THE EXPERIENCE OF NURSES WHO USE AUTOMATED EARLY WARNING SYSTEMS TECHNOLOGY IN CLINICAL PRACTICE

By PATRICIA GEERLINKS, R.N., B.Sc.N.

A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirements for the Degree of Master of Science in Nursing

Descriptive Note

Master of Science (2016) McMaster University

(Nursing) Hamilton, Ontario

TITLE: The Experience of Nurses who use Automated Early Warning Systems Technology in Clinical Practice

AUTHOR: Patricia Geerlinks, R.N., B.Sc.N. (McMaster University)

SUPERVISOR: Professor Dr. C. McKey

Number of Pages: i-xi; 1-115

Abstract

Failure to rescue (FTR) outcomes may be one consequence of the relationship between healthcare provider behaviors and attitudes, organizational factors, and environmental factors that intersect to potentially threaten patient safety. Early warning systems (EWS) were designed as surveillance systems to reduce failure to rescue events and avoid morbidity and mortality. Challenges with EWS include lack of standardization, organizational barriers, such as culture and supports, and human factor attributes such as intuition, expertise, and experience. The experience and perceptions of nurses using EWS technology as it relates to their clinical assessment, critical thinking, and decision-making skills has yet to be undertaken. This study adds to the body of EWS and FTR literature and the broader culture of safety literature in acute care environments.

The purposes of this exploratory qualitative descriptive study was to explore the experiences of nurses using EWS in acute care practice settings and how they perceive it impacts on their critical thinking and clinical decision-making processes. The study identified three informative findings: a) EWS has added value particularly with novice nurses or nurses new to practice settings, b) EWS provides benefits to nurses working in acute clinical environments that experience high volumes and high acuity of patients by alerting or reminding them about potential FTR situations, and c) Existing EWS may require modification to improve adequacy, reduce redundancy, and reduce alarm fatigue. Based on the evidence reviewed, a qualitative study to increase our understanding of the experience of nurses and their perception of the impact of EWS and related technology on their critical thinking and other nursing practice processes has the potential to contribute to a wider evaluation of EWS systems and to improve patient outcomes.

Acknowledgements

It is my honour to thank my esteemed supervisory committee, whom I hold in very high regard and whose expertise and clinical practice experience I value deeply. To Dr. Colleen McKey, I am ever indebted to you for agreeing to meet with me, hearing my passion for practice, quality, and human factors analysis, and allowing me to learn and grow under your tutelage. I knew I stood to gain a great deal from you when I sought after you because of your professional and research history in the areas of professional practice, nursing leadership and education, and quality management. And I was right. You have coached me down research paths of clinical excellence in all phases of my thesis work. You never failed to give me expert insights, unconditional encouragement, and vaults of practice and quality wisdom. I would not have accomplished the body of work that I did without your sound advice and recommendations for discovery.

To Dr. Sandra Ireland, with whom I began my graduate journey as my graduate advisor, I am grateful for your generous support and encouragement in guiding me to transfer from the course-based Masters of Science in Nursing program to the thesis-based Masters of Science in Nursing program. I will never regret that decision. I am equally appreciative that you graciously agreed to remain on my committee. Your clinical leadership, knowledge, and expertise as an acute care nursing practice leader has sharpened my own clinical expertise both academically and professionally. Finally, I wish to thank you for ensuring that I had access to an exceptional nursing practice expert as graduate supervisor.

To Dr. Nancy Carter, whose methods expertise in all things qualitative research I coveted, I am wholeheartedly thankful for your thought-provoking approach to finding

new truths. I am also very appreciative of your research expertise and the extra time you were able to dedicate to my learning in the areas of data collection, analysis, and interpretation, particularly with coaching sessions on N-Vivo software. Your passion and interest for the topic of discovery was especially encouraging in times of perseverance and fueled me toward the finish of this graduate journey. I am grateful for the entire committee's contribution to me as a learner and as a researcher. I am deeply proud of the work we accomplished together. The opportunity to conduct nursing research in an area in which I am impassioned professionally as well as academically has been invigorating and inspiring.

Finally, to the nurses that participated in the study, I thank you for your bravery in sharing with me your nursing practice stories. I truly appreciated and enjoyed your candor in sharing your experiences and challenges, and I thank you for the clinical excellence you embody in nursing practice every single day at the point of care. I am proud to call you colleagues. It is my hope that I have represented your stories in a way that also makes you proud.

