety, there must be evidence-based education on the importance of competence and following safe practice guidelines. Federal agencies such as the Centers for Medicare and Medicaid Services (CMS) and Agency for Healthcare Research and Quality (AHRQ) support hospitals by promoting more effective utilization of incident reporting systems. Recommendations include a national evaluation system of healthcare technology that would encourage all stakeholders to participate and enable the FDA to concentrate on creating policies that will promote processes to allow clinicians to use medical technologies safely and effectively. Designers of healthcare technology should be mindful of the impact on the end-users' workflow. Redundancy, irrelevant alarms, and persistent reminder messages may be ignored by end-users as insignificant, thus promoting behaviors that are incongruent with safe practice. Incorporating safety culture principles into the nursing curriculum is also recommended (Piscotty et al., 2015; Shuren & Califf, 2016).

Technology, Human Factors, and Safe Nursing Practice

The number of device-related errors is increasing, yet the problem is not clearly understood. What is known is that technology-related mistakes occur due to two main reasons: manufacturer-related errors and device-use error. Understanding human factor principles and how to mitigate the risks of mistakes can significantly reduce harm to patients. Human factors refer to the study of social interactions with the devices and products in their work and personal daily living environments. Many factors can affect peak human performance, such as the work environment or the complexity of a device. Human factors research examines and employs information about human strengths, behaviors, restrictions, and other physiognomies to create

systems, tasks, tools, and devices for safe and effective utilization within the workplace environment. Nurses use multiple complex technologies in highly disruptive, stressful work environments and follow institutional policies to perform nursing care. Some nurses may not possess the strengths, behaviors, and cognitive abilities for the job; hence, they may provide unsafe care and suboptimal job performance (Henriksen et al., 2008).

Nursing workflow and clinical practice are rapidly evolving due to the advancement in technology and changes in healthcare policies. To make patient care delivery safer, human factors researchers have developed medical devices with the end-users' strengths and limitations in mind. The ease of use and error recognition are vital considerations when designing new technology. Standardization and simplification of device processes and functions can minimize errors and improve performance efficiency. However, despite these safeguards in technology design, the number of device-related errors continue to escalate. In addition to expert clinicians, it takes knowledge and understanding of the systems in which they work to achieve successful outcomes. The workflow processes, situational stresses, and long work hours are contributing factors to fatigue and increase risk for errors. Accurate equipment interfaces such as cables and adaptors that are necessary for device function and operations are safety factors for clinicians to remember. Incident rates can be improved by anticipating the limitations as well as the risks for failure within systems and creating an early error detection mode. Human behaviors were the main reason for these errors (Henriksen et al., 2008).

Unsafe actions include practice violations, errors, mistakes, slips, and lapses. These behaviors increase the risk of harm in modern technologically-advanced healthcare systems. Using clinical pathways as a method of behavior modification may improve quality and safety outcomes (Mitchell & Tehrani, 2017; Reasons, 1995). According to Vincent (2003),

understanding adverse events and how to respond to them are challenges that healthcare leaders must embrace. The investigative framework used to analyze the event should provide lessons to the individuals involved in an incident. The approach to understanding the problem consists of addressing (a) the care-management problems, (b) the context in which the event occurred, and (c) the contributing factors to the problem. Hospitals are implementing high-reliability organization (HRO) concepts and strategies aimed at preventing errors and improving patient safety. The HRO principles include standardizing processes, embedding redundancy, fostering teamwork, effective communication, and increased leadership visibility. Nurses are encouraged to speak up and participate in organizational policy development. Unit leaders should provide staff with guidance and support while holding them accountable for safe patient care. Engaging the healthcare team to utilize safety checklists and procedures is crucial to decreasing patient harm. Empowering staff to report unsafe situations anonymously is another way to improve patient safety. All nurses should work in HROs that have a safe practice environment (Padgett et al., 2017).

The nature of technology-related errors remains unclear and warrants research for better understanding and safety interventions (Mattox, 2012). There is insufficient evidence of effective medical surveillance systems designed to improve patient safety in hospitals (Polisena et al., 2015). However, some errors are design and device-related, while others are user-related (Mattox, 2012). The Joint Commission and other healthcare organizations focus on the manufacturing and safe utilization of medical devices (Lukasewicz & Mattox, 2015). Murdoch and Cameron (2008) recommended that smart infusion technology becomes the minimum safety standard in ICUs. The smart infusion pump contains a customized drug library and lockout drug limits to improve patient safety. Dobrzykowski et al. (2016) reported that using a lean

methodology in healthcare operations can result in favorable safety outcomes. Other benefits included improvements in financial and professional service operations. Nurses' perceptions of safety about their work environment and leadership support can influence how they interact with technology in daily practice (Sabzevari et al., 2015). Gaining insight into their safety perceptions and interactions with complex devices can provide baseline information for nurse leaders, educators, and researchers.

Nurses' Experiences When Using Complex Medical Technology

Nurses are vulnerable to the risk of errors associated with using cutting-edge devices predominantly due to time constraints to operate the machines proficiently and limited training. The complexities of new technology, coupled with inadequate training and the urgency to adeptly utilize the technology, can become stressful for nurses. Inadequately prepared nurses may experience anxiety and stress when providing care with complex machines leading to fear of technology. Similarly, Polisena et al. (2015) stated that the complexity of technology and medical devices requires nurses to be competent in error recognition. When nurses lack the competence to operate correctly and effectively identify device errors, unintentional patient harm can result. Adequate education and training can increase their technical capabilities and promote safe care (Kiekkas, 2014; Polisena et al., 2015).

Seven international qualitative studies exploring critical care nurses' experiences and perceptions uncovered that nurses have both positive and negative experiences when using technology in nursing practice. Australian, Greek, and Swedish nurses asserted their dissatisfaction with their lack of autonomy in choosing devices to purchase. They viewed technology as essential to their practice, but they sometimes perceived it as an impediment to care. Technology provided accurate, accessible, and patient predictive information to manage

patients' situations. However, they also expressed feeling overwhelmed, frustrated, and afraid when working with new advanced technology, which can be time-consuming when nurses are unable to operate or troubleshoot the device. Nurses would benefit from training on how to use technology to recognize patterns in patient data and make clinical decisions to improve patient outcomes (Kiekkas et al., 2006; O'Connell et al., 2007; Tunlind et al., 2015). Alastalo et al. (2017) interviewed 20 ICU nurses using semi-structured questions to elicit their observational skills and competence. Their thematic analysis showed that despite the abundance of information obtained from medical devices, nurses rely on their assessment skills. Although nurses felt that it was essential to understand the operational principles of medical equipment, they trusted their observations more than the device. Nurses placed more value on being able to use their senses to evaluate the clinical situation compared to using the data from medical technology.

In a study of Irish nurses, McGrath (2008) reported that although they valued technology as a catalyst in critical care nursing practice, it can dehumanize nursing care and become a source of anxiety and panic when nurses unfamiliar with the devices. While technology was significant to their practice, nurses stated that it was time-consuming to use and high maintenance, leaving them with less time for nursing care. Nurses and physicians disclosed that the rapid turnover of medical devices made it difficult for them to learn the nuances of devices. Ribeiro et al. (2016) observation of Brazilian ICU nurses' use of equipment revealed issues of inconsistencies in practice, lack of knowledge, and failure to follow procedures. The gap in the literature shows a lack of evidence of American nurses' perceptions and attitudes about the increase of new technology in nursing practice and the impact on safe patient outcomes. Research is needed to understand the current state of this phenomenon from the American critical care nurses' perspectives (Alasad, 2002; Polisena et al., 2015).

Crocker and Timmons' (2009) ethnographic study found that while new nurses were more task-oriented and focused on caring for the technology, experienced nurses viewed technology as an adjunct to their nursing care. The increase of technology in nursing practice promotes autonomy and enhances critical thinking, but successfully incorporating technology into daily nursing practice depends mainly on its ease and utility from the nurses' perspectives (Smallheer, 2015). Similar findings in a cross-sectional study on the effects of technology on nursing care revealed that younger nurses viewed technology negatively compared to more experienced nurses. A primary challenge for most new nurses is their ability to adopt technology and blend it with nursing care. Novice nurses had more difficulty determining how to harmonize and leverage patient care technology in their practice. One of the reasons for this problem is the lack of continuing education on how to adapt and integrate new technology into nursing practice to maximize patient care delivery. It requires nurses to commit to lifelong learning and embracing innovative approaches to patient care (Bagherian et al., 2017). As nurses assume responsibility for maintaining the knowledge and technical skills required to deliver patient care safely, healthcare organizations and leaders are accountable for maintaining an organizational culture of safety. However, despite the many safety initiatives from governmental and professional organizations to improve the healthcare delivery systems, more opportunities exist (Mannion & Braithwaite, 2017). This study assessed nurses' perceptions of safety within their work environment to achieve an understanding of the factors affecting their practice.

Medical Technology and Patient Safety Culture

When nurses are knowledgeable about patients' conditions and the medical devices used to deliver care, they can anticipate and recognize equipment problems. Huston (2013) warned that nurses will need to acquire new skills to integrate emerging medical technology into nursing

practice. The literature suggests that ICU nurses may develop complacency when using medical devices, which can lead to inadequate monitoring and failure to identify problems and device errors. Placing such high reliability on automation can result in fatal outcomes. There are concerns about the possible harmful effects of nurses' complacency and inappropriate trust in medical technology (Brown & Cook, 2011). According to Ewertsson et al. (2015), only 19% of nurses admitted to reporting device-related incidents, and over 50% sometimes or never reported incidents. Stated reasons for not reporting events included time constraints, overlooking, inexperience, and humiliation (Ewertsson et al., 2015; Polisena et al., 2015; Sowan et al., 2017).

The complexity and severity of critically ill patients warrant the use of life-saving technology. Severely ill patients with life-threatening health issues such as organ failure, for example, are admitted to ICUs for care and treatment with sophisticated technology (Skinner et al., 2015). According to Sabzevari et al. (2015), more than 50% of the American population becomes critically ill as they age, thus requiring ICU care, and many do not survive despite advanced medical interventions. Furthermore, there is an increasing need for ICUs and trained professionals to care for patients with life-threatening medical illnesses. ICU nurses provide care to critically ill patients and their families using complex machines, devices, and procedures. Some patients require a mechanical ventilator to breathe for them to recover from severe medical conditions such as a stroke or a traumatic brain injury. Other patients may suffer from complete kidney failure, therefore, requiring a continuous renal replacement therapy machine to keep them alive.

When patients are their sickest and struggling to stay alive, it takes a highly skilled team of medical and nursing professionals to manage their recovery safely and successfully. The need for continuous monitoring of patients' vital signs from minute to minute is only possible by

using physiologic monitors that are capable of capturing and displaying patients' heart rate, respiration, blood pressure, body temperature, and oxygen saturation percentage simultaneously. Critical care nurses are responsible for monitoring and managing the data produced by the highly technical devices attached to the care of critically ill patients. Therefore, the risk for sentinel events is higher in the ICU setting (Basuni & Bayoumi, 2015).

Critical Care Nursing and the Practice Environment

The ICU environment is defined by the physical space, the situations occurring in that space, and workspace ergonomics. Other critical environmental considerations include light, noise level, and architectural design and floorplan (Powell-Cope et al., 2008). Given the critical nature of patient care, ICUs are designed, organized, staffed, and equipped to handle life-threatening emergencies at all times. Patients are highly visible, and nurses are present at the bedside continuously monitoring and intervening to provide care as needed. Emergency life-saving devices such as defibrillators and airway management tubes are readily available for immediate use. Hallways and corridors are kept unobstructed by equipment and crowds of people (Crosbie, 2014). Patients may have individual rooms separated by glass doors that allow for continuous visibility. Individual ICU rooms are also used to isolate patients with contagious diseases. Floorplans may be in pods of two or four patients separated by movable curtains. Centralized nurses' workstations have physiologic monitoring with specific parameters and alarm settings for all of the ICU patients. ICU beds themselves have unique features such as buttons in the side rails that enable nurses to elevate the patient's bed, turning features to assist with placing patients in the desired position, and mattress pressure adjustments function to prevent pressure ulcers (Crosbie, 2014).

The ICU environment is populated with numerous technologies and medical devices that create a foundation for critical care nursing practice. Since they are working in complex, high-stress environments where patients are the sickest, nurses must operate cutting-edge technologies safely and provide safe patient care competently. Physiologic monitoring systems, mechanical ventilators, smart infusion pumps, and ICU beds are among the many sophisticated critical care devices and technology necessary to manage the care of patients in the ICU.

Exploring innovative ways to integrate new technology into nursing practice is significant in advancing the nursing profession. There is a need to ensure a balance between technologic influence and human concepts of nursing care. Investigating and understanding nurses' viewpoint of how technology can improve the quality, safety, and efficiency of patient care is crucial to advancing nursing practice (Barnard, 2007; Sabzevari et al., 2015; Sandelowski, 2000).

Critical Care Nursing Competencies

There is no confirmed theoretical definition of nursing competency, and a lack of consensus exists among employers, governmental and regulatory agencies, educators, and patients. Despite the ambiguity in the literature for the term competency, most descriptions mention one's ability to make reasonable decisions and perform their work. In nursing, core competencies are specific sets of knowledge and skills needed to provide patient care safely. In addition to skills, one's level of motivation, maturity, attitudes, astuteness, and approachability are associated with their competencies. The foundations of nursing care are associated with both technical and human skills. For example, hemodynamic monitoring is the technical aspects of nursing, while therapeutic communication is the humanistic qualities of nursing competence. Developing competency can be difficult and complicated. Therefore, nurses need to gain

experience and develop the knowledge and skills necessary to become competent in clinical practice (Axley, 2008).

The Joint Commission expected standards for nursing competency include knowledge, skills, and capacity to perform nursing care. Nursing competence directly impacts the quality and safety of patient care. Hence, the absence of competence can result in harm to patients. A primary concern in nursing is the technological competency of nurses to operate and identify device errors appropriately. Critical care nurse competence should include skillful use of medical devices based on understanding their operational principles and ability to recognize device errors, malfunctions, and artifacts and validate the reliability of the data (Alastalo et al., 2017; Axley, 2008).

Axley (2008) stated that ICU nurses' competence cannot be observed directly. Little (2000), meanwhile, argued that there is an undisputed concern that critical care practice has a unique requirement for technological competence that is missing in the nursing curriculum. Little emphasized that the critical care technical environment provides an opportunity to conceptualize nursing fundamentals of nursing practice. Little distinguished between the nature of ICU nurses' practice and their required competencies. Nonetheless, she does not discuss the mitigating factors affecting the nurses' ability to gain technological competency. Bench et al. (2003) developed a competency framework for critical care nurses consisting of three main categories of competence: (a) assessment and interpretation, (b) therapeutic intervention, and (c) evaluation strategies. These are highly complex competencies that require specific criteria to evaluate the work performance of novice and experienced ICU nurses. The framework, which focuses on nurses' competency based on the patients' severity of illness, may provide a feasible method for

evaluating ICU nurses' competencies. However, it does not include technological competency and how nurses use technology to manage care.

Alastalo et al.'s (2017) descriptive qualitative study of 20 ICU nurses concluded that, aside from using medical devices to gather patient data, nurses' patient observation skills were valuable to include in clinical practice education and orientation framework. Patient observation skills consist of four categories: (a) information-gaining skills, (b) information-processing skills, (c) decision-making skills, and (d) cooperation skills. These researchers recommended using patient observation skills as part of the ICU nurses' competency evaluation. Similarly, Martinez (2016) descriptive correlational study reported findings of technological competence related to caring and clinical decision making. However, the study did not address the defining characteristics of the advanced medical devices used to provide nursing care or how nurses use technology. This study posited that nurses' internal attributes such as self-confidence and competence, combined with education, resources, and feeling supported, all contribute to good decision making. However, it does not present the barriers of nurses using sophisticated technology. The current study aimed to gain insight into issues that ICU nurses encounter when using complex technology and how it affects their practice. Understanding the technological challenges associated with patient care will promote developing tools to educate and evaluate nurses' technical competence better.

Technological Competence

Locsin and Purnell (2015) referred to critical care nurses as "technological connoisseurs." According to the authors, ICU nurses have mastery using technology to care for patients seamlessly. Critical care nurses are technologically skilled in the art of knowing and doing, thereby creating a balance between using technology to assist in managing the complexity of

human responses and sustaining life. The ICU nurse demonstrates technological competence by maintaining a patient with a critically low blood pressure who is considered hemodynamically unstable. The nurse stabilizes the patient's blood pressure by titrating a potent vasoconstricting medication while being guided by the blood pressure readings produced by the arterial pressure monitoring device. The arterial line produces a waveform and the systolic and diastolic blood pressure numerical values that are recorded and displayed on a physiological monitoring device in real-time. Nurses are technologically skilled in discerning the meaning of arterial waveform and blood pressure readings using their knowledge and astute decision-making abilities to maintain the patient's hemodynamic stability by manipulating a powerful drug carefully. Nurses use these advanced technologies to gather critical information to provide nursing care. Being proficient in using complex devices allow nurses to focus on the patient as a person while providing valuable information to manage the patient's medical condition (Locsin & Purnell, 2015).