Dedication

This thesis is dedicated with love to my family. To my husband, John, who jokes I have been in school "forever", I wish to thank you for being so encouraging and patient in my pursuit for academic excellence. You have been incredibly supportive with my passion to meet career goals as well as academic achievements, both at the same time no less! Your sacrifices while I worked and wrote on many a late evening and weekend has been so appreciated. This accomplishment is as much yours as it is mine.

To my daughters Kyara and Arielle, it is true that I have been in school for most of your lives. I hope that I have set an example for you that you are proud of and that inspires you to be and do anything you want in your own careers and lives. It has been an honour to be your mom and you don't know how proud I am of both of you. Kyara, you are a beautiful, strong, intelligent, passionate woman. I was never more proud of you then on your wedding day when you joined lives and love with Taylor, who is a wonderful partner for you. Your humor got me through this accomplishment and you are a terrific friend to me. Arielle, you are a beautiful, smart, caring, kind woman, with incredible inner strength and courage. You have wonderful talents and gifts that are going to serve you well. Your resilience is inspiring and you have grown into someone that makes me more and more proud every day. I love all of you very much. Thank you for believing in me and letting me demonstrate and live out my passion for learning.

Finally, to my brothers Len and Mike, whom I also consider dear friends and academic colleagues. I have always valued your shared love for lifelong learning and academic excellence. We have all been in school together over the years and it has been amazing to share this journey and accomplishment with you both. I love you dearly.

Table of Contents

List of Figures and Tables

List of Abbreviations and Symbols

Alert, Verbal, Pain, Unresponsive (AVPU)

Canadian Federation of Nurses' Union (CFNU)

Early Warning Systems (EWS)

Failure to Rescue (FTR)

Hamilton Integrated Research Ethics Board (HIREB)

Human Factors Analysis (HFA)

Infection Prevention and Control (IPAC)

Intensive Care Units (ICU)

Modified Early Warning Systems (MEWS)

National Early Warning Score (NEWS)

Paediatric Early Warning System (PEWS)

Public Health Agency of Canada (PHAC)

Registered Nurse (RN)

Registered Practical Nurse (RPN)

Vital Early Warning Scores (VIEWS)

Declaration of Academic Achievement

The following is a declaration that the content of the research in this document has been completed by Patricia Geerlinks and recognizes the contributions of Dr. Colleen McKey, Dr. Sandra Ireland, and Dr. Nancy Carter in the research process and the completion of the thesis.

CHAPTER 1: BACKGROUND

Background

Before admission to critical care, 24-48 hours before a serious harmful event such as sepsis or a cardiac arrest, hospitalized patients may experience abnormal vital signs and subtle physiological changes. The patient safety literature suggests that such events may be preventable (Alam, et al., 2014; Baker et al., 2004; Elliot et al., 2015). The need to enhance and support early assessment of risk and optimize timely clinical responses to patients with physiologically deteriorating conditions has led to the development of early warning systems (Elliot et al., 2015). Early warning systems (EWS) are simple algorithms with specific criteria that have been developed based on specific physiological and clinical observations that identify patients who are at risk for clinical deterioration (McGaughey et al., 2009).

Failure to Rescue

Failure to rescue has been defined as the inability to save a patient's life after the development of a physical complication in that patient (Aiken, Clarke, Cheung, Sloan, & Silber, 2003; Schmid, Hoffman, Happ, Wolf, & Devita, 2007). The Agency for Healthcare Research and Quality further defines failure to rescue to include factors that lead to patients' health deterioration or death, such as underlying disease, complications of medical care, and response to an acute situation (Askew, Trotter, Vacchiano, Garvey, & Overcash, 2012). A review of the literature suggests that failure to rescue is the end result of a series of failure events, including failure to anticipate, recognize, respond, and intervene (Ashcraft, 2004; Levett-Jones et al., 2009; Manojlovich & Talsma, 2007; Schubert, 2012; Taenzer, Pyke, & McGrath, 2011).

Patient safety depends on nurses' clinical judgment in identifying physiologically deteriorating patients, and additional resources are needed to evaluate and validate EWS in conjunction with clinical judgment and decision-making (Kyriacos, Jelsma, & Jordan, 2011). Approximately 30% of patients who are admitted to critical care from a general hospital ward have experienced a cardio-respiratory arrest (Page, Blaber, & Snowden, 2008). Patients with in-hospital cardiac arrest reported, on average, surviving the event between 15% to 20% of the time; if treatment is delayed, these patients have a higher mortality rate when admitted from general hospital wards versus from other critical care areas (Day & Oxton, 2014; McGaughey et al., 2009; Sandroni, Nolan, Cavallaro, & Antonelli, 2007). Nurses' ability to demonstrate accurate clinical assessment, effective critical thinking, and sound clinical judgment and decision-making influence patient safety through early recognition of clinical deterioration in patients' conditions.

Clinical signs have been reported to go unnoticed by nurses at the early onset of patients' physiological deterioration (Elliot et al., 2015; Johnstone, Rattray, & Meyers, 2007; Kyriacos, Jelsma, & Jordan, 2011; McNeill & Bryden, 2013; Morris & Davies, 2010). Life threatening complications associated with failure to identify these signs include pneumonia, shock, sepsis, cardiac arrest, and upper gastrointestinal bleeding. These complications have been described as failure-to-rescue situations because correct nursing or medical interventions using clinical judgment and critical thinking could have identified and positively influenced them (Schmid, Hoffman, Happ, Wolf, & DeVita, 2007).

Failure to rescue outcomes may be one consequence of the relationship between healthcare provider behaviors and attitudes, organizational factors, and environmental factors, all of which intertwine to threaten patient safety and impact the efficacy of EWS

and rescue efforts (Harrison, Koppel, & Bar-Lev, 2007; Reason, 2004). Human factor analysis addresses the interplay between the three factors, studying the strengths and limitations of human performance, the impacts of organizational behavior such as leadership and safety culture, and the existing workflows and technical systems in an environment (Cafazzo et al., 2009; Harrison, Koppel, & Bar-Lev, 2007). While the application of human factor analysis principles in healthcare is relatively new, this evolution, rooted in an emphasis on patient safety, has proven to be effective in system redesign for medical technology and in the identification of potential system-related errors (Cafazzo & St-Cyr, 2012).

Seminal research by Silber et al. (1992) showed that improvement efforts focused at the system and organizational level are more successful at reducing rates of failure to rescue than efforts that are focused on patient characteristics (Manojlovich & Talsma, 2007; Silber, Williams, Krakauer, & Schwartz, 1992). There is a growing body of evidence suggesting that patient morbidity and mortality outcomes are correlated to failure to rescue rates and potentially result from complex interactions among patient, providers, and organizational factors (Kendall-Gallagher, Aiken, Sloane, & Cimiotti, 2011). Empirical links have been reported among failure to rescue processes of care (Manojlovich & Talsma, 2007), rapid response teams, effective rescue interventions (Massey, Aitken, & Chaboyer, 2010), higher than ever nurse-to-patient ratios, more educated nurses, improved nursing work environments (Aiken et al., 2011), nursing's ability for patient surveillance (Shever, 2011), simulation exercises (Askew, Trotter, Vacchiano, Garvey, & Overcash, 2012), and difficulties relaying and interpreting information across occupational and professional boundaries (Mackintosh & Sandall, 2010).

Early Warning Systems

EWS were designed as surveillance systems, primarily for general hospital units, to reduce failure to rescue events and avoid morbidity and mortality (Schmidt et al., 2015). In 60-80% of patients, early signs of clinical deterioration, characterized by slow and progressive physiological decline, can be detected hours before a serious harmful event. EWS supports early intervention, timely response, and the successful rescue of a patient from potentially adverse health outcomes. (Capan, Ivy, Rohleder, Hickman, & Huddleston, 2015; Day & Oxton, 2014; Kolic, Crane, McCarney, Perkins, & Taylor, 2015). How nurses experience EWS technology and how they perceive the impact of EWS on nursing practice, including their critical thinking, is not well researched, understood, or explained in the literature. More broadly, little is known about EWS in clinical practice, and the evidence on its impact on clinical outcomes is inconclusive (McDonnell et al., 2012; McGaughey et al., 2009).