The challenge for nurses, especially ICU nurses, is to balance technological competence with all aspects of human care. Integrating technology and the art of caring would be an ideal care model for nursing; however, it is difficult to accomplish. Parcells and Locsin (2011) developed a psychometric testing instrument to measure technological competence as caring. While this tool focuses on the caring aspects of technological competence, it does not address the concerns about nurses' abilities to use advanced technologic devices safely. Several factors influence the nurse's ability to provide technologically competent care. Locsin (1995) argued that since medical technology is embedded in nursing practice, technological proficiency is part of nursing care. Technological competence is evident when nurses integrate technology into care delivery using a seamless and harmonious approach that benefits patients. The current

exploration of technological competence from a theoretical perspective is the engineering of technology that mimics human beings through artificial intelligence embedded in autonomous robots. Technologies will remain an inevitable part of patient care delivery. Hence, demanding that healthcare organizations adopt the advances of technology into patient care practices is critical. The literature questions the role of autonomous robots programmed with artificial general intelligence and whether it will replace nurses. Though these advanced technologies may not replace nurses, they will proliferate throughout nursing practice in the future. The literature suggests that nurses examine current predictable care processes and tasks that can be overtaken by technology (Locsin, 2017). Meanwhile, the research to date does not address the barriers that nurses currently encounter when using complex technology. Therefore, this study examined the work-related dimensions that inhibit safe nursing practice by impeding technological competence.

Continuing Clinical Education for Nurses

The literature promotes awareness of device-related errors. Fundamentally, there are two types of device-related errors: design flaws and user errors. It is sometimes difficult to identify the difference between the two kinds of mistakes. Nurses can reduce the potentially harmful effects of device-related errors by knowing how to intervene when devices malfunctions. Nurses should be prepared to promptly intervene, replace the flawed device, secure the device, and report the incident (Swayze & Rich, 2012). Poorly design medical devices, combined with environmental factors, inadequate training, stress, inexperience, and fatigue, can affect nurses' ability to deliver safe care. These factors can lead to unsafe practices.

Nurses at the bedside are in a unique position to prevent errors or near-miss events and evaluate the failure from their perspective. Mattox (2012) suggested several strategies for

decreasing device-related errors, starting with acknowledging that mistakes happen. Secondly, removing the culture of blame and promote and encourage awareness and incident reporting. The third approach is to mandate that devices meet the standards of human factor engineering and that the design meets care needs. Involve clinical staff nurses in the evaluation of the new equipment before purchasing and listen to their feedback.

The literature suggests that nurses using sophisticated monitoring gadgets seem to lack awareness of failures or errors of the machines. Because of technological complexity, many nurses have verbalized the need for more education and training to manage technological medical devices safely. However, many nurses are silent about their deficiency of technical competence. Nurses stated reasons for not reporting events included time constraints, overlooking the error, inexperience, and humiliation (Ewertsson et al., 2015; Lange et al., 2014; Mattox, 2012). Many nurses reported being self-taught and learned how to use patient care technology through trial and error. Inadequate preparation to use patient care technology compromises patient safety, nursing practice, self-efficacy, and consumer confidence (Ewertsson et al., 2015; McConnell, 1995; Sowan et al., 2017). The complexity of technology and medical devices requires nurses to have astute error recognition skills. Because of the continuous development of medical devices, nurses need ongoing and updated clinical education to maintain technical competence (Ewertsson et al., 2015; Polisena et al., 2015; Sowan et al., 2017).

Without the skillful abilities of nurses to integrate technological competence into nursing practice, patient safety is jeopardized. The literature suggests that simulation-based learning is an innovative, effective, and safe teaching strategy to educate ICU nurses (Burnette et al., 2016). Both employers and nurses are responsible for continued learning to enhance technical skills. Ongoing clinical education and skills training in managing medical devices can promote safe

patient care. Providing adequate support, resources, mentors, and training guides can contribute to the safe use of technology. Clinical educational strategies should incorporate simulation in a clinical skill laboratory that includes discussions on the principles of medical device application, a review of device-related incidents, and an analysis of how to prevent clinical errors (De Veer et al., 2011; Ewertsson et al., 2015; Weckman & Janzen, 2009).

Legal and Ethical Aspects Medical Technology and Nursing Practice

The American Nurses' Association (ANA, 2015) scope of practice outlines the duty of nurses to maintain competence in practice. Nurses have legal and ethical obligations to provide safe patient care when using medical technology (Harding et al., 2011). Nurses depend on modern technology to guide their clinical decision-making and to provide safe nursing care (Powell-Cope et al., 2008). The literature illuminates patient safety concerns related to using medical technology and devices among critical care nurses. An error made in healthcare can result in serious patient injury or death. Annually, an estimated 44,000 to 98,000 patients die due to mistakes during care delivery. Reporting errors is a critical part of the risk management information system. The literature suggests that to improve the safe use of medical devices, leaders, administrators, and all stakeholders should have a clear understanding of the implications of technology-related adverse events and implement safety processes. Organizations should have an open disclosure policy and guidelines for communicating mistakes to patients and families. Employees experience anxiety and embarrassment when involved in medical incidents. Providing employees fundamental education about the legalities associated with the incident may help to alleviate concerns about potential litigation (Mattox, 2012; Reason, 1995; Sherwood & Barsteiner, 2017; Vincent, 2003).

Clinical alarms are a significant safety problem for medical equipment. Although not a new issue, it continues to be a leading contributor to serious adverse events resulting in deaths. Edworthy (2013) argued that there should be directives for how new technology should meet basic alarm safety standards. The time has come for stringent processes to assess and evaluate new patient care technologies for reliability, validity, suitability, and appropriate use to prevent patient harm. From a legislative perspective, manufacturers should be required to design medical equipment that is intuitive and can anticipate the risk of different types of errors, thereby preventing harm. All devices should include tutorials and educational guides, thus, preparing nurses to manage complicated medical devices better. Another workplace hazard for nurses is sensory overload resulting from multiple equipment alarms sounding excessively, termed "alarm fatigue." Nursing organizations and The Joint Commission made alarm fatigue and alarm management a 2014–2016 National Patient Safety Goal. Improvements in medical equipment designs and research to aimed at a better understanding of alarm management and what is most useful for nurses (Edworthy, 2013, Korhonon et al., 2015; Shostek, 2007; Winters et al., 2017).

From a moral and ethical perspective, nurses view medical technology as interference to nursing care. At times, the complexity of the machinery requires nurses to pay more attention to their functions than to the person it is intended to help. While technological competence is revered and viewed as prestigious, nurses must learn how to maintain a balance between caring and how they use technology. Nurses who face the challenges accompanied with medical devices may develop workarounds. The person using a device and the context in which it is used influence safety outcomes. Therefore, understanding the relationship between nursing care and how to use medical technology is necessary. The equilibrium between caring and technological effectiveness is a plea for ethical consciousness. An example of the need for nursing conscience

is, believing a patient who is in pain without a visual or numeral display on a monitor to validate the patient's subjective assessment. Nurses' increased reliance on technology to provide clinical evidence when the truth may only exist within the human being, and assessing the human caring that nurses provide, is an increasing dilemma for nurses (Korhonon et al., 2015).

Although a few recent studies have focused on the ethical issues related to medical technology, there is a need for more research and evidence. The rapid and pervasive nature of technology in healthcare delivery over the last two decades have provided sparse and fragmented knowledge about the ethical aspects associated with its use. The nursing profession has encountered the crossroad of acknowledging the ethical challenges of integrating technology into the art and science of caring. Nursing concepts of caring and ethics have to include technology as an inextricable component of nursing practice. Technology is essential to delivering nursing care, and the literature provides evidence that supports both the actual and potential benefits of high-quality patient care.

Nonetheless, there are concerns about the risks associated with care technology and holistic nursing care. A current challenge that nurses must overcome is balancing technological competence and compassionate patient-centered care. Nursing professionals need to learn how to integrate the knowledge, technological skills, and safety behaviors required in that practice environment. Additionally, nurses will also need to recognize the ethical issues that are associated with medical technology and be prepared to advocate for their patients and practice. Nurses must address their concerns with administrators, nursing leaders, and educators. Therefore, contributing to improving the patient safety culture (Barnard & Sandelowski, 2001; Korhonon et al., 2015; Wolpin & Stewart, 2011).

Future Nursing and Medical Devices Research

Advances in healthcare technology have contributed to improvements in patient care delivery. However, there is insufficient evidence of the impact on the safety, effectiveness, and efficiency of patient care. There are opportunities to improve the safe use of complex technologies by identifying and addressing the primary sources of medical errors. Government agencies, healthcare organizations, and professional nursing organizations must partner with manufacturers to discuss how to design and implement new medical technology (Wolpin, 2011).

The U.S. first industry council partnership was established by AAMI (2016) with vendors and healthcare professionals from the American Association of Critical Care Nurses to advocate for patient safety. The AAMI acknowledges that medical devices have become more complicated and directly interrelated with patient care delivery. While there is an intense focus on nursing education and training, there is a need for chief executives, chief operations, and chief financial officers, and chief nursing officers to become involved in these dialogues as well. Several opportunities were identified, including a lack of technical competency requirements, inconsistencies in the educational programs, and inefficient hospital systems. Administrators lack a clear understanding of training costs, the increase in complex technologies, and the demand for the most innovative technologies from patients and families (AMMI, 2016).

In the future, addressing new technologies should be accompanied by involving nurses in technology design and ongoing clinical education that is adequate and consistent with best practices. Research is needed to develop tools to monitor and maintain equipment safety. Defining technological competence and designing competencies is essential to ensure safe clinical practice. Engaging healthcare leaders to support safety initiative and accountability to safe patient care is required for successful program implementation.

Administrative and organizational support is necessary to assess the costs and benefits of investing in staff education and competencies that promote quality, safe patient care. True collaboration and partnership among clinicians, educators, administrators, and manufacturers are needed to ensure the safe advancement of healthcare technology. The Systems Engineering Initiative for Patient Safety (SEIPS) model and the human factors framework are recommended approaches to improving the quality and safety of patient care. Balancing staff engagement and better work systems can produce positive outcomes. Nursing leaders have the power and influence to drive patient safety. By using evidence-based practice and engaging in human factors research, nursing leaders can make a significant impact on improving the culture of safety (AMMI, 2016; Carayon et al., 2014; Fischer et al., 2017; Grote, 2014).

Chapter Summary

This chapter has illuminated the gap between nurses' behaviors and attitudes towards new technology in their daily work and developing mastery using these devices. Qualitative studies reported that critical care nurses viewed technology as both a benefit and a hindrance to their practice. The ability to retrieve data from the machines easily was seen as beneficial to patient care. This feature allowed nurses to develop a timely plan of care or to intervene rapidly based on observed patterns and trends. Nurses also felt stressed when using complex medical devices due to the level of difficulty associated with operating them. The perceived usefulness of the technology and ease of using it may be contributing factors to nurses' level of proficiency and capacity when they are introduced to innovative machines.

Although the literature has discussed some of the problems associated with complex medical devices, it does not address the challenges of American critical care nurses in the current U.S. healthcare environment. There is sufficient discourse in the literature regarding

technological competence and its importance of complex healthcare technologies. However, the literature lacks a consensus definition of nurses' technological competence. A nurse-technology theoretical framework is necessary for developing nursing technological competence. This study examined critical care nursing practice and perceptions of safety when using complex machines. This study aims to gain insight into the current state of American critical care nurses' clinical practice and elucidate their experiences of using complex medical devices.

CHAPTER 3

METHODS

The purpose of this research is to examine the experiences, perceptions, and practices related to critical care nurses when using complex medical devices to provide patient care. The study aimed to gain insight into critical care nurses' perceptions of safety and competence related to using technology in the ICU environment. One of the main concerns that critical care nurses expressed in the previous literature was the need for continuing education and adequate training in the safe use of medical technology (Ruppel & Funk, 2018). This study also explored continuing educational strategies for improving nurses' technological competence and safe patient care. Chapter 3 will present the methodology used for this research study. A description of the research process, design selection, data collection, and management methods, as well as the recruitment strategies, will be outlined. The validity and reliability of the research instrument will be discussed with supportive evidence of its use in previous studies. Ethical considerations and limitations will also be addressed. Included is an overview of the data analysis strategies and techniques used to conduct the research.

Research Design

This research study used a mixed-methods approach to evaluate and explain the experiences and safety perceptions of ICU nurses when using complex medical devices to provide patient care. A mixed-methods approach means that data is collected and analyzed using both qualitative and quantitative methods for a single study. Using both a qualitative and quantitative approach could produce more information about the research topic and provide a balanced view of the problem. Mixed methodology research is an increasingly desirable research method for examining the complex issues associated with delivering healthcare. This

methodology allows the researcher to investigate distinct perspectives and discover connections among complicated levels of the research questions and decrease the gap in collected data. It appeals to the strengths of both the qualitative and quantitative methods to answer research questions of complex healthcare delivery problems from diverse perspectives using robust data. Qualitative design generally includes a small sample size and open-ended questions to yield detailed information. In contrast, a quantitative design uses closed-ended questions and large samples to gain generalized information. A mixed-methods approach allows researchers to amalgamate data from both the qualitative and quantitative methods while building connections and drawing conclusions from the findings (Creswell, 2014; Ingham-Broomfield, 2016; Shorten & Smith, 2017).

Three primary mixed methods designs can be used to answer the research questions. The most common designs are explanatory sequential, exploratory sequential, and convergent parallel. Explanatory sequential design begins with quantitative data collection and data analysis, which are followed by qualitative data collection that is utilized to explain preliminary quantitative outcomes. Exploratory sequential design collects and analyzes qualitative data first; then, the researcher collects quantitative data to examine and expand the initial qualitative results. The convergent parallel design utilizes both quantitative and qualitative methods to collect and analyze the data independently, followed by a complete interpretation of the results derived from both methods (Creswell, 2014; Schoonenboom & Johnson, 2017).

This study utilized a convergent parallel design consisting of simultaneous qualitative and quantitative data collection. The quantitative data collection included an online questionnaire survey from a large sample of ICU nurses about their safety perceptions within their work environment. Open-ended questions were included in the qualitative portion of the survey to

obtain participants' responses to their experiences working with complicated medical devices in daily practice. Qualitative and quantitative data were collected from the same sample. Participants from the larger sample who participated also responded to the open-ended questions. The participants who responded to the open-ended questions comprised a small sample; this approach is called the nested method, which refers to using the same sample to conduct both the quantitative and qualitative data collection (Creswell, 2014; Keptner, 2011; Morse & Niehaus, 2009; Onwuegbuzie & Leech, 2007; Palinkas et al., 2015).

Research Assumptions

The researcher's assumptions included the following:

- the methodology is suitable for answering the research questions;
- the participants will meet the eligibility criteria;
- ICU nurses' safety perceptions are related to their years of experience and level of education;
- ICU nurses' perceptions of their technological competence are linked to organizational learning and continuous process improvement;
- the research instrument is reliable and valid; and
- there is a need for standardized medical device education.

Setting

The study was conducted in a large nonprofit professional nursing organization that serves over 120,000 American critical care nurses. This nursing organization is recognized nationally for establishing and maintaining critical care nursing standards and for providing information, educational resources, and opportunities for specialty training. Internationally, it is the world's largest nursing specialty organization with regional and local chapters that allow

critical care nurses to connect. This organization was chosen due to its sizeable critical care nurse membership, which presented the possibility of gathering the desired sample. Site approval to conduct the online survey on the organization's website was obtained from the institution.

Sampling Plan

The sampling plan was to obtain the essential data from a large sample of participants who were representative of the desired population. The goal of this sampling plan was to allow the researcher to gather adequate data for analysis and to construct valid generalizations. Creswell (2014) emphasized the importance of procuring a relevant sample, which will significantly affirm the validity and generalizability of the research. The sampling strategy will be discussed in this chapter.

Sampling Strategy

This study used a nonprobability purposive sampling technique to answer the research questions. Participants with experience using complex medical technology to care for critically ill patients in ICUs were invited to complete an online survey. Sampling is a process used to select participants from a population. There are two types of sampling techniques: probability and nonprobability sampling. Probability sampling involves randomly selecting participants from the population using a process that allows different people to have an equal opportunity to be selected. The strength of probability sampling is that it provides a broad representation of the population, which makes the results more rigorous, precise, and credible. However, disadvantages to the probability sampling technique are; it is time-consuming, requires more resources, and may not be suitable for the research (Etikan et al., 2016; Palinkas et al., 2015).

In contrast, nonprobability selection applies convenience or purposive sampling. Firstly, convenience sampling is the process of choosing members of an intention population based on

the practicality and ease for the researcher to collect data. For example, the criteria could be that the group is easy to access, willing to participate, flexible, and available to the researcher. Secondly, purposive sampling refers to the careful selection of participants because their knowledge and experience are relevant to the research topic. The disadvantages of this method include bias sampling and unreliable data. The researcher has particular strategies in mind to uncover information for the issue of focus (Etikan et al., 2016; Palinkas et al., 2015).

Eligibility Criteria

Nurses participating in this study were required to be working in an ICU currently to be eligible to participate in the study. Working with multiple complex medical technologies including but not limited to mechanical ventilators, smart IV pumps, physiological monitors, ICU beds, hypothermia devices, and continuous renal replacement therapy machines was required. Eligibility required at least six months of ICU experience working with complex medical devices and critically ill patients.

Inclusion Criteria

Critical care nurses were required to have at least six months of experience working in an ICU as a full time or part-time staff member to participate in the study.

Exclusion Criteria

The exclusion criteria applied to nurses who were on ICU orientation. Nurses who had not used highly complex patient care technology to provide patient care in the ICUs were not eligible to participate in the study.

Determination of Sample Size: Power of Analysis

A convenient sampling of participants of critical care nurses from ICUs was needed for the study. The G*Power version 3.1 calculator was used to determine the *a priori* sample size

of $n = 314$ participants, for a confidence level of 95% and confidence interval or margin of error of 5%, as shown in Table 1 (Faul et al., 2009).

Table 1

Power Analysis Calculation : *T tests - Correlation : Point Biserial Model*

Analysis:	A priori: Compute required sample size	
Input:	Tail(s)	= Two
	Effect size |ρ|	= 0.2
	α err prob	= 0.05
	Power (1-β err prob)	= 0.95
Output:	Noncentrality parameter δ	= 3.6170891
	Critical t	= 1.9675965
	Df	= 312
	Total sample size	= 314
	Actual power	= 0.9501149

Note. Adapted from Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses, Faul et al. (2009), *Behavior Research Methods*, *41*, 1149-1160.

The sample size for qualitative data was dependent on the researcher's determination that saturation had occurred. In the qualitative method, saturation is defined as the point in data analysis when the same themes begin recurring and additional sources will produce no new insights (Saunders et al., 2018). To ensure sufficient data were collected to answer the research questions, an *a priori* sample of all eligible participants' responses was selected from the interview questions. The research considered the quality and quantity of the data collected by analyzing to determine saturation. When no new themes emerged after the analysis of all the participants' responses, the researcher concluded that the information was redundant and that saturation had been reached (Malterud et al., 2015).

Recruitment

The organization posted a brief abstract of the study along with an invitation to participate in the survey on its website. A recruitment letter was sent to the institution's regional

leaders requesting that they share the survey link. The regional leaders were asked to disseminate the information to local chapters, including posting on Facebook pages and in newsletters (see Appendix D).

Protection of Human Subjects

Institutional Review Board (IRB) approval from Nova Southeastern University (NSU) and the organization were obtained to conduct this study (see Appendix A). The research presented no more than minimal risk of harm to participants, and no personal identifiers were collected from the participants. The online survey was anonymous, and there was no personal identification information collected that could result in a breach of confidentiality. A consent form was included at the beginning of the survey. Participants proceeded to complete the survey voluntarily after reading the consent document, which followed the NSU's IRB requirements (see Appendix B).

Risks and Benefits of Participation

There were no foreseen detrimental effects from participating in the survey. Likewise, there were no direct benefits to participants in this study. However, participants had the opportunity to enhance knowledge important to optimizing nursing care and for improving patient safety.

Data Management and Organization

The data was collected and stored in the Research Electronic Data Capture (REDCap ©). REDCap© is a secure password access web-based application created by Vanderbilt University and hosted by NSU (see Appendix E). The web-based tool was designed to collect data, including survey data, for clinical research. The databases are secure and use intuitive interfaces for data entry validation, including audit trails and exporting the data to compatible software,

such as SPSS© (Harris, 2018). The data were downloaded and stored on the researcher's password-protected personal computer (Creswell, 2014).

Data Collection

Qualitative Data Collection

Within the REDCap© survey were five open-ended questions that allowed participants to write a narrative response, which allowed them to share their experiences in their own words. The semi-structured questions included follow up questions to further elaborate on the participants' answers. This method was best suited for this study since it allowed the researcher to format the interview questions to the topic of interest. The purpose of using semi-structured questions was designed to deduce the participants' viewpoints and attitudes and answer the research questions (Bengtsson, 2016; Creswell, 2014).

Qualitative Data Analysis

The researcher used a descriptive and interpretive data analysis approach. The first step entailed data aggregation of all text-formatted responses to the interview questions. NVivo© is computer-assisted qualitative data analysis software used to manage qualitative data. The next step was to organize the data into tables according to the research questions. The data was coded based on patterns and themes to gain an understanding of recurring concepts and allow the researcher to compile a summary of the dominant themes. The research determined that there was saturation when no new emerging themes were observed. The quality and quantity of the data were sufficient to answer the research questions by producing thick and rich descriptive data (Malterud et al., 2015; Saunders et al., 2018). Validating the reliability and consistency of data, one of the most important steps of qualitative research, was the focus throughout the data analysis process. The validity of the study refers to whether the appropriate tools and processes

were used to collect qualitative data. Triangulation is a technique used to integrate data in mixed methods research. First, the researcher analyzed the qualitative and quantitative data separately, then the findings of each method were listed, and the similarities and/or the differences among the issues were identified. The research questions were designed to elicit participant responses suitable for answering the research questions. The reliability of the qualitative approach depends on the consistency of the data.

The researcher used constant comparison and data verification during data extraction to confirm accuracy (Bengtsson, 2016; Creswell, 2014; Leung, 2015). The researcher provided trustworthiness of the study by assuring (a) credibility, which means that the researcher illustrates an accurate representation of the phenomenon being investigated; (b) transferability, which allows a reader to agree that there are ample contextual fieldwork details to suggest that the situation would be applied to another location and the findings similarly; (c) dependability, which refers to future researchers being able to replicate the qualitative work; and (d) confirmability, which verifies that the study findings were not based on the researchers' inclinations but only on the data collected (Shenton, 2004).

Instrumentation

Instrument—Hospital Survey on Patient Safety Culture (HSOPSC)

The quantitative approach investigated nurses' perceptions of the patient safety climate in their ICUs to explore potential predictors of overall safety perceptions using complex technology. The demographic data collected in the survey were used to answer the research questions. The instrument used to conduct the survey was the Hospital Survey on Patient Safety Culture (HSOPSC; see Appendix C). The Agency for Healthcare Research and Quality (AHRQ) and the Medical Errors Workgroup of the Quality Interagency Coordination Task Force

developed the survey to gather data about the attitudes and beliefs of hospital employees regarding their hospital's patient safety culture. This tool collected quantitative data on ICU nurses' perceptions of their work environment's safety practices and social characteristics. Specifically constructed using appropriate words and terminology, the instrument included essential aggregates of hospital safety culture, such as background questions pertinent to hospital and employee characteristics (Sorra & Nieva, 2004).

Validity

Patient safety is currently a central focus of healthcare research both nationally and internationally. Hence, several instruments have been designed to gauge patient safety in various environments and situations. The HSOPSC self-administered questionnaire is one of the most frequently used safety surveys. The instrument was designed to collect and measure data about individuals and groups of employees' safety perceptions, attitudes, and behaviors (Sorra & Nieva, 2004). For this study, the instrument was used to survey ICU nurses about their perceptions of barriers and facilitators associated with the safe delivery of patient care.

> The AHRQ defines an organization's safety culture as follows:
>
> the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures. (Sorra et al., 2016, p. 1)

In 2014, 653 American hospitals participated in the HSOPSC sixth national survey. The results of the study provided comparative data for leaders that assisted them in recognizing the strengths

and opportunities within their organizational safety cultures. Similarly, to emphasize the increasing need for a safer healthcare delivery system, the French National Health Authority in 2010 incorporated updated patient safety standards into their national accreditation process for all hospitals in France. The HSOPSC has been used as a valid safety assessment tool because of an increasing need for accurate assessment of hospital safety culture and patient safety. This tool provides data that is valuable not only to healthcare leaders, educators, and clinicians but also to policymakers. Survey results have safety implications that can lead to improvements in hospitals' safety culture and design safety education for employees (Giai et al., 2017; Sorra & Nieva, 2004).

Reliability

This survey was developed based on a literature review explicitly focused on safety management and accidents related to organizational safety culture using existing safety climate instruments. The instrument was pilot tested before the release of use. The survey items were statistically analyzed, and the reliability and validity of the safety culture scales were confirmed. Revisions were made to the tool to ensure that only the appropriate items and scales remained, thus verifying the psychometric properties. Satisfactory levels of reliability, described as a Cronbach's alpha equal to or greater than .60, were demonstrated in all dimensions (Sorra & Nieva, 2004).

The HSOPSC was designed to evaluate patient safety climate with the option to create intra- and inter-institutional comparisons of healthcare settings and report incident rates (Sorra & Dyer, 2010; Sorra & Nieva, 2004). HSOPSC was pilot tested in hospitals across the U.S. and multiple countries, including in Norwegian settings (Haugen et al., 2010; Olsen, 2008) and within ICUs (Armellino et al., 2010; Snijders et al., 2009). The Norwegian translation was tested

for validity and reliability among the healthcare staff in a hospital, with results indicating that the psychometric properties of HSOPSC were satisfactory and could be used in Norwegian hospital settings (Haugen et al., 2010; Olsen, 2008).

Etchegaray and Thomas (2012) conducted a study comparing the HSOPSC and the Safety Attitudes Questionnaire (SAQ) tools for validity and reliability. The ICU staff of 12 large southern hospitals in the U.S. participated in the safety surveys. Based on the regression analyses, it was suggested that the HSOPSC safety culture measurements were better predictors of reporting events, including patient safety perceptions. A cross-sectional study of 16 units with similar specialties at a Norwegian hospital examined the safety culture of incident reporting feedback. A total of 631 employees were surveyed on the seven dimensions of safety culture. The outcome measures for incident reporting culture showed a mean score of 3.10 ($SD = 0.65$), indicating a significant variance between the hospitals and clinics. A positive score for culture reporting was rated as equal to or greater than 4, revealing an opportunity for a practice improvement (Vifladt et al., 2015). In the Netherlands, the instrument was used with 583 employees in four hospitals to evaluate its validity and reliability. Post-translation, the psychometric properties of the tool's twelve-factor exploratory analysis were found to be satisfactory for 11 factors, similar to the original survey. Both the Dutch and American survey instruments were similar for most of the items included. However, some internal consistency factors were removed to strengthen the components. The study concluded that HSOPSC was a suitable tool for evaluating patient safety culture in foreign hospitals, including the Netherlands (Smits et al., 2008).

Scoring

The instrument consists of 42 questions with numerical scoring in 12 safety culture composites and items measured on a Likert scale ranging from 1 to 5: "strongly disagree" (1), "disagree" (2), "neither" (3), "agree" (4), and "strongly agree" (5). Item rating is also measured on a numerical scale, ranging from "never" (1), "rarely" (2), "sometimes" (3), "most of the time" (4), and "always" (5). The outcome item was rated based on the number of reported incidents within twelve months. Ratings for the number of incidents ranged from "no incident" (1), "one to two incidents" (2), "three to five incidents" (3), "six to 10 incidents" (4), "11 to 20 incidents" (5), and "greater than 21" (6). The patient safety grade ranged from "failing" to "excellent." Positive scores comprised the average percentage of responses on the items in each dimension (Giai et al., 2017; Nieva & Sorra, 2003; Sorra & Nieva, 2004).

Data Analysis and Statistical Strategy

The data collected using the HSOPSC surveys were analyzed using the R (version 4.2.0) statistical package. Descriptive analysis that included measures of central tendencies, such as the mean and standard deviation, was used to analyze the data. The range scores, lowest and highest ratings in the data sets, and data frequency were analyzed to evaluate the quality of the data. A two-tailed Pearson's correlation and linear regression model were used to test the hypothesis. All hypothesis testing was carried out at the 5% two-tailed significance level. The *p*-values were rounded to three decimal places. The *p*-values less than 0.001 were reported as <0.001 in tables. *P*-values greater than 0.999 were reported as >0.999. The researcher calculated the Cronbach's alpha coefficient for the 12 patient safety culture composites at a significance level of $p < 0.05$ to measure the internal consistency of the questions. The post analysis data were displayed using descriptive statistics, frequency charts, and model results. In the summary tables of continuous

variables, the minimum and maximum statistics, arithmetic mean (*AM*), median, 95% confidence interval (*CI*), standard deviations (*SD*), and standard error (*SE*) were presented at one decimal place from the original data.

Data Cleaning

Data cleaning is a necessary process to confirm data quality and validity. This process ensures that outliers are removed from the data to avoid threats to the validity and generalizability of the research findings. Researchers can increase accuracy and reduce the risk of error variances by utilizing a data cleaning process (Osborne, 2010). The survey was examined to ensure that each item all had responses in the correct range. No individual identifiers were used in the survey; therefore, a respondent identifier was produced electronically and assigned in each respondent's data file. ICU specialties were identified in the demographic data section of the survey. The researcher carefully reviewed the participants' written comments and de-identified any information that may have exposed their identities. Response frequencies were calculated with consideration to those responses with missing data. Percentages of positive scores were computed based on the guidelines for the reverse coding of negatively phrased items (Sorra et al., 2016).

Descriptive Analysis

Descriptive statistics were used both to describe the sample and to find the central tendency of the scores obtained. The R (version 4.2.0) statistical package was used for the descriptive calculation, reliability estimation, the participants' demographic characteristics, and the total number of positive responses. The percentage of positive response rates in each dimension was used to calculate the employees' attitudes and perceptions of the ICU's safety

culture. Quantitative variables were analyzed using the means and standard deviations. The significance level used for this study is $p = 0.05$ (Creswell, 2014; Sorra & Nieva, 2004).

Inferential Analysis

Inferential statistics were used to report the central tendency of the scores obtained from the HSOPSC instrument.

Reliability Testing

Reliability was tested for the HSOPSC instruments with an acceptable Cronbach's alpha of at least .70 as the minimum criterion based on an alpha range from 0 to 1.00. Each item was analyzed for internal consistency to ensure that the scale is reliable. The instrument was tested and validated for its consistency in measuring the constructs covered by the survey's 12 dimensions. The Cronbach's alpha was computed by comparing the scores for each item with the score of each respondent, followed by a comparison of that score to the variance of each item score (Sorra et al., 2016, Sorra & Dryer, 2010).

Hypothesis Testing

The demographic data collected from a sample of the population in this study provided the independent variables to test the hypotheses. Participants' number of years nursing, years worked in the ICU, levels of education, and medical device competency were used to test both hypotheses. The HSOPSC survey data included the dependent variables. The dependent variable used to test H_1 was overall safety. Organizational learning and continuous improvement was the dependent variable utilized to test hypothesis H_2, *p*-values less than 0.05, 0.001 were reported as <0.001, and *p*-values greater than 0.999 were reported as >0.999. The null hypotheses were rejected when the findings were significantly correlated with *p*-values less than 0.05.

H_{01}: There is no relationship between the safety perceptions of critical care nurses' and the level of education and years of experience using complex medical devices to provide patient care.

H_{a1}: There is a relationship between the safety perceptions of critical care nurses' and the level of education and years of experience using complex medical devices to provide patient care.

H_{02}: There is no relationship between organizational learning education and continuous improvement processes and critical care nurses' perceptions of technological competence.

H_{a2}: There is a relationship between organizational learning education and continuous improvement processes and critical care nurses' perceptions of technological competence.

A two-tailed correlation and a linear regression model were used to test the hypothesis. Both statistical analyses were also used to test the strength and direction of the correlation between the independent and dependent variables. The hypotheses were tested at a 5% significance level.

Threats to Internal Validity

Participants may have been unaware of the organizational procedures to answer all the survey questions. Some participants may have considered answering some of the questions to be a conflict of interest and chosen not to risk a response. They may have chosen not to answer some questions. All the survey questions may not have applied to all participants in all areas.

Limitations

Threats to External Validity

Participants might have discussed the content with others who have not yet completed the survey, which may have potentially influenced their responses. Access to the web-based survey

link may not have been readily available to all participants. The ICU work environment might not have allowed for adequate time to complete the survey (Creswell, 2014).

Chapter Summary

This chapter has outlined the specific steps in the mixed-methods approach used to conduct the study. A parallel mixed methodology was most suitable for answering the research questions regarding ICU nurses' experiences using complex medical devices. Using parallel mixed-methods meant that both qualitative and quantitative data were collected simultaneously from the same sample. A convenient sampling of critical care nurses was invited to participate in the online survey hosted by a professional nursing organization serving critical care nurses throughout the United States. Ethical considerations such as IRB approval, organizational site approval, and consent from participants, including the recruitment strategies, were discussed. Open-ended questions within the online survey were design to elicit qualitative data, and the HSOPSC survey instrument was developed to collect quantitative data. Data analysis and interpretation strategies were outlined as well. The validity and reliability of the HSOPSC tool were discussed, as well as the qualitative data collection method used. Potential internal and external threats were also examined.

CHAPTER 4

RESULTS

The purpose of this study was to explore the experiences and safety perceptions of critical care nurses' practice using complex medical devices in an ICU setting. The aim was to understand the challenges, including the barriers and facilitators that nurses encounter when providing nursing care. Additionally, the study examined the educational strategies for improving nurses' technological competence and safe nursing practice. The online REDCap© survey link was posted on the nursing organization's website with an invitation to participate. Data collection opened on February 5th, 2020 and closed on May 5th, 2020. Data analysis was run using R (version 4.2.0) statistical package and NVivo© for Mac 11.4.3. The demographic data, response measurements, hypothesis testing, and qualitative data analysis results will be discussed. Triangulation was used to compare, contrast, integrate, and interpret the quantitative and qualitative data.

Data Cleaning

The data was collected using REDCap©, a web-based survey. The survey link was posted on a nursing organization's website with an invitation for ICU nurses to participate. During the data collection phase, the data were monitored for the number of complete and incomplete responses. After the survey link was closed, the raw data were exported from REDCap© to R (version 4.2.0). The qualitative and quantitative data were separated for cleaning, sorting, and analysis. After a review of the quantitative data, all outliers and incomplete survey items were removed. A total of 269 surveys were analyzed, and 39 incomplete surveys had missing data. After they were cleaned, the data were examined for distribution and dispersion through descriptive numerical summaries and graphical tools to assess the distributional assumptions and

relationships among variables. The NVivo© software was used to review the qualitative data and identify codes, assign meaning, categories, and themes. There was a total of 74 narrative responses with 51 completed responses. Saturation was achieved after analyzing 468 response sets. The analysis, which involved constant comparison, resulted in 96 open codes from the first review of the data. There were 25 focused codes, which included categorical, conceptual, and thematic coding. There were six themes and one unifying theme. Both quantitative and qualitative data were used to answer the research questions.