Some researchers suggest that EWS should be used as an adjunct to clinical assessment and not as a replacement for clinical judgment (Alam et al., 2014; Johnstone, Rattray, & Meyers, 2007; McGaughey et al., 2010; McNeill & Bryden, 2013). Researchers have recommended focused study of the intersection and impact of EWS and the following important health care factors: a) social factors such as physician and nurse communication; b) behavioral factors such as individual user acceptance of EWS; and c) organizational factors such as EWS education and training (Alam, 2014; Capan, Ivy, Rohleder, Hickman, & Huddleston, 2015; McGaughey, Blackwood, O'Halloran, Trinder, & Porter; McNeill & Bryden, 2013).

The EWS is a physiological score that prescribes a response for a particular deteriorating patient using a simple categorical method for clinical decision-making (Capan, Ivy, Rohleder, Hickman, & Huddleston, 2015; Kolic, Crane, McCarney, Perkins, & Taylor, 2015). Physiological parameters and clinical observations used in EWS include, but are not limited to, heart rate, blood pressure, respiratory rate, temperature, urinary output, and level of consciousness. An example of a clinical deterioration in which EWS has been used successfully is the early identification of sepsis. The physiological parameters of systemic inflammatory response syndrome (SIRS) present in early sepsis are built into EWS assessment criteria and documentation algorithms. The EWS algorithms may be a paper-based scoring tool or may be automated using technological-based systems to trigger early detection. Since the introduction of EWS in healthcare, there have been revised versions, such as Modified Early Warning Systems (MEWS), National Early Warning Scores (NEWS), Pediatric Warning Systems (PEWS), and Vital Early Warning Scores (VIEWS), which are all designed to standardize clinical assessments, promote early recognition of deteriorating conditions in patients, and guide clinical decision-making (Capan, Ivy, Rohleder, Hickman, & Huddleston, 2015).

EWS surveillance activities involve the purposeful acquisition and interpretation of patient data to support clinical decision-making (Shever, 2011). Nurses are the healthcare providers most likely to anticipate, identify, and activate a timely response to complications in a patient's condition. Taenzer, Pyke, and McGrath (2011), in their review of approaches to addressing failures to rescue, cautioned that patient surveillance using biotechnology should not replace other forms of clinical monitoring, so as to avoid a false sense of security regarding patients at risk for deterioration. Nurses are tasked

with gathering and interpreting complex assessment data in dynamic clinical environments that may affect how they interpret early warning scores (Johnstone, Rattray, & Meyers, 2007). Johnstone, Rattray, and Meyers (2007) further found that when and how nurses decide to intervene may be multifactorial.

Purpose of Research

While there is international evidence showing that nurses do not always recognize or respond to the clinical deterioration of patients, little is known about the impact of EWS on nursing practice, particularly nursing assessment, critical thinking, and clinical judgment (McDonnell et al., 2012). Some researchers posit that clinical knowledge and experience influence critical thinking, which in turn impacts clinical decision-making (Riddell, 2007). However, there remains a gap in the literature about the experiences of nurses with EWS and technology and the influence of these, if any, on nursing practice.

The primary objective of this exploratory qualitative descriptive study is to understand and describe how nurses experience electronic and automated EWS technology in a large, acute care community hospital. The guiding framework for this study was human factors analysis, which examines the interplay between human beings and technology in the workplace (Mahlmeister, 2010; Reason, 1995). The science of human factors analysis has successfully prevented error in high-risk industries such as nuclear power and aviation; yet healthcare organizations, as high-risk industries, lag behind these in applying human factor principles to research and user-centered system design processes (Carayon, 2006; Grosbee, 2002; Karsh, Holden, & Alpen, 2006; Mahlmeister, 2010; Reason, 1995). A second objective involves the exploration of nurses' perceptions of automated EWS technology. In this study, human factor analysis will be used to explore and describe

nurses' perceived experiences. The overall aim of this study is to review the experience of nurses using automated EWS technology in order to understand the effects of EWS on nursing practice, critical thinking, and clinical decision-making.

Two questions will be investigated using an exploratory, descriptive research design:

1. What are the experiences of nurses who use automated early warning systems technology in acute clinical practice settings?
2. What are the perceptions of these nurses using automated early warning system technology in acute care practice settings of its impact on their critical thinking and decision-making processes?