RQ1: What are the experiences of critical care nurses working with complex patient care technology in daily practice?

A descriptive and interpretive analysis of participants' narrative responses and descriptive analysis of the HSOPSC variables were used to answer this research question. These composites were the following:

- Supervisor/Manager Expectations & Actions Promoting Patient Safety: B3. Whenever pressure builds up, my supervisor/manager wants us to work faster, even if it means taking shortcuts, and
- Staffing: A2. We have enough staff to handle the workload.

RQ2: What are the facilitators and barriers to using complex patient care technology to provide nursing care?

A descriptive and interpretive analysis of participants' narrative responses and descriptive analysis of the HSOPSC variables were used to answer this research question. These composites were the following:

- Teamwork Within Units: A1. People support one another in this unit;

- Feedback and Communication About Error: C5. In this unit, we discuss ways to prevent errors from happening again; and
- Communication Openness: C2. Staff will freely speak up if they see something that may negatively affect patient care and G1. In the past 12 months, how many event reports have you filled out and submitted? were used to answer this research question.

RQ3. What are the perceptions of nurses of the clinical education that they received to use complex patient care technology?

The descriptive and interpretive analysis of participants' responses and a demographical question on medical device education/competency were used to answer this research question.

RQ4. Which educational strategies are most useful to facilitating patient care technological competence?

The descriptive and interpretive analysis of participants' narrative responses and descriptive analysis of the following HSOPSC composite were used to answer research question 4.

- Organizational Learning and Continuous Improvement: A13. After we make changes to improve patient safety, we evaluate their effectiveness.

RQ5. What are the challenges encountered when using complex patient care technology to facilitate clinical decision making and providing patient care?

A descriptive and interpretive analysis of participants' narrative responses and descriptive analysis using the following the HSOPSC composites were used to answer research question 5:

- Organizational Learning and Continuous Improvement: A9. Mistakes have led to positive changes, and
- Overall Perceptions of Patient Safety: A18. Our procedures and systems are good at preventing errors from happening.

Descriptive Analysis

Description of the Sample

Participants were nurses with ICU experience working with complex medical technology. The survey was posted on the nursing organization's website and a letter was sent to the organization's national regional leaders to enhance awareness of the study. The demographic information collected provided specific variables of the sample population. The variables include participants' years worked in nursing and years worked in ICU. The ages ranged from 22 years to 71 years, and the majority of the participants were female. The participants' experiences were in the SICU and MICU predominantly. Over 50% of participants worked the day shift, and 61% had completed an ICU Internship Program. More than 89% of participants completed medical device safety education/competency. Most of the participants had a BSN level of education, and over 50% had a specialized certification. Participants from 27 states were represented in the study. One third were from Florida. Table 2 shows the sample's demographic data.

Table 2

Frequencies and Percentages of Sample Demographic Data

Variable	Category	*n*	%
Specialized ICU experience	CCU	34	12.6
	CVSICU	11	4.1
	MICU	53	19.7
	Neuro ICU	30	11.2
	NICU	6	2.2
	PICU	14	5.2
	SICU	70	26

Table 2 (cont'd)	TICU	29	10.8
	Other	12	4.5
Shift	Day	149	55.4
	Night	111	41.3
ICU Internship	Yes	163	60.6
	No	97	36.1
Medical Device Competency	Once	116	43.1
	Annually	116	43.1
	Don't Know	24	8.9
	Never	4	1.5
Educational Strategy	High-Fidelity Simulation	58	21.6
	Virtual Simulation	23	8.6
	Instructor Led	166	61.7
	Other	10	3.7
Education Level	Diploma	4	1.5
	ADN	46	17.1
	BSN	178	66.2
	MSN	29	10.8
	DNP	3	1.1
Specialized Certification	CCRN	134	49.8
	SCRN	1	.4
	TCRN	6	2.2
	Other	5	1.9

Table 2 (cont'd)	N/A	114	42.4
Gender	Female	197	73.2
	Male	63	23.4
Primary language	English	242	90
	Other	31	11.5
Hospital Capacity	Equal or Less than 100 beds	2	0.7
	Equal or Less than 250beds	27	10
	Equal or Less than 500 beds	58	21.6
	Equal or Less than 750 beds	66	24.5
	Equal or Less than 1000 beds	56	21.8
	Unknown	48	17.8

Note. $N = 260$.

Reliability Testing

The reliability of the HSOPSC survey items was calculated using Cronbach's alpha. Survey reliability, as measured by Cronbach's alpha, was acceptable, with a high of 0.91 for the events reported on subscales for three items and a low of 0.84 for the supervisor subscale of four items, as shown in Table 3.

Table 3

Item Reliability – Cronbach's Alpha

Items	Cronbach's Alpha 95% CI	*n* of Items
Work Unit Safety	0.88 (0.86,0.90)	18
Supervisor Expectations	0.84 (0.81,0.87)	4
Communication Openness	0.88 (0.87,0.89)	6
Events Reported	0.91 (0.88,0.92)	3
Hospital Safety	0.85 (0.82,0.88)	11

Responses to the Measurements

Table 4 shows the HSOPSC subscale numbers, means, and standard deviations. The item responses were scored on a Likert scale ranging from "Strongly Disagree" to "Strongly Agree." Some items used a Likert scale ranging from "Never" to "Always." For the Patient Safety Grade scale, the possible responses included "Excellent," "Very Good," "Acceptable," "Poor," and "Failing." The Number of Events Reported scores included "No event reports," "1 to 2 event reports," "3 to 5 event reports," "6 to 10 event reports," "11 to 20 event reports," and "21 event reports" or more.

Table 4

Subscale Descriptive

12 Composites and Items	*n*	mean	*SD*	median	min	max	Skew	kurtosis
Teamwork Within Units	236	2.97	0.47	3.00	1.50	4.00	-0.69	1.92
Manager Expectations	236	3.05	0.72	3.25	0.75	4.50	-0.60	0.60
Organizational Learning	236	2.46	0.67	2.33	0.67	4.00	-0.15	0.06
Management Support	234	2.58	0.74	2.67	0.33	4.33	-0.23	0.43
Overall Safety Perceptions	236	2.68	0.37	2.75	1.00	3.75	-1.02	1.91
Feedback Communication	235	2.11	0.83	2.00	0.00	4.00	0.59	0.02
Communication Openness	235	2.52	0.66	2.33	0.67	4.33	0.82	0.94
Frequency Events	235	1.84	0.87	1.67	0.00	4.00	0.85	0.48
Teamwork Across Units	234	2.60	0.36	2.75	1.25	3.75	-0.69	1.70
Staffing	236	2.70	0.46	2.75	1.00	4.25	-0.12	0.60
Handoffs	234	2.55	0.74	2.25	1.25	5.00	1.30	0.97
Errors	236	2.56	0.77	2.33	1.00	5.00	0.89	0.54

Hypothesis Testing

Hypothesis Testing

To address the first research hypothesis, which aims to assess whether there is a relationship between the safety perceptions of critical care nurses and years of experience and clinical education in the use complex medical devices used to provide patient care, 260 nurses from eight specialized and one general ICU departments were selected based on their experience

with these devices. A total of 26% of nurses worked in the SICU and 20% in the MICU, and 50% had 5 or more years of experience as a nurse. The mean age for the group was 38.58 (*SD* = 12.06), while the majority (197, 73%) were female. The same sample was used to address the second hypothesis, which was meant to determine if there is a relationship between organizational learning education, continuous improvement processes, and critical care nurses' perceptions of technological competence. To gain a better understanding of the participating nurses, (210) 79 % of the participants earned a BSN or higher level of education, (146) 54% had a specialized certification, (116) 43.1% received medical device safety education once, and (116) 43.1% annually. Table 5 describes the sample, indicating the means and standard deviations for the variables of interest as related to this study.

Table 5

Means and Standard Deviations for Nurse Participants

	Age *n* = 257	Years of Nursing *n* = 255	Years of ICU *n* = 255
Mean	38.58	12.98	10.77
SD	12.06	10.64	9.20

H_{01}: There is no relationship between the safety perceptions of critical care nurses and the level of education and years of experience using complex medical devices to provide patient care.

H_{a1}: There is a relationship between the safety perceptions of critical care nurses and the level of education and years of experience using complex medical devices to provide patient care.

Pearson's correlations, two-tailed, and significance at alpha <0.05 at 95 % CI were conducted on the seven variables of interest. The variables were (a) "Prevent Errors," (b) "Patient Safety," (c) "Safety Grade," (d) "Safety Events Reported," (e) "Medical Device Competency," (f) "Years in Nursing," and (g) "Education Level." As indicated in Table 6, the results of the correlation analyses of the variable Prevent Errors was significantly correlated with Medical Device Education, $r = 0.179$, $p = 0.006$. Prevent Errors was also correlated with the variable Patient Safety, $r = 0.325$, $p = 0.001$. Similarly, variable Patient Safety was significantly correlated with Medical Device Education, $r = 0.201$, $p = 0.002$. Variable Safety Grade was significantly correlated with Years in Nursing $r = 0.272$, $p = 0.001$, and Education Level, $r = 0.200$, $p = 0.002$. Safety Grade was also significantly associated with Safety Events Reported, $r = 0.199$, $p = 0.002$. Variable Safety Events Reported was significantly interconnected with Medical Device Education, $r = 0.223$, $p = 0.001$, Years in Nursing, $r = 0.237$, $p = 0.001$, and Education Level, $r = 0.256$, $p = 0.001$. Furthermore, variable Medical Device Education was significantly related to Years in Nursing, $r = 0.175$, $p = 0.005$. Nonetheless, the results suggest these variables were not significantly correlated, Prevent Errors and Years in Nursing, $r = -0.007$, $p = 0.913$, Patient Safety and Years in Nursing, $r = 0.048$, $p = 0.462$, Medical Device Education with Education Level, $r = 0.02$, $p = 0.749$. Similarly, the results indicate that these variables were also not significantly related, Prevent Errors with Education Level, $r = -0.005$, $p = 0.939$, and Patient Safety with Education Level, $r = 0.108$, $p = 0.097$. These findings allowed for rejection of the null for H_{01}.

Table 6

Correlation Matrix for Nurses' Safety Perceptions

N= 260		Prevent Errors	Patient Safety	Safety Grade	Safety Events Reported	Medical Device Competency	Years In Nursing	Education Level
Medical Device Competency	*r*	0.179**	0.201**	0.037	0.223**		0.175**	0.112
	p	0.006	0.002	0.573	0.001	1	0.005	0.007
Years in Nursing	*r*	-0.007	0.048	0.272**	0.237**	0.175**	1	0.02
	p	0.913	0.462	0.001	0.001	0.005		0.749
Education Level	*r*	-0.005	0.108	0.200**	0.256**	0.112	0.02	1
	p	0.939	0.097	0.002	0.001	0.007	0.749	
Prevent Errors	*r*	1	0.325**	0.002	0.093	0.179**	-0.007	-0.005
	p		0.001	0.976	0.154	0.006	0.913	0.939
Patient Safety	*r*	0.325**	1	-0.016	0.106	0.201**	0.048	0.108
	p	0.001		0.808	0.106	0.002	0.462	0.097
Safety Grade	*r*	0.002	-0.016	1	0.199**	0.037	0.272**	0.200**
	p	0.976	0.808		0.002	0.573	0.001	0.002
Safety Events Reported	*r*	0.093	0.106	0.199**	1	0.223**	0.237**	0.256**
	p	0.154	0.106	0.002		0.001	0.001	0.001

Note: * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed)

The regression model for predictors of Overall Perception included participants' number of years in nursing, number of years in ICU, medical device competency; annual versus once, educational levels; BSN versus non-BSN, MSN versus non-BSN, and specialized certification versus no certification as predictor variables, where $N = 210$. The outcome variable was overall safety. The specifications resulting from the model are shown in Table 7. The variables selected for this model predicted a significant amount of criterion variance, $F(6, 203) = 3.264$, $p = 0.001$. $R^2 = 0.088$. Thus, the model explained 9% of the variation that occurred in the model's prediction of

overall perception, which is not significant. This outcome is possible since there are many more underlying variables that contribute to the overall perceptions of nurses. For instance, variables such as the complexity of medical devices, the intensity of the patient's condition, insufficient medical devices, and low resources have been noted as factors affecting nurses' perceptions of safety.

Table 7

Models: 5.8 Results

	Dependent variable:			
	Overall Perceptions (1)	Feedback Communication (2)	Communication Openness (3)	Frequency Events (4)
Years in Nursing	0.004	0.055***	0.037***	0.062***
	(0.007)	(0.015)	(0.012)	(0.015)
Years in ICU	-0.005	-0.050***	-0.039***	-0.062***
	(0.008)	(0.017)	(0.014)	(0.017)
Medical Devices Competency. Annual vs Once	-0.128***	0.290***	0.220***	0.384***
	(0.038)	(0.083)	(0.069)	(0.085)
Education Level BSN vs No BS	0.115*	0.243	0.166	0.275*
	(0.068)	(0.149)	(0.123)	(0.151)
Education Level. MS+ vs. No BS	-0.008	-0.142	-0.168**	-0.118
	(0.047)	(0.103)	(0.085)	(0.105)
Specialized Certifications. Yes vs No	0.084**	-0.087	-0.031	-0.016
	(0.036)	(0.078)	(0.065)	(0.080)
Constant	2.701***	1.880***	2.394***	1.704***
	(0.052)	(0.114)	(0.095)	(0.116)
Observations	210	209	209	209

Table 7 (cont'd)

R^2	0.088	0.206	0.153	0.254
Adjusted R^2	0.061	0.182	0.128	0.232
Residual Std. Error	0.348 ($df = 203$)	0.760 ($df = 202$)	0.629 ($df = 202$)	0.772 ($df = 202$)
F Statistic	3.264^{***} ($df = 6; 203$)	8.712^{***} ($df = 6; 202$)	6.097^{***} ($df = 6; 202$)	11.461^{***} ($df = 6; 202$)

Note. $^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$

H_{02}: There is no relationship between organizational learning education and continuous improvement processes and critical care nurses' perceptions of technological competence.

H_{a2}: There is a relationship between organizational learning education and continuous improvement processes and critical care nurses' perceptions of technological competence.

Pearson's correlations, two-tailed, and significance at alpha <0.05 at 95 % CI were conducted on the seven variables of interest. The variables were (a) Improve Safety, (b) Positive Changes, (c) Effective Evaluations, (d) Medical Device Competency, (e) Years in Nursing, (f) Specialty in ICU, and (g) Education Level. Table 8 shows the results of the correlation analyses, and as indicated on the table. Variable Improve Safety was significantly correlated with Years in Nursing, $r = 0.194$, $p = 0.003$; and variable Specialty In ICU, $r = 0.134$, $p = 0.041$; variable Positive Changes, $r = 0.552$, $p = 0.001$; and variable Effective Evaluations, $r = 0.559$, $p = 0.001$. However, variable Positive Changes was significantly correlated with Specialty In ICU, $r = 0.147$, $p = 0.024$ but was not significantly associated with Medical Device Competency, $r = 0.017$, $p = 0.801$, and Years in Nursing, $r = 0.053$, $p = 0.229$. Significantly related variables were Effective Evaluations with Medical Device Competency, $r = 0.153$, $p = 0.019$, and Specialty in ICU, $r = 0.195$, $p = 0.003$. Variables that were not significantly interrelated were Effective Evaluations and Years of Nursing, $r = 0.053$, $p = 0.421$ and Education Level, $r = 0.09$, $p = 0.171$. The results indicate that variable Improve Safety was significantly correlated with

Education Level, $r = 0.193$, $p = 0.003$, and variable Positive Changes, $r = 0.129$, $p = 0.049$. These findings allowed for rejection of the null for H_{02}.

Table 8

Correlation Matrix for Nurses' Technological Competency Perceptions

N= 260		Improve Safety	Positive Changes	Effective Evaluations	Medical Device Competency	Years In Nursing	Specialty In ICU	Education Level
Medical Device Competency	*r*	0.093	0.017	0.153**	1	0.175**	-0.014	0.112
	p	0.158	0.801	0.019	0.001	0.005	0.829	0.007
Years in Nursing	*r*	0.194**	0.079	0.053	0.175**	1	-0.084	0.02
	p	0.003	0.229	0.421	0.005		0.183	0.749
Specialty In ICU	*r*	0.134*	0.147*	0.195**	0.014	-0.084	1	0.152*
	p	0.041	0.024	0.003	0.829	0.183		0.014
Education Level	*r*	0.193**	0.129*	0.09	0.112	0.02	-0.014	1
	p	0.003	0.049	0.171	0.007	0.749	0.829	
Improve Safety	*r*	1	0.552**	0.559**	0.093	0.194**	0.134*	0.193**
	p		0.001	0.001	0.158	0.003	0.041	0.003
Positive Changes	*r*	0.552**	1	0.545**	0.017	0.079	0.147*	0.129*
	p	0.001		0.001	0.801	0.229	0.024	0.049
Effective Evaluations	*r*	0.559**	0.545**	1	0.153**	0.053	0.195**	0.09
	p	0.001	0.001		0.019	0.421	0.003	0.171

Note. *Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).

The regression model for the predictors of Organizational Learning includes participants' number of years in nursing, number of years in ICU, medical device competency, educational levels, and specialized education as predictor variables, where $N = 210$. The resulting specifications for the model are shown in Table 9. The model was shown to be statistically significant, such that the variables selected for this model predicted a significant amount of criterion variance, $F(6;203) = 6.277$, $p = 0.001$.

Table 9

Models. 1.6 Results

	Dependent variable:			
	Teamwork	Manager Expectations	Organizational Learning	Management Support
	(1)	(2)	(3)	(4)
Years in Nursing	0.026***	0.041***	0.045***	0.050***
	(0.009)	(0.013)	(0.012)	(0.014)
Years in ICU	-0.032***	-0.042***	-0.048***	-0.046***
	(0.010)	(0.015)	(0.014)	(0.016)
Medical Devices Competency. Annual vs. Once	0.055	0.073	0.210***	-0.047
	(0.050)	(0.074)	(0.068)	(0.079)
Education Level. BSN vs No BS	-0.084	0.214	0.088	0.109
	(0.089)	(0.132)	(0.121)	(0.141)
Education Level. MS+ vs. No BS	-0.028	-0.090	-0.152	-0.100
	(0.061)	(0.091)	(0.084)	(0.097)
Specialized certifications. Yes vs No	0.022	0.042	0.027	0.018
	(0.047)	(0.069)	(0.064)	(0.074)
Constant	2.983***	2.967***	2.360***	2.415***
	(0.068)	(0.102)	(0.093)	(0.108)
Observations	210	210	210	208
R^2	0.056	0.091	0.156	0.075
Adjusted R^2	0.028	0.065	0.132	0.048
Residual Std. Error	0.454 ($df = 203$)	0.676 ($df = 203$)	0.619 ($df = 203$)	0.718 ($df = 201$)
F Statistic	2.003* ($df = 6$; 203)	3.406*** ($df = 6$; 203)	6.277*** ($df = 6$; 203)	2.726** ($df = 6$; 201)

Note. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Research Questions

This research study consists of five main questions. Qualitative and quantitative data were used to answer the research questions. The demographic data provided information about the sampled population. This section describes the qualitative data, including descriptive statistics, frequencies, and percentages.

Research Question 1

What are the experiences of critical care nurses working with complex patient care technology in daily practice?

Fewer than 50% of nurses reported that they had enough staff to handle the workload (n = 236): "Strongly Agree" (10, 4.2%), "Agree" (90, 38.1%), "Neither" (71, 30.1%), "Disagree" (56, 23.7%), and "Strongly Disagree" (9, 3.8%). However, 70% of nurses indicated that their manager or supervisor did not want them to take shortcuts to get work done faster when pressure was increasing (n = 236): "Strongly Disagree" (21,8.9%), "Disagree" (143,60.6%), "Neither" (48, 20.3%), "Agree" (20, 8.5%), and "Strongly Agree" (4, 1.7). The expectation was always to maintain patient safety, regardless of the circumstances. This expectation was expressed within the nurses' narrative responses as a source of stress, anxiety, and frustration. Nurses described not having enough time to manage the workload. Others expressed being exhausted, not being able to take a break, and having to stay late after the end of shift to complete documentation. Inadequate staffing and unavailable resources were voiced as reasons for nurses feeling stressed.

Nurses reported that not having adequate staffing and resources sometimes meant that the unstable patient received more care and attention than a critical but stable patient. One nurse's response illustrates both the positive and negative feelings that ICU nurses experience:

> Very stressful if there is not enough staff to help you when you have a very critical patient. Sometimes the equipment is not available, and the doctors get mad at the nurse when they want the patient to be on a therapy. It's just not safety sometimes because of the amount of work. It can be a real struggle to save your patients. But I feel good knowing that I'm doing all I can for my patients.

Many nurses described their days as busy or hectic, and they sometimes struggled to get through their day. In contrast, some accepted the complexity as a challenge and described it as rewarding: "Sometimes [it is] very rewarding to have technology to help save patient lives. But [it is] also overwhelming and stressful to manage a crashing patient and all the devices."

The narrative responses of ICU nurses illustrated their experiences using complex devices. While some nurses described negative emotions associated with their experiences, others stated that they loved being an ICU nurse and working with supportive team members. Nurses who expressed more positive feelings about their experiences working with complex devices in the ICU also stated that they had ample resources and good teamwork to assist them.

Research Question 2

What are the facilitators and barriers to using complex patient care technology to provide nursing care?

The findings revealed that peer support was associated with positive feelings and emotions among ICU nurses. Teamwork and communication were subthemes that were valued aspects of facilitating patient care. Nurses described depending on their peers when there is a problem with a piece of equipment, such as the CVVHD tubing becoming clotted and needing help to troubleshoot the problem. One respondent noted, "I generally rely on our resource nurse for help with unstable patients, and I have amazing coworkers that offer help before being

asked. . . . Communicated with my coworkers . . . to prevent problems before they happen and be prepared when they do arise." Another stated, "It requires fast thinking and actions to stabilize the patient. Also, getting the assistance of fellow nurses to get the job done."

Teamwork was identified as a facilitator to providing nursing care. Over 90% of nurses responded that people supported one another in the unit (n = 236, "Strongly Agree" (41, 17.4%), "Agree" (176, 74.6%), "Neither" (12, 5.1%), "Disagree" (7, 3.0%), and "Strongly Disagree' (0, 0.0%). Some nurses described having a resource nurse to assist them with caring for an unstable patient. Having educational resources to help with using new technology or complex devices was identified as a facilitating factor. Nurses shared that sometimes they would forget how to use a device if they did not use it often. Having an expert clinician or educator as a resource was highly valued as helpful to nurses safely using the devices. Nurses also explained that many novice nurses are working in the ICUs and that they needed support from the experts to practice safely.

Barriers to using complex devices included lack of updated devices, being unable to locate a device when needed, and replacing a malfunctioning device. Nurses described their experiences as time-consuming, stressful, and sometimes frustrating. Device malfunctions were reported to include devices not working well, correctly, or at all. Malfunctioning devices were described as "scary" because nurses sometimes did not know what to do. One nurse reported,

> New ICU beds have so many functions, and sometimes they don't work and you have to know which they were to find all the instructions to fix it. It takes too much time when you have a sick patient. Also, the IV pumps have the same issues. It sends error messages, and one can figure out what to do about it, so the nurse has to walk around and

find another pump instead of focusing on caring for the patient. It's very stressful and frustrating.

Frustration with devices was expressed as a negative experience for nurses when having to adopt new devices. Managing new or malfunctioning devices and an unstable patient was described as a source of frustration for nurses. A safety survey question asked whether staff would speak up if they see something that may negatively affect patient care, 32 % responded "most of the time" or "always" (*n* = 234, "Most of the Time," 50, 21.4%; "Always," 24, 10.3%). In this study, several nurses reported IV pump malfunction as a serious patient safety problem: "Not [for] myself but co-worker . . . an Alaris pump had issues with sedation and pressors causing vital sign changes . . . I went to management and company, and we no longer use them." Another stated, "Yes. The IV pump infused the med quickly."

Most nurses reported that they sequestered a malfunctioning device and told their charge nurse or supervisor about the issue. The survey results showed that in a 12 month period, 52.1% of nurses reported one to two events (*n*= 234, "No Events," 50, 21%; "1 to 2 Events," 122, 52.1%; "3 to 5 Events," 41, 17.5%; "6 to 10 Events," 15, 6.4%; "11 to 20" Events, 3, 1.3%; and "21 or More Events" (3, 1.3%). When asked how often a mistake that could have harmed the patient but did not report it, approximately 34% of nurses responded that they reported the mistake most of the time or always (*n* = 234, "Most of the Time," 55, 23.5 %; "Always," 24, 10.3%).

Device problems included difficultly of use, being big and bulky, requiring updates, and needing cleaning and maintenance. Devices were described as complicated or as malfunctioning frequently. Nurses recounted that errors and malfunctions were reported to their supervisor. Communication and feedback about errors are safety components of using devices that have a

high risk of errors. Approximately 28% of nurses responded that there is communication about ways to prevent errors from happening again in their unit (n = 233, "Most of the Time," 41, 17.6%, and "Always," 24, 10.3%).

Research Question 3

What are the perceptions of nurses of the clinical education that they received to use complex patient care technology?

The results showed that most ICU nurses received some training on how to use complex medical devices. Over 88% stated they received medical device safety education. However, despite having medical device training, some ICU nurses expressed a lack of confidence when using complex devices. The reason for this lack of confidence was explained as insufficient training:

> As long as we receive proper training and come in contact with the medical device regularly, I typically feel confident. If it's a device that I see only once every few months, I would feel less confident . . . such as the CRRT. We all receive training, but they are so rare, only a few nurses feel completely confident in caring for a patient receiving it.

Several nurses expressed that using a piece of equipment repeatedly was one way of keeping their technological skills updated. The results revealed inconsistencies among organizations regarding medical device education and training. Some nurses described having a specific complex medical device education plan to meet nurses' learning needs. Other nurses explained that their annual training and competencies included a review of high-risk devices and that "skills are listed as high or low risk the high or low volume to determine if annual verification needs to be done." In contrast, several nurses stated that there was no training or that training was not designed to meet ICU nurses' needs.

The results also revealed that when new medical devices were introduced into practice, ICU nurses were briefly trained, usually by the manufacturer's representative and sometimes by a nurse educator. Some nurses describe their education for new devices as brief in-services conducted during their busy workday:

> The problem is that most in service is too brief and does not cover all the things the nurse needs to know . . . I had a patient on a PCA pump that was new, and it kept beeping malfunction no matter what I did. No one can fix the problem. I have to get another pump. . . They don't teach us how to really troubleshoot the machines.

Nurses expressed needing sufficient training, exposure to complex medical devices, and troubleshooting skills to improve their practice.

Research Question 4

Which educational strategies are most effective in facilitating patient care technological competence?

Organizational learning and continuous improvement are essential to promoting patient safety and providing nurses with knowledge of their unit's safety performance. This study showed that 37.5% of the nurses felt that changes to improve patient safety were evaluated for effectiveness after they were implemented (*n* = "Strongly Disagree," 1.7%, "Disagree," 15.3%, "Neither," 45.5%, "Agree," 31.5%, and "Strongly" Agree, 6%). This finding may be related to inconsistencies among healthcare organizations to communicate safety outcomes and engaging nurses in the continuous learning and improvement process. Most nurses reported receiving medical device safety education or competency either once or annually (*n*= 260, Once, 43.1%, Annually, 43.1%). The result reinforces previous findings that illustrate the inconsistencies among healthcare organizations to provide nurses with adequate medical device education.

Most nurses articulated that hands-on learning was the preferred way of promoting technological competence. Instructor-led competency education was chosen by 61.7% of nurses as the best strategy to meet their learning needs for safely using medical devices. A total of 21.6% of nurses preferred high fidelity simulation competency, 8.6% chose virtual simulation competency, and 3.7% preferred a combination of styles as the best way of learning.

Research Question 5

What are the challenges encountered when using complex patient care technology to facilitate clinical decision making and providing patient care?

The study illustrates that ICU nurses' most common challenges included a heavy workload, inadequate resources and training, and device difficulties. Nurses describe ways in which they manage circumstances to ensure high-quality patient care not only for the patient but for their families as well:

> It is not just caring for an unstable patient, it is ensuring orders are correct, pharmacy stocks, drips are available, equipment works, families are updated, patient remains stable, doctors respond in a timely manner, lab results are quick and released in time.

Nurses emphasized needing peer support to care for patients and manage complex equipment safely. Infrequent use of or limited exposure to highly complex devices were reported as a challenge. Nurses described feeling less confident using a complex device that they had not used for a while. Nurses said that sometimes they had forgotten some of the details of how to use the device safely and relied on a peer to help them manage it.

Attending to malfunctioning equipment was described as time-consuming and risk to patient safety. A lack of training on troubleshooting medical device malfunctions was reported as an impedance to patient care and a source of frustration. However, nurses felt that mistakes led to

positive changes (*n* = 234, "Strongly Agree," 14, 6.0%; "Agree," 134, 57.3%; "Neither," 69, 29.5%, "Disagree," 16, 6.8%; and "Strongly Disagree," 1, 0.4%). Most agreed that procedures and systems were in place to prevent errors (*n* = 235, "Strongly Agree," 8, 3.4% ; "Agree," 180, 76.6% ; "Neither," 40, 17%; "Disagree," 6, 2.6%, and "Strongly Disagree," 1, 0.4%). Approximately 80% graded their unit's overall safety as excellent, very good, or acceptable (*n* = 229, "Excellent," 4.5%; "Very Good," 39.8.7%, "Acceptable" 35.7%, "Poor," 5.2%).

Chapter Summary

This chapter presented the results and answered the research questions using both qualitative and quantitative data. Data analysis was conducted using R (version 4.2.0) statistical package and NVivo © for Mac 11.4.3 software. Descriptive, frequencies, and percentages as well as interpretive analysis and descriptions of participants' personal experiences, were used to answer all the research questions. Survey reliability was calculated using Cronbach's alpha. Hypothesis testing was completed using two-tailed Pearson's correlation and linear regression models at a 95% CI and 5% significance level. The data revealed American critical care nurses' safety perceptions related to using complex technology of current daily practices. Chapter 5 will discuss the findings, implications, and recommendations.

CHAPTER 5

DISCUSSION AND SUMMARY

The purpose of this study was to explore the safety perceptions and experiences of critical care nurses when using complex medical devices in daily practice. The aim was to gain insight into the challenges encountered in their practice as well as uncover the best education strategies that may improve nursing practice and patient safety. The study findings may offer administrators, nurse managers, and nurse educators useful information for improving the clinical work environment and educational resources. This chapter will recapitulate the research findings and present the results and implications of this mixed-methods study. Limitations and recommendations for future research will also be discussed.

Summary of the Findings

Hypothesis Testing

The first research hypothesis assessed whether there is a relationship between the safety perceptions of ICU nurses and the medical device education they receive. The results suggest that there is a significant relationship between the safety perceptions of critical care nurses and their level of education, as well as their years of experience using complex medical devices to provide patient care. Nurses who worked longer, had more practiced expertise, and had a BSN or higher level of education graded their units' overall safety as very good or excellent. Subsequently, nurses with more experience were more likely to report more safety events. Furthermore, the results suggest that nurses with medical device competency reported perceptions of safety that were significantly interrelated with preventing errors and reporting safety events. Findings reveal correlational significance to reject the null hypothesis.

The second hypothesis tested whether there is a relationship between organizational learning education and continuous improvement processes and critical care nurses' perceptions of technological competence. The findings revealed that nurses with more years of experience and who worked in specialty ICUs had a significant association between their perceptions of technical competency and organizational learning. Nurses' educational level and medical device competency were significantly correlated with the variable "Improve Safety." Similarly, medical device competency was highly associated with the variable "Effective Evaluations." There were strong relationships among the three organizational learning variables and nurses' years in nursing, specialty in the ICU, education level, and medical device competency. Therefore, the findings indicated a significant relationship between organizational learning and nurses' perceptions of technological competence. The null hypothesis was rejected based on the results.

Research Question 1

Research question 1 examined: What are the experiences of critical care nurses working with complex patient care technology in daily practice? The following descriptive and interpretive analysis of participants' narrative responses and descriptive analysis of the HSOPSC composites were used to answer this research question: Supervisor/Manager Expectations & Actions Promoting Patient Safety: B3. Whenever pressure builds up, my supervisor/manager wants us to work faster, even if it means taking shortcuts, and Staffing: A2. We have enough staff to handle the workload. The findings of this research provided insight into the experiences of ICU nurses and how they work with complex medical devices. Nurses expressed a positive openness and acceptance of complex medical devices. They recognize the benefits of devices for patient care, safety, and patient outcomes. One advantage of using complex devices was that it helped nurses to take *"good"* care of patients and improve patient outcomes. Sophisticated

medical devices like the ECMO were described as needed to care for critically ill patients and save lives.

Nurses reported stress and anxiety as a result of difficulties "managing" amid organizational insufficiencies. Common insufficiencies recounted by nurses involved inadequate staffing, training, supplies, equipment, and support. Nurses stated that stress and anxiety can be common experiences within ICUs. However, in their discussions, nurses express experiences wherein stress resulting from organizational insufficiencies caused them to have to manage issues beyond the immediate needs of patients while trying to take care of patients. This "managing" involved handling technical issues with the devices, not having sufficient supports to help with the devices, not having supplies readily available, and being under-staffed. Although nurses experienced stress when working with complex medical devices and caring for unstable patients, they also described their work as rewarding. Nurses expressed that their work was stressful but also rewarding. The stress originated from multiple sources, and the sense of reward stemmed from helping patients and working well with others.

The ICU nurses identified the need for and appreciation of relying on teammates to help them figure out and respond to technical problems, manage patients, medical devices, and learn about complex technology. Nurses described needing support from their peers, charge nurse, and supervisor to "do a good job" and "get through the day." The nurses shared experiences that illustrated how they rely upon colleagues to help them manage the competing factors at play when delivering care in ICUs. Nurses relied on their peers in situations resulting from problematic devices, devices they were unfamiliar with or lack sufficient training, or caring for unstable patients. Teamwork was emphasized as a part of their unit's culture, and they relied on team support to do their work.

Integration of the Finding with Previous Literature

Critical care nurses' perceptions revealed that they have both positive and negative experiences when using technology in nursing practice. The findings are consistent with the literature. According to Zhang et al. (2014), nurses' perceptions of working with medical devices involve adequate training, management, and using the device. While some nurses view medical technology as an asset to improving patient outcomes, others feel it creates stress, is laborious, and infringes on nursing independence. Nurses described the ICU workload as stressful.

Similarly, Sabzevari et al.'s (2015) quantitative study concluded that Iranian ICU nurses expressed both positive and negative opinions about technological influences in their practice. Although the literature is consistent with most of the findings, insufficient organizational resources to manage the workload was emphasized. More explicit findings revealed that stress and negative emotions were associated with the complexity and intensity of the workload, the work environment, and managing complex devices. Inadequate staffing, coupled with a lack of such resources as reliable functioning equipment, was a source of stress and frustration. However, despite the work environment challenges, 39.8 % of nurses graded their units' safety as very good, 35.7 % as acceptable, and 5% as excellent.

Research Question 2

What are the facilitators and barriers to using complex patient care technology to provide nursing care? The following descriptive and interpretive analysis of participants' narrative responses and descriptive analysis of the HSOPSC composites were used to answer this research question: Teamwork Within Units: A1. People support one another in this unit; Feedback and Communication About Error: C5. In this unit, we discuss ways to prevent errors from happening again; Communication Openness: C2. Staff will freely speak up if they see something that may

negatively affect patient care, and G1. In the past 12 months, how many event reports have you filled out and submitted?

Nurses' responses to this research question revealed that they recognized the benefits and advantages of complex medical devices. They see the devices as improving their ability to monitor their patients, to care for their patients, and to achieve positive patient outcomes. Nurses depended on their peers, charge nurses, and supervisors for support to safely care for unstable patients and manage complex devices. The benefits of teamwork included learning, dealing with problematic devices, and peer support when caring for unstable patients. Having an expert clinician assist with troubleshooting a device or mentoring novice nurses was reported as a major benefit. The safety survey composite for teamwork asked whether people support one another in their unit; the response was highly positive. Nurses also identified the emotional and social benefits of nurses and other providers working together as teams and communicating with one another. Communication was reported as a facilitating factor when providing safe care to unstable patients and managing complex devices. Nurses described the need to communicate with physicians and other healthcare professionals about patients' conditions, to update families, to report device malfunctions, and to ask for help getting the work done.

The nurses participating in this study also reported that a disadvantage of medical devices was that they were overly complex, which could be detrimental to patient care, safety, and efficient nursing care. The nurses also articulated that malfunctioning devices were a source of frustration and negative experiences. They described their experiences with handling a malfunctioning device as time-consuming and noted that reporting the device malfunction and having to find another device interfered with patient care. The safety survey findings indicated that approximately one-third of ICU nurses spoke up when something impacted patient care and

discussed ways to prevent errors from happening again. The majority of nurses reported seeing one or two events within the last 12 months.

The availability of education, training, and information were reported as facilitating factors for safely using complex medical devices. Nurses expressed that their organizations provide education, training, and device information in ways that are useful and available. However, some nurses reported the need for more training and support on new devices. The training was described as brief and as not addressing how to troubleshoot device errors or problems. The training was also scheduled during nurses' shifts, so sometimes they were unable to attend and relied on their peers to show them how to use a device. Nurses reported that training on new devices occurred months before actually using the device. Suggestions for facilitating training on new devices included timely education, scheduling training away from the work unit, and providing nurses with time to learn.

Integration of the Finding with Previous Literature

Despite advances in technology, device-related medical errors are increasing. The literature discusses the struggles of healthcare organizations to maintain adequate staffing and appropriate and updated medical technology (James, 2013; Powell-Cope et al., 2008; Stone & Weiner, 2001). Similarly, organizational insufficiencies were reported in this study as barriers to nurses effectively using complex medical devices. Although these problems are not new, the challenge continues as a need for improvements and resolutions (Hignett et al., 2018). Nurses articulated workplace difficulties they experienced when using medical devices, which provides insight into how it affects patient care. They were explicit about needing adequate medical device training and resources to care for patients safely. Study results revealed that nurses spoke up and reported safety concerns to their supervisors. Administrators and nurse leaders are in a

position to promote a culture of safety and provide the necessary resources, support, and opportunities to staff (Armellino et al., 2010). Organizational structure and leadership are essential to developing structures and processes that empower nurses to promote quality and safe patient care outcomes. The IOM 2004 report recommends that leaders provide learning opportunities for novice and experienced nurses to transform the work environment and improve patient care (Sherwood & Barnsteiner, 2017). Findings uncovered opportunities for nurse administrators that may guide workplace changes. Understanding ICU nurses' challenges and developing solutions for safer patient care requires leadership competence. Communication and teamwork were reported with highly positive scores and indicated that nurses worked together to provide safe care. Skilled managers can leverage these attributes to engage nurses to improve systems and workplace safety (Gunawan & Aungsroch, 2017). Providing adequate education, resources, and requesting real-time feedback from nurses are among the essential elements needed to support nurses' use of medical technology (Hignett et al., 2018; Kiekkas, 2014; Ruppel & Funk, 2018).

Research Question 3

What are the perceptions of nurses of the clinical education that they received to use complex patient care technology? This question was answered through a descriptive, interpretive analysis of participants' narrative responses and a demographical question on medical device safety education/competency.

Results revealed that most nurses received medical device safety education and training. Most nurses reported receiving medical device training once or annually. Nurses expressed that their organizations provide formal education, training, and device information in ways that were useful and available to them. They also reported informal ways of learning and gaining technical

competence by helping their peers troubleshoot a device when there was a problem. Sometimes nurses relied on a more experience coworker or an expert educator for help to manage device problems and malfunctions. Ways of gaining knowledge were described as a "learn as we go" method. Training and support for new devices were reported as deficient. Nurses also said that training did not include how to troubleshoot the devices. ICU nurses believed that they were not trained sufficiently on how to use complex devices. They reported not maintaining skills due to lack of practice, which resulted from the infrequent use of particular devices and/or infrequent training. When nurses lack adequate training, they may not be able to utilize the full functionality of complex devices, might use them incorrectly or, may not actualize the potential safety and health outcome benefits that the devices could otherwise offer. To maximize using the functionalities of complex medical devices, organizations must ensure that nurses are competent utilizers of the devices. Findings indicate a lack of consistency among organizations on standards for medical device education.

Integration of the Finding with Previous Literature

Study outcomes align with the literature which identified the need for adequate medical device education. Technological competence is essential to practice in ICUs safely. Complex medical devices require nurses to have astute error recognition skills. Nurses' lack of confidence and technological competence when working with medical equipment is related to inconsistent and inadequate medical device education standards. According to Ewertsson et al. (2015), less than 50% of nurses had the training to reinforce their technical skills. Forty-three percent of new nurses avowed that they were involved in device-related incidents, indicating a potential patient safety issue. Many nurses reported being self-taught and learned how to use medical equipment by trial and error, even with medical device training. Inadequate preparation to use medical

equipment compromises patient safety, nursing practice, and nurses' self-confidence. Research findings by authors McConnel (1995), Ewertsson et al. (2015), and Sowan et al. (2017) are consistent with this study's results.

Similarly, Martinez (2016) reported that technological competence was related to self-confidence. Good decision making was attributed to competence, having resources, and feeling supported. The researcher gained insight into the issues that ICU nurses encountered when using complex technology and how it affects their practice. This study notably emphasized ICU nurses' need for ongoing medical device education, including error identification and troubleshooting skills. Nurses articulated the preferred ways of learning and how their organization can facilitate their learning needs. The literature accounted for similar findings that continuous development of medical devices necessitates nurses receive ongoing and updated clinical education to maintain technological competence (Ewertsson et al., 2015; Polisena et al., 2015; Sowan et al., 2017).

Research Question 4

Which educational strategies are most effective in facilitating patient care technological competence?

The descriptive and interpretive analysis of participants' narrative responses and descriptive analysis of the HSOPSC suggested that to ensure patient and nurse safety and to maximize the benefits of using complex medical devices, nurses must receive timely, thorough hands-on training from experts. Training should not occur several weeks or months before new devices are introduced into the care setting. They should (a) involve multiple modalities and (b) be scheduled in ways that allow nurses to focus on their training without compromising patient care. Refresher training and informative materials should be incorporated. Nurses conveyed

needing to be taught by an expert who can answer questions and provide clinical scenarios to make their learning experiences valuable. They expressed a preference for hands-on learning to develop the competence and confidence needed to utilize medical devices. Other learning methods include informally on the job training and formal simulation training with devices. One way of learning to use complex devices safely was to "play with it," make mistakes, and correct the errors. Nurses suggested that learning should occur away from the bedside to allow nurses to concentrate on seizing the knowledge and technical skills needed to use complex devices safely. Technical skills assessment was described as formal, informal, or not assessed. Methods of technical skills assessment included a formal yearly self-evaluation not specific to technical skills to recognize their deficiencies informally. Continuous improvement and learning opportunities within the organization were other ways of gaining competence.

Integration of the Finding with Previous Literature

Understanding the technological challenges associated with patient care allows leaders and educators to develop tools that better educate and evaluate nurses' technological competence. Currently, there are no standards for medical device safety education or technical competency assessment for using complex devices. No studies were found that have examined the number of medical devices that new nurses utilize in their daily practice or the required technical skills they need to care for patients safely (Ewertsson et al., 2015). This study explored ICU nurses' viewpoints to gain an understanding of some of their challenges of using complex equipment and the best ways to develop technical competency.

Most nurses expressed the need for "hands-on" learning to develop their technical competence. High fidelity simulation may provide the cognitive and psychomotor skills needed to operate and manage complex medical devices safely. Simulation—an instructional technique

that mimics reality—is considered a suitable teaching strategy for practicing complex technical skills. It is a teaching tool that can verify competency for a vast range of skills, from simple to complex (Burnette & Thibodeau-Jarry, 2016). This study's findings concur with the literature regarding the need for continuous and updated clinical education to maintain technical competence (Ewertsson et al., 2015; Polisena et al., 2015; Sowan et al., 2017). Evidence-based education on the importance of competence and following safe practice guidelines are needed to improve the culture of safety. The FDA has developed policies to promote safe and effective use of medical devices. Designers of healthcare technology should consider the impact on the end-users' workflow. A recommendation for improving safe practice includes integrating safety culture principles into curriculums and educational programs (Piscotty et al., 2015; Shuren & Califf, 2016).

Research Question 5

What are the challenges encountered when using complex patient care technology to facilitate clinical decision making and providing patient care?

The descriptive and interpretive analysis of participants' narrative responses and descriptive analysis of the HSOPSC showed that the main challenges ICU nurses encountered using complex medical devices were associated with organizational insufficiencies related to inadequate staffing, training, supplies, equipment, and support. The lack of resources, education, and support accounted for most of the negative experiences. Device malfunction was a recurring theme in nurses' responses. Problematic devices not only posed a safety risk, but they also took the nurses' attention away from patient care. Having to "manage" circumstances was another theme that illustrated the challenges of ICU nurses' daily practice. Nurses reported having to do what they could within their given circumstances to provide a high quality of care as possible to

patients. Managing was described as handling patient needs, labs, meds, treatments, devices, families, physicians, paperwork, and housekeeping issues. Part of managing involved nurses having to prioritize commitments and obligations given the particular circumstances they were facing at any given time. The situational context, coupled with malfunctioning devices, added to the challenges of the workday.

Integration of the Finding with Previous Literature

This study uncovered several challenges to patient care delivery in the ICU. Challenges such as inadequate medical device training, insufficient staffing, and available equipment reinforce the findings in the literature. Device malfunctions were reported as a problem that impeded workflow and contributed to situational stress. Henriksen et al. (2008) emphasized that despite safeguards in technology design, the number of medical device-related errors continues to escalate. One suggestion for improving workflow and decreasing barriers to care delivery is to consider an ICU nurse's partnership with human factors researchers to design medical devices. Medical technology design should include ease of use, error recognition, standardization, and a built-in tutorial. Minimizing device malfunctions and errors can improve nurses' workflow processes and efficiency of care delivery.

Nurses voiced feeling overwhelmed and frustrated when working with complex devices. They explained that it was stressful and time-consuming when they were unable to operate or troubleshoot a device. These findings are consistent with the literature showing that ICU nurses also expressed the need for adequate training and exposure to highly complex devices, such as the CRRT and the Artic Sun machines, to maintain competence. Limited exposure to some devices for several months or insufficient training on new complex devices were challenges that impeded nurses' ability to use medical devices properly. While several challenges were reported,

nurses expressed the view that medical technology provided valuable clinical information for managing patients' situations. Education and technical skills training are needed to guide the use of medical device data for recognizing patterns in patient data and making clinical decisions. Providing nurses with the necessary medical device training can improve patient outcomes (Kiekkas et al., 2006; O'Connell et al., 2007; Tunlind et al., 2015).

Implications of the Findings

This research study described the safety perceptions and experiences of ICU nurses when using complex medical devices. The results also revealed nurses preferred ways of learning when using new and complex medical devices. This section will discuss the implications for nursing practice, nursing education, nursing research, and public policy.

Implications for Nursing Education

Critical care nurses are the end-users of complex medical devices to monitor, make clinical decisions, and provide therapeutic interventions. Therefore, their level of technological competence can have a significant impact on patient outcomes. It is essential to introduce continuing education programs designed to train nurses on how to operate medical devices safely. This study provided some insight into how ICU nurses interact with technology and the impact on their practice and patient care. Nurses explained that new devices are introduced into their daily practice with the expectation that they adapt to these devices with minimal support or clinical education. Insufficient education, technical, and clinical support can result in misuse of the equipment and nurses creating workarounds. When nurses are unprepared to use complex devices safely, this behavior can affect the quality and safety of patient care. Nurses at the bedside are in a unique position to prevent an error or a near-miss event and evaluate the failure from their perspective. Fundamentally, there are two types of device-related errors: design flaws

and user errors. It can be challenging to distinguish between the two kinds of mistakes. However, nurses should be prepared to intervene promptly, replace the flawed device, secure the device, and report the incident (Mattox, 2012).

A collaborative approach and partnership among clinicians, educators, administrators, and manufacturers are needed to ensure the safe use of medical technology. Developing medical device competencies may be difficult and complicated. However, competency in device utilization is imperative for safe nursing practice. Nurses need adequate training and clinical practice to gain experience and develop the necessary knowledge and skills to become competent. Medical device education and training should include reviewing (a) the purpose of the device, (b) manufacturers' safety instructions, and (c) possible complications, warnings, and contraindications. Troubleshooting the equipment should be part of the training. Reporting equipment problems and following the organization's safety policies and procedures are also imperative. Nurses should be trained to check the expiration and preventive maintenance date of all medical equipment before using them (Konecny, 2003; Sowan et al., 2017; Swayze & Rich, 2012). Promoting nurses' technological competence and awareness of device-related errors prevention strategies can improve the quality and safety of patient care.

Implications for Nursing Practice

Unsafe actions such as practice violations, errors, mistakes, slips, and lapses can result in a risk for harm in highly technologically advanced healthcare systems. Creating a balance between staff engagement and better work systems can produce positive outcomes. Understanding adverse events and how to resolve safety concerns remains a challenge for healthcare leaders. This study revealed the need for more feedback from leadership on the effectiveness of safety initiatives and nurses being able to speak up about safety concerns. Some

nurses worry that mistakes may be kept in their personnel file. Changing the unit and organizational culture to encourage reporting of potential and actual errors can improve event reporting and patient safety. Using an investigative non-punitive approach to analyze safety events may provide lessons learned for individuals involved in the incident. Understanding the context in which the event occurred and the factors contributing to the problem are vital to developing practical solutions. Strategies should be aimed at preventing errors and improving patient safety. A key initiative is encouraging staff to speak up about safety concerns and engaging staff to participate in organizational policy development. Another strategy is providing staff with the guidance, support, and resources they need while holding them accountable. Utilizing safety checklists and procedures is also an important strategy to decrease patient harm. Empowering staff to report unsafe situations anonymously is another measure to improving patient safety (Mitchell & Tehrani, 2017; Padgett et al., 2017).

Implications for Nursing Research

Evidence-based research, clinical guidelines, and best practices are needed to advance nursing education and practice. More research is required to understand how critical care nurses attain technical competence to use complex equipment safely and how knowledge and technical skills are integrated into patient care. The study uncovered inconsistencies and inadequacies of medical device education amongst healthcare organizations nationally, which supports the findings of previous studies. Some participants reported not having any training programs, while others reported not having time to attend annual competency training. Currently, medical device education lacks consistency and proficiency standards for fundamental educational requirements. Research is needed to develop tools to monitor and maintain equipment safety. To successfully implement a device safety program, healthcare leaders need to engage staff and hold them

accountable for safe patient care. Leaders should also encourage staff to speak up when there is a safety concern.

The increasing complexity of medical devices create challenges for nurses to become competent in a high-stress environment with limited time to learn. Future research is needed to develop cost-effective, continuing clinical education and develop standardized competencies. Healthcare leaders and clinicians have initiated a partnership with AAMI (2016) to establish safety standards for education and practice. Research can generate recommendations for further exploration to advance device training. An innovative approach to the problem is developing a manufacturer-healthcare partnership involving nurses in technology design and continuous education to promote competence and safe care delivery.

Implications for Public Policy

Patient safety is of paramount importance in the American healthcare system. The American Nurses' Association, in partnership with professional and governmental agencies, are continuously leading the adoption of technological advances in healthcare. As consumers of medical technologies, nurses must be prepared to interface with, interact with, and integrate new technology into nursing practice. Nursing competence directly impacts the quality and safety of patient care. Therefore, the Joint Commission standards for nursing competency include knowledge, skills, and capacity to perform nursing care. The FDA's patient safety concerns related specifically to recommendations that nursing organizations develop position statements to promote safer medical device utilization for better patient outcomes. The position statements should outline professional nursing standards, policies, and procedures to strengthen nursing practice. The FDA has provided nursing organizations with information on defective medical devices sequestered due to adverse event reports assist with creating impactful position

statements intended to improve device safety and patient outcomes (Alastalo et al., 2017; Axley, 2008; Swayze & Rich, 2012).

Limitations

The calculated sample size of 314 responses was not met. A total of 269 surveys were collected, and 39 were incomplete. Several reasons exist for not achieving the desired sample size. The online survey took approximately 15 to 20 minutes to complete, and answering the interview questions may have been time-consuming. Interruptions while completing the surveys may account for the high percentage of incomplete surveys. Having an option for participants to save and return to complete the survey would have been beneficial. The remoteness of the website may have limited access to the survey link. Finally, the specific population sampling may have limited the generalization of the findings and research outcomes.

Recommendations for Future Research

The conceptual model was adapted from a previous model to illustrate the relationship between nursing and technology. Although this model was useful, further research is needed to create a theoretical model of nursing to address technology and technological competence. Including medical device safety and competency into the nursing curriculum is recommended to prepare nurses for a work environment populated by numerous medical devices. The FDA's 2018 Report recognizes the issue of inadequate knowledge, training, technical skills, and experience of end-users of these devices. This research supports and reinforces recommendations in the literature for adequate medical device education and training. Reported safety concerns were related specifically to the technical complexity of modern devices and servicing them. As consumers of medical devices, nurses are valuable partners for sharing their experiences, suggestions, and concerns about safety features and designs. A pioneering approach to improving

medical device safety is to involve nurses in the development and design phase. Robust error reporting systems that include details of the problem and specific recommendations for improving the safety of the product can promote patient safety.

Chapter Summary

The research study results revealed that nurses view medical devices as both a benefit and interference to their practice. Critical care nurses voiced the need for adequate knowledge and skills to use complex medical devices safely. Continuing education and resources are needed to promote medical device safety, improve nursing practice, and deliver safer patient care. The most significant experiences and safety perceptions of American critical care nurses were discussed. Finally, the limitations of the study were acknowledged.

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APPENDIX A

IRB APPROVAL

NOVA SOUTHEASTERN UNIVERSITY
Institutional Review Board

MEMORANDUM

To: **Violet Rhagnanan-Kramer**

From: **Marcia Derby-Davis,**
Center Representative, Institutional Review Board

Date: **June 19, 2019**

Re: **IRB #: 2019-342; Title, "Critical Care Nurses' Perceptions of Safety Related to Using Complex Medical Devices in Daily Nursing Practice."**

I have reviewed the above-referenced research protocol at the center level. Based on the information provided, I have determined that this study is exempt from further IRB review under **45 CFR 46.101(b) (Exempt 2: Interviews, surveys, focus groups, observations of public behavior, and other similar methodologies)**. You may proceed with your study as described to the IRB. As principal investigator, you must adhere to the following requirements:

1) CONSENT: If recruitment procedures include consent forms, they must be obtained in such a manner that they are clearly understood by the subjects and the process affords subjects the opportunity to ask questions, obtain detailed answers from those directly involved in the research, and have sufficient time to consider their participation after they have been provided this information. The subjects must be given a copy of the signed consent document, and a copy must be placed in a secure file separate from de-identified participant information. Record of informed consent must be retained for a minimum of three years from the conclusion of the study.

2) ADVERSE EVENTS/UNANTICIPATED PROBLEMS: The principal investigator is required to notify the IRB chair and me (954-262-5369 and Marcia Derby-Davis, respectively) of any adverse reactions or unanticipated events that may develop as a result of this study. Reactions or events may include, but are not limited to, injury, depression as a result of participation in the study, life-threatening situation, death, or loss of confidentiality/anonymity of subject. Approval may be withdrawn if the problem is serious.

3) AMENDMENTS: Any changes in the study (e.g., procedures, number or types of subjects, consent forms, investigators, etc.) must be approved by the IRB prior to implementation. Please be advised that changes in a study may require further review depending on the nature of the change. Please contact me with any questions regarding amendments or changes to your study.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed in Part 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: Vanessa A Johnson, Ph.D.
Vanessa A Johnson, Ph.D.

3301 College Avenue • Fort Lauderdale, Florida 33314-7796
(954) 262-0000 • 800-672-7223, ext. 5369 • Email: *irb@nova.edu* • Web site: www.nova.edu/irb

NOVA SOUTHEASTERN UNIVERSITY
Institutional Review Board

MEMORANDUM

To: Violet Rhagnanan-Kramer
Ron and Kathy Assaf College of Nursing

From: Office of the Institutional Review Board

Date: January 31, 2020

Subject: IRB Exempt Amendment Approval Memo

TITLE: Critical Care Nurses' Perceptions of Safety Related to Using Complex Medical Devices in Daily Nursing Practice.– NSU IRB Protocol Number 2019-342

Dear Principal Investigator,

Your submission has been reviewed and approved by the Institutional Review Board on **June 18, 2019**. You may proceed with your study.

Please Note: If you receive stamped copies of consent, assent, and recruiting materials indicating approval date, these documents must be used when recruiting and consenting or assenting participants.

Level of Review: Exempt

Type of Approval: Amendment

Exempt Review Category: Exempt 2: Interviews, surveys, focus groups, observations of public behavior, and other similar methodologies

Post-Approval Monitoring: The IRB Office conducts post-approval review and monitoring of all studies involving human participants under the purview of the NSU IRB. The Post-Approval Monitor may randomly select any active study for a Not-for-Cause Evaluation.

Final Report: You are required to notify the IRB Office within 30 days of the conclusion of the research that the study has ended using the IRB Closing Report Form.

The following modifications were approved:

- Addition of/change to recruitment or compensation procedure(s)
- Addition of/change to study population

3301 College Avenue • Fort Lauderdale, Florida 33314-7796
(954) 262-5369 • 866-499-0790 • Fax: (954) 262-3977 • Email: *irb@nova.edu* • Web site: *www.nova.edu/irb*

APPENDIX B

PARTICIPANT LETTER FOR ANONYMOUS SURVEYS

Participant Letter for Anonymous Surveys
NSU Consent to be In a Research Study Entitled

Critical Care Nurses' Perceptions of Safety Related to Using New Technology in Daily Nursing Practice

Who is doing this research study?

This person doing this study is Violet Rhagnanan-Kramer with Nova Southeastern University Ron and Kathy Assaf College of Nursing They will be helped by Vanessa A. Johnson, Ph.D., RN Advisor/Dissertation Chair.

Why are you asking me to be in this research study?

You are being asked to take part in this research study because you are a critical care nurse with at least six months of experience working in an ICU in a full time, part-time or per diem status.

Why is this research being done?

The purpose of this study is to find out the ICU nurses' perceptions of safety related to using new technology and also explore continuing educational strategies for improving safe patient care.

What will I be doing if I agree to be in this research study?

You will be taking a one-time, anonymous survey. The survey will take approximately 15-20 minutes to complete.

Are there possible risks and discomforts to me?

This research study involves minimal risk to you. To the best of our knowledge, the things you will be doing have no more risk of harm than you would have in everyday life.

What happens if I do not want to be in this research study?

You can decide not to participate in this research and it will not be held against you. You can exit the survey at any time.

Will it cost me anything? Will I get paid for being in the study?

Page 1 of 2

There is no cost for participation in this study. Participation is voluntary and no payment will be provided.

How will you keep my information private

Your responses are anonymous. Information we learn about you in this research study will be handled in a confidential manner, within the limits of the law. This is an online survey that is anonymous and there is no trace or personal identification information collected that can result in a breach of confidentiality. This data will be available to the researcher, the Institutional Review Board and other representatives of this institution, and any granting agencies (if applicable). All confidential data will be kept securely stored on a password locked computer that can be accessed only by the researcher. The researcher, IRB, Dissertation chair and regulatory institution as applicable may have access to the data. All data will be kept for 36 months from the end of the study and destroyed after that time by deleting and erasing the electronic data from the NSU and researcher's data base.

Who can I talk to about the study?

If you have questions, you can contact Violet Rhagnanan-Kramer at [redacted] and Vanessa A. Johnson, Ph.D. at [redacted].

If you have questions about the study but want to talk to someone else who is not a part of the study, you can call the Nova Southeastern University Institutional Review Board (IRB) at (954) 262-5369 or toll free at 1-866-499-0790 or email at IRB@nova.edu.

Do you understand and do you want to be in the study?

If you have read the above information and voluntarily wish to participate in this research study, please continue by answering the survey questions below.

Page 2 of 2

APPENDIX C

SURVEY

Hospital Survey on Patient Safety

Instructions

This survey asks for your opinions about patient safety issues, medical error, and event reporting in your hospital and will take about 10 to 15 minutes to complete.

If you do not wish to answer a question, or if a question does not apply to you, you may leave your answer blank.

- *An "event" is defined as any type of error, mistake, incident, accident, or deviation, regardless of whether or not it results in patient harm.*
- *"Patient safety" is defined as the avoidance and prevention of patient injuries or adverse events resulting from the processes of health care delivery.*

SECTION A: Your Work Area/Unit

In this survey, think of your "unit" as the work area, department, or clinical area of the hospital where you spend *most* of your work time or provide *most* of your clinical services.

What is your primary work area or unit in this hospital? Select ONE answer.

- ☐ a. Many different hospital units/No specific unit
- ☐ b. Medicine (non-surgical)
- ☐ c. Surgery
- ☐ d. Obstetrics
- ☐ e. Pediatrics
- ☐ f. Emergency department
- ☐ g. Intensive care unit (any type)
- ☐ h. Psychiatry/mental health
- ☐ i. Rehabilitation
- ☐ j. Pharmacy
- ☐ k. Laboratory
- ☐ l. Radiology
- ☐ m. Anesthesiology
- ☐ n. Other, please specify: _____

Please indicate your agreement or disagreement with the following statements about your work area/unit.

Think about your hospital work area/unit...	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. People support one another in this unit	☐1	☐2	☐3	☐4	☐5
2. We have enough staff to handle the workload	☐1	☐2	☐3	☐4	☐5
3. When a lot of work needs to be done quickly, we work together as a team to get the work done	☐1	☐2	☐3	☐4	☐5
4. In this unit, people treat each other with respect	☐1	☐2	☐3	☐4	☐5
5. Staff in this unit work longer hours than is best for patient care	☐1	☐2	☐3	☐4	☐5

SECTION A: Your Work Area/Unit (continued)

Think about your hospital work area/unit...	Strongly Disagree ▼	Disagree ▼	Neither ▼	Agree ▼	Strongly Agree ▼
6. We are actively doing things to improve patient safety	☐1	☐2	☐3	☐4	☐5
7. We use more agency/temporary staff than is best for patient care	☐1	☐2	☐3	☐4	☐5
8. Staff feel like their mistakes are held against them	☐1	☐2	☐3	☐4	☐5
9. Mistakes have led to positive changes here	☐1	☐2	☐3	☐4	☐5
10. It is just by chance that more serious mistakes don't happen around here	☐1	☐2	☐3	☐4	☐5
11. When one area in this unit gets really busy, others help out	☐1	☐2	☐3	☐4	☐5
12. When an event is reported, it feels like the person is being written up, not the problem	☐1	☐2	☐3	☐4	☐5
13. After we make changes to improve patient safety, we evaluate their effectiveness	☐1	☐2	☐3	☐4	☐5
14. We work in "crisis mode" trying to do too much, too quickly	☐1	☐2	☐3	☐4	☐5
15. Patient safety is never sacrificed to get more work done	☐1	☐2	☐3	☐4	☐5
16. Staff worry that mistakes they make are kept in their personnel file	☐1	☐2	☐3	☐4	☐5
17. We have patient safety problems in this unit	☐1	☐2	☐3	☐4	☐5
18. Our procedures and systems are good at preventing errors from happening	☐1	☐2	☐3	☐4	☐5

SECTION B: Your Supervisor/Manager

Please indicate your agreement or disagreement with the following statements about your immediate supervisor/manager or person to whom you directly report.

	Strongly Disagree ▼	Disagree ▼	Neither ▼	Agree ▼	Strongly Agree ▼
1. My supervisor/manager says a good word when he/she sees a job done according to established patient safety procedures	☐1	☐2	☐3	☐4	☐5
2. My supervisor/manager seriously considers staff suggestions for improving patient safety	☐1	☐2	☐3	☐4	☐5
3. Whenever pressure builds up, my supervisor/manager wants us to work faster, even if it means taking shortcuts	☐1	☐2	☐3	☐4	☐5
4. My supervisor/manager overlooks patient safety problems that happen over and over	☐1	☐2	☐3	☐4	☐5

SECTION C: Communications

How often do the following things happen in your work area/unit?

Think about your hospital work area/unit...	Never	Rarely	Some-times	Most of the time	Always
1. We are given feedback about changes put into place based on event reports	☐1	☐2	☐3	☐4	☐5
2. Staff will freely speak up if they see something that may negatively affect patient care	☐1	☐2	☐3	☐4	☐5
3. We are informed about errors that happen in this unit	☐1	☐2	☐3	☐4	☐5
4. Staff feel free to question the decisions or actions of those with more authority	☐1	☐2	☐3	☐4	☐5
5. In this unit, we discuss ways to prevent errors from happening again	☐1	☐2	☐3	☐4	☐5
6. Staff are afraid to ask questions when something does not seem right	☐1	☐2	☐3	☐4	☐5

SECTION D: Frequency of Events Reported

In your hospital work area/unit, when the following mistakes happen, *how often are they reported?*

	Never	Rarely	Some-times	Most of the time	Always
1. When a mistake is made, but is *caught and corrected before affecting the patient*, how often is this reported?	☐1	☐2	☐3	☐4	☐5
2. When a mistake is made, but has *no potential to harm the patient*, how often is this reported?	☐1	☐2	☐3	☐4	☐5
3. When a mistake is made that *could harm the patient*, but does not, how often is this reported?	☐1	☐2	☐3	☐4	☐5

SECTION E: Patient Safety Grade

Please give your work area/unit in this hospital an overall grade on patient safety.

☐	☐	☐	☐	☐
A	B	C	D	E
Excellent	Very Good	Acceptable	Poor	Failing

SECTION F: Your Hospital

Please indicate your agreement or disagreement with the following statements about your hospital.

Think about your hospital...	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. Hospital management provides a work climate that promotes patient safety	☐1	☐2	☐3	☐4	☐5
2. Hospital units do not coordinate well with each other	☐1	☐2	☐3	☐4	☐5
3. Things "fall between the cracks" when transferring patients from one unit to another	☐1	☐2	☐3	☐4	☐5
4. There is good cooperation among hospital units that need to work together	☐1	☐2	☐3	☐4	☐5

SECTION F: Your Hospital (continued)

Think about your hospital...	Strongly Disagree ▼	Disagree ▼	Neither ▼	Agree ▼	Strongly Agree ▼
5. Important patient care information is often lost during shift changes	☐1	☐2	☐3	☐4	☐5
6. It is often unpleasant to work with staff from other hospital units	☐1	☐2	☐3	☐4	☐5
7. Problems often occur in the exchange of information across hospital units.....	☐1	☐2	☐3	☐4	☐5
8. The actions of hospital management show that patient safety is a top priority	☐1	☐2	☐3	☐4	☐5
9. Hospital management seems interested in patient safety only after an adverse event happens.....	☐1	☐2	☐3	☐4	☐5
10. Hospital units work well together to provide the best care for patients	☐1	☐2	☐3	☐4	☐5
11. Shift changes are problematic for patients in this hospital.....	☐1	☐2	☐3	☐4	☐5

SECTION G: Number of Events Reported

In the past 12 months, how many event reports have you filled out and submitted?

- ☐ a. No event reports
- ☐ b. 1 to 2 event reports
- ☐ c. 3 to 5 event reports
- ☐ d. 6 to 10 event reports
- ☐ e. 11 to 20 event reports
- ☐ f. 21 event reports or more

SECTION H: Background Information

This information will help in the analysis of the survey results.

1. **How long have you worked in this hospital?**
   - ☐ a. Less than 1 year
   - ☐ b. 1 to 5 years
   - ☐ c. 6 to 10 years
   - ☐ d. 11 to 15 years
   - ☐ e. 16 to 20 years
   - ☐ f. 21 years or more
2. **How long have you worked in your current hospital work area/unit?**
   - ☐ a. Less than 1 year
   - ☐ b. 1 to 5 years
   - ☐ c. 6 to 10 years
   - ☐ d. 11 to 15 years
   - ☐ e. 16 to 20 years
   - ☐ f. 21 years or more
3. **Typically, how many hours per week do you work in this hospital?**
   - ☐ a. Less than 20 hours per week
   - ☐ b. 20 to 39 hours per week
   - ☐ c. 40 to 59 hours per week
   - ☐ d. 60 to 79 hours per week
   - ☐ e. 80 to 99 hours per week
   - ☐ f. 100 hours per week or more

SECTION H: Background Information (continued)

4. What is your staff position in this hospital? Select ONE answer that best describes your staff position.

- ☐ a. Registered Nurse
- ☐ b. Physician Assistant/Nurse Practitioner
- ☐ c. LVN/LPN
- ☐ d. Patient Care Asst/Hospital Aide/Care Partner
- ☐ e. Attending/Staff Physician
- ☐ f. Resident Physician/Physician in Training
- ☐ g. Pharmacist
- ☐ h. Dietician
- ☐ i. Unit Assistant/Clerk/Secretary
- ☐ j. Respiratory Therapist
- ☐ k. Physical, Occupational, or Speech Therapist
- ☐ l. Technician (e.g., EKG, Lab, Radiology)
- ☐ m. Administration/Management
- ☐ n. Other, please specify: _____

5. In your staff position, do you typically have direct interaction or contact with patients?

- ☐ a. YES, I typically have direct interaction or contact with patients.
- ☐ b. NO, I typically do NOT have direct interaction or contact with patients.

6. How long have you worked in your current specialty or profession?

- ☐ a. Less than 1 year
- ☐ b. 1 to 5 years
- ☐ c. 6 to 10 years
- ☐ d. 11 to 15 years
- ☐ e. 16 to 20 years
- ☐ f. 21 years or more

SECTION I: Your Comments

Please feel free to write any comments about patient safety, error, or event reporting in your hospital.

THANK YOU FOR COMPLETING THIS SURVEY.

Sorra, J., Gray, L., Streagle, S., Famolaro, M. P. S., Yount, N., & Behn, J. (2016). AHRQ Hospital Survey on Patient Safety Culture: User's Guide. (Prepared by Westat, under Contract No. HHSA290201300003C). AHRQ Publication No. 15-0049-EF (Replaces 04-0041). Rockville, MD: Agency for Healthcare Research and Quality. January 2016 https://www.ahrq.gov/sites/default/files/wysiwyg/professionals/quality-patient-safety/patientsafetyculture/hospital/userguide/hospcult.pdf

APPENDIX D

RECRUITMENT LETTER

Recruitment Letter

Dear [redacted] Region Leader,

I'm an [redacted] member and PhD candidate currently conducting a nursing research online survey that is posted on the [redacted]. If possible, this is a request to share the study on your region's Facebook page, in newsletters, and with your local chapter board members to disseminate via email to chapter members in an effort to increase awareness of the study. The study information is:

Your thoughts and experiences are Important! If you are an ICU nurse with greater than 6 months experience you are invited to participate in an online nursing research survey currently posted on [redacted] titled: *Critical Care Nurses' Perceptions of Safety Related to Using New Technology in Daily Nursing Practice.* The purpose of this research study is to gain insight into ICU nurses' safety perceptions related to barriers and facilitators of using new technology and explore continuing educational strategies for improving nurses' technological competence for safer patient care.

Thank you,

Violet Rhagnanan-Kramer

APPENDIX E

REDCAP© SURVEY

Confidential

Critical Care Nurses' Perceptions of Safety Related to Using New Technology in Daily Nursing Practice

Who is doing this research study?

This person doing this study is Violet Rhagnanan-Kramer with Nova Southeastern University Ron and Kathy Assaf College of Nursing. They will be helped by Vanessa A. Johnson, Ph.D., RN Advisor/Dissertation Chair.

Why are you asking me to be in this research study?

You are being asked to take part in this research study because you are a critical care nurse with at least six months of experience working in an ICU in a full time, part-time or per diem status.

Why is this research being done?

The purpose of this study is to find out the ICU nurses' perceptions of safety related to using new technology and also explore continuing educational strategies for improving safe patient care.

What will I be doing if I agree to be in this research study?

You will be taking a one-time, anonymous survey. The survey will take approximately 15-20 minutes to complete.

Are there possible risks and discomforts to me?

This research study involves minimal risk to you. To the best of our knowledge, the things you will be doing have no more risk of harm than you would have in everyday life.

What happens if I do not want to be in this research study?

You can decide not to participate in this research and it will not be held against you. You can exit the survey at any time.

Will it cost me anything? Will I get paid for being in the study?

There is no cost for participation in this study. Participation is voluntary and no payment will be provided.

How will you keep my information private

Your responses are anonymous. Information we learn about you in this research study will be handled in a confidential manner, within the limits of the law. This is an online survey that is anonymous and there is no trace or personal identification information collected that can result in a breach of confidentiality. This data will be available to the researcher, the Institutional Review Board and other representatives of this institution, and any granting agencies (if applicable). All confidential data will be kept securely stored on a password locked computer that can be accessed only by the researcher. The researcher, IRB , Dissertation chair and regulatory institution as applicable may have access to the data. All data will be kept for 36 months from the end of the study and destroyed after that time by deleting and erasing the electronic data from the NSU and researcher's data base.

Who can I talk to about the study?

If you have questions, you can contact Violet Rhagnanan-Kramer at 305-951-2624 and Vanessa A. Johnson, Ph.D. at 954.262.1522.

If you have questions about the study but want to talk to someone else who is not a part of the study, you can call the Nova Southeastern University Institutional Review Board (IRB) at (954) 262-5369 or toll free at 1-866-499-0790 or email at IRB@nova.edu.

Do you understand and do you want to be in the study?

If you have read the above information and voluntarily wish to participate in this research study, please continue by answering the survey questions below.

Demographic Information

Please select one of the answers that best fits your response or fill in the blank space.

Number of years worked in nursing?

_____

Number of years worked in ICU?

_____

Specialized ICU experience?

◯ CCU
◯ CVSICU
◯ MICU
◯ Neuro ICU
◯ NICU
◯ PICU
◯ SICU
◯ TICU
◯ Other

Other:

_____

What shift do you work?

◯ Day Shift
◯ Night Shift

Completed ICU Internship Program

◯ Yes
◯ No

Medical Devices Safety Education /Competency

◯ Once
◯ Annually
◯ Don't Know
◯ Never

Which educational strategy best meet your learning needs for safe use of medical devices?

◯ High-Fidelity Simulation Competency
◯ Virtual Simulation Competency
◯ Instructor Led Competency
◯ Other

Other

_____

What is your level of education?

◯ Diploma
◯ ADN
◯ BSN
◯ MSN
◯ DNP
◯ PhD

Specialized Certification?

◯ CCRN
◯ CNRN
◯ SCRN
◯ TCRN
◯ N/A
◯ Other

Other

_____

What is your gender?

◯ Female
◯ Male
◯ Other

Other:

_____

What is your age?

_____

What state do you live in ?

- ◯ Alabama
- ◯ Alaska
- ◯ Arizona
- ◯ Arkansas
- ◯ California
- ◯ Colorado
- ◯ Connecticut
- ◯ Delaware
- ◯ Florida
- ◯ Georgia
- ◯ Hawaii
- ◯ Idaho
- ◯ Illinois
- ◯ Indiana
- ◯ Iowa
- ◯ Kansas
- ◯ Kentucky
- ◯ Louisiana
- ◯ Maine
- ◯ Maryland
- ◯ Massachusetts
- ◯ Michigan
- ◯ Minnesota
- ◯ Mississippi
- ◯ Missouri
- ◯ Montana
- ◯ Nebraska
- ◯ Nevada
- ◯ New Hampshire
- ◯ New Jersey
- ◯ New Mexico
- ◯ New York
- ◯ North Carolina
- ◯ North Dakota
- ◯ Ohio
- ◯ Oklahoma
- ◯ Oregon
- ◯ Pennsylvania
- ◯ Rhode Island
- ◯ South Carolina
- ◯ South Dakota
- ◯ Tennessee
- ◯ Texas
- ◯ Utah
- ◯ Vermont
- ◯ Virginia
- ◯ Washington
- ◯ West Virginia
- ◯ Wisconsin
- ◯ Wyoming

(Please fill state.)

What is your primary language?

- ◯ English
- ◯ Other

Other language:

_____

What is the approximate capacity of the hospital where you work ?

◯ Equal or less than 100 beds
◯ Equal or less than 250 beds
◯ Equal or less than 500 beds
◯ Equal or less than 750 beds
◯ Equal or less than 1000 beds
◯ Unknown

Instructions
This survey asks for your opinion about patient safety issues, medical error, and event reporting in your hospital and will take about 10 to 15 minutes to complete.
If you do not wish to answer a question, or if a question does not apply to you, you may leave your answer blank.

- An "event" is defined as any type of error, mistake, incident, accident, or deviation, regardless of whether or not it results in patient harm.

-"Patient safety" is defined as the avoidance and prevention of patient injuries of adverse events resulting from the processes of health care delivery.
SECTION A: Your Work Area/Unit
In this survey, think of your "unit" as the work area, department, or clinical area of the hospital where you spend most of your work time or provide most of your clinical services.

What is your primary work area or unit in this hospital? Select ONE answer.

- ◯ a. Many different hospital units/No specific unit
- ◯ b. Medicine (non-surgical)
- ◯ c. Surgery
- ◯ d. Obstetrics
- ◯ e. Pediatrics
- ◯ f. Emergency department
- ◯ g. Intensive care unit (any type)
- ◯ h. Psychiatry/mental health
- ◯ i. Rehabilitation
- ◯ j. Pharmacy
- ◯ k. Laboratory
- ◯ l. Radiology
- ◯ m. Anesthesiology
- ◯ n. Other, please specify:

Other, please specify:

_____

Please indicate your agreement or disagreement with the following statements about your work area/unit.
Think about your hospital work area/unit...

Confidential

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. People support one another in this unit	○	○	○	○	○
2. We have enough staff to handle the workload	○	○	○	○	○
3. When a lot of work needs to be done quickly, we work together as a team to get the work done	○	○	○	○	○
4. In this unit, people treat each other with respect	○	○	○	○	○
5. Staff in this unit work longer hours than is best for patient care	○	○	○	○	○
6. We are actively doing things to improve patient safety	○	○	○	○	○
7. We use more agency/temporary staff than is best for patient care	○	○	○	○	○
8. Staff feel like their mistakes are held against them	○	○	○	○	○
9. Mistakes have led to positive changes here	○	○	○	○	○
10. It is just by chance that more serious mistakes don't happen around here	○	○	○	○	○
11. When one area in this unit gets really busy, others help out	○	○	○	○	○
12. When an event is reported, it feels like the person is being written up, not the problem	○	○	○	○	○
13. After we make changes to improve patient safety, we evaluate their effectiveness	○	○	○	○	○
14. We work in "crisis mode" trying to do too much, too quickly	○	○	○	○	○
15. Patient safety is never sacrificed to get more work done	○	○	○	○	○
16. Staff worry that mistakes they make are kept in their personnel file	○	○	○	○	○
17. We have patient safety problems in this unit	○	○	○	○	○
18. Our procedures and systems are good at preventing errors from happening	○	○	○	○	○

SECTION B: Your Supervisor/Manager

Please indicate your agreement or disagreement with the following statements about your immediate supervisor/manager or person to whom you directly report.

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. My supervisor/manager says a good word when he/she sees a job done according to established patient safety procedures	○	○	○	○	○
2. My supervisor/manager seriously considers staff suggestions for improving patient safety	○	○	○	○	○
3. Whenever pressure builds up, my supervisor/manager wants us to work faster, even if it means taking shortcuts	○	○	○	○	○
4. My supervisor/manager overlooks patient safety problems that happen over and over	○	○	○	○	○

SECTION C: Communications

How often do the following things happen in your work area/unit?

Think about your hospital work area/unit...

	Never	Rarely	Sometimes	Most of the time	Always
1. We are given feedback about changes put into place based on event reports	○	○	○	○	○
2. Staff will freely speak up if they see something that may negatively affect patient care	○	○	○	○	○
3. We are informed about errors that happen in this unit	○	○	○	○	○
4. Staff feel free to question the decisions or actions of those with more authority	○	○	○	○	○
5. In this unit, we discuss ways to prevent errors from happening again	○	○	○	○	○
6. Staff are afraid to ask questions when something does not seem right	○	○	○	○	○

SECTION D: Frequency of Events Reported

In your hospital work area/unit, when the following mistakes happen, how often are they reported?

	Never	Rarely	Sometimes	Most of the time	Always
1. When a mistake is made, but is caught and corrected before affecting the patient, how often is this reported?	○	○	○	○	○
2. When a mistake is made, but has no potential to harm the patient, how often is this reported?	○	○	○	○	○
3. When a mistake is made that could harm the patient, but does not, how often is this reported?	○	○	○	○	○

SECTION E: Patient Safety Grade

	A. Excellent	B. Very Good	C. Acceptable	D. Poor	E. Failing
Please give your work area/unit in this hospital an overall grade on patient safety	○	○	○	○	○

SECTION F: Your Hospital
Please indicate your agreement or disagreement with the following statements about your hospital. Think about your hospital...

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. Hospital management provides a work climate that promotes patient safety	○	○	○	○	○
2. Hospital units do not coordinate well with each other	○	○	○	○	○
3. Things "fall between the cracks" when transferring patients from one unit to another	○	○	○	○	○
4. There is good cooperation among hospital units that need to work together	○	○	○	○	○
5. Important patient care information is often lost during shift changes	○	○	○	○	○
6. It is often unpleasant to work with staff from other hospital units	○	○	○	○	○
7. Problems often occur in the exchange of information across hospital units	○	○	○	○	○
8. The actions of hospital management show that patient safety is a top priority	○	○	○	○	○
9. Hospital management seems interested in patient safety only after an adverse event happens	○	○	○	○	○
10. Hospital units work well together to provide the best care for patients	○	○	○	○	○
11. Shift changes are problematic for patients in this hospital	○	○	○	○	○

SECTION G: Number of Events Reported
In the past 12 months, how many event reports have you filled out and submitted?

◯ a. No event reports
◯ b. 1 to 2 event reports
◯ c. 3 to 5 event reports
◯ d. 6 to 10 event reports
◯ e. 11 to 20 event reports
◯ f. 21 event reports or more

SECTION H: Background Information
This information will help in the analysis of the survey results.

1. How long have you worked in this hospital?

◯ a. Less than 1 year
◯ b. 1 to 5 years
◯ c. 6 to 10 years
◯ d. 11 to 15 years
◯ e. 16 to 20 years
◯ f. 21 years or more

2. How long have you worked in your current hospital work area/unit?

◯ a. Less than 1 year
◯ b. 1 to 5 years
◯ c. 6 to 10 years
◯ d. 11 to 15 years
◯ e. 16 to 20 years
◯ f. 21 years or more

3. Typically, how many hours per week do you work in this hospital?

◯ a. Less than 20 hours per week
◯ b. 20 to 39 hours per week
◯ c. 40 to 59 hours per week
◯ d. 60 to 79 hours per week
◯ e. 80 to 99 hours per week
◯ f. 100 hours per week or more

4. What is your staff position in this hospital? Select ONE answer that best describes your staff position.

◯ a. Registered Nurse
◯ b. Physician Assistant/ Nurse Practitioner
◯ c. LVN/LPN
◯ d. Patient Care Asst/ Hospital Aide/Care Partner
◯ e. Attending/Staff Physician
◯ f. Resident Physician/Physician in Training
◯ g. Pharmacist
◯ h. Dietitian
◯ i. Unit Assistant/Clerk/Secretary
◯ j. Respiratory Therapist
◯ k. Physical, Occupational, or Speech Therapist
◯ l. Technician (e.g., EKG, Lab, Radiology)
◯ m. Administration/Management
◯ Other, please specify:

Other, please specify:

_____

5. In your staff position, do you typically have direct interaction or contact with patients?

◯ a. YES, I typically have direct interaction or contact with patients.
◯ b. NO, I typically do NOT have interaction or contact with patients.

6. How long have you worked in your current specialty or profession?

◯ a. Less than 1 year
◯ b. 1 to 5 years
◯ c. 6 to 10 years
◯ d. 11 to 15 years
◯ e. 16 to 20 years
◯ f. 21 years or more

Section I: Your Comments

Please feel free to write any comments about your patient safety, error, or event reporting in your hospital.
(Sorra J, Gray L, Streagle S, et al. (2016). AHRQ Hospital Survey on Patient Safety Culture: User's Guide. (Prepared by Westat, under Contract No. HHSA290201300003C). AHRQ Publication No. 15-0049-EF (Replaces 04-0041). Rockville, MD: Agency for Healthcare Research and Quality. January 2016
https://www.ahrq.gov/sites/default/files/wysiwyg/professionals/quality-patient-safety/patientsafetyculture/hospital/userguide/hospcult.pdf)

Interview Questions

1. What are your lived experiences working in the ICU and using complex medical devices such as ventilators, ICU beds, hypothermia devices, and continuous renal replacement therapy machines to deliver nursing care?

1a. Describe your day caring for an unstable patient?

1b. What do you do if you have a problem with a device?

1c. Do you self-evaluate your technical skills? If yes, please explain.

2. How do you feel about using the new medical devices to safely provide patient care?

2a. Please tell me more about that and give examples.

3. What do you think are the safety advantages and disadvantages of complex medical devices?

3a. Have you reported any device related event? If so, please describe.

4. How were you educated to use new medical devices and the safety features?

4a. Please describe how you update your technical skills.

4b. What ongoing workplace opportunities are available to practice technical skills?

5. What do you think are the best methods to educate nurses on the safe use of new equipment?

5a. What would make you feel more competent and confident to use new devices?

6. Is there anything else you want to tell me about your experience working with new complex equipment?