The purpose of the literature review provided in Chapter Two was to gain insight into the interaction of nurses with EWS technology. Included is an in-depth overview of the published evidence related to failure to rescue and EWS designed for the early detection of physiological deterioration in hospitalized patients. In addition, the literature reviewed includes research regarding clinical assessment and critical thinking as these relate to nurses' interactions with potential of failure to rescue situations and EWS. Chapter Three describes the research design and related methods to address the research questions. Chapter Four provides the research findings. Chapter Five will present a discussion of the research findings as they relate to current evidence, limitations of the study, and implications for nursing practice.

CHAPTER II: LITERATURE REVIEW

To create a foundation for this research, literature searches on the topics of failure to rescue, early warning systems, clinical assessment, and critical thinking were conducted. CINAHL, Medline, and Cochrane Systematic Reviews databases were searched for articles between 2004 and 2015. The key search terms used included *failure to rescue, clinical deterioration, clinical assessment, critical thinking, critical judgment, early warning scores, early warning systems, modified early warning systems and technology,* and *human factor analysis*. Sixty-eight abstracts were reviewed on the topic of failure to rescue, of which thirty-eight articles were selected for full review. Eighty-eight abstracts were reviewed on the topic of early warning systems, of which forty-eight were selected for full review. Thirty-six abstracts were reviewed on the topic of clinical assessment and critical thinking, eighteen of which were selected for full review.

The inclusion criteria for the literature review were that the articles were in English and written for adult populations and nurses in acute care settings. Articles were excluded if they reported solely on neonatal or pediatric patient populations and if they did not include nurses in the study or review. Applying the inclusion and exclusion criteria eliminated nearly half of the articles searched. White papers from patient safety literature, as well as grey literature, were explored on the topic of human factor analysis (HFA). In addition, reference lists from the articles were reviewed for further sources. Only English language studies were reviewed; thus, some studies that may have merited inclusion were excluded from the literature review.

Failure to rescue (FTR) has been defined in the literature as the inability to save a patient's life after the development of a complication (Aiken, Clarke, Cheung, Sloan, &

Silber, 2003; Schmid, Hoffman, Happ, Wolf, & Devita, 2007). More recently, this definition has been expanded to include "the failure to recognize and intervene with serious conditions that could result in death" (Henneman, Gawlinski, & Giuliano, 2012, p. 10). The need to both enhance and support the early assessment of risk and to optimize timely clinical responses for patients with physiologically deteriorating conditions has led to the development of early warning systems (Elliot et al., 2015).

The literature describes early warning systems (EWS) as surveillance systems that are primarily designed for use in general hospital clinical settings to reduce FTR events and avoid morbidity and mortality (Alam et al., 2014; Kyriacos, Jelsma, & Jordan, 2011; Schmidt et al., 2015). Mcloskey and Bulecheck (2004) described surveillance as a nursing intervention that is defined by the Nursing Intervention Classification as "the purposeful and ongoing acquisition, interpretation and synthesis of patient data for clinical decision-making," while monitoring is an assessment process and is not on its own considered surveillance (p. 5). Thus, EWS monitoring systems were established to support nursing surveillance. The monitoring of EWS emphasizes observing, measuring, and recording data, whereas surveillance involves the integration of these data with environmental data and the synthesis of multiple sources of information (Henneman, Gawlinski, & Giuliano, 2012). Effective processing and clinical assessment of this information, and critical thinking, lead to timely and effective clinical decision-making (Taenzer, Pyke, & McGrath, 2011).

Often in the literature reviewed, the terms *clinical reasoning*, *clinical judgment*, *clinical decision-making*, and *critical thinking* were used interchangeably. Descriptions of these terms included the complex and logical thinking processes by which nurses col-

lect, interpret, and draw inferences from clinical data, come to an understanding of a situation, and respond appropriately (Levett-Jones et al., 2009). The literature review included a Cochrane review paper, systematic reviews, literature reviews, integrative review papers, data review papers, and various studies that employed such qualitative methods as retrospective descriptive correlation, exploratory descriptive, cross-sectional analysis, prospective and retrospective observational approaches, and peer reviewed case studies. The following is a comprehensive summary of the literature for FTR, EWS, and nursing clinical assessment and critical thinking.

Failure to Rescue

Failure to rescue (FTR) has been conceptualized in the literature as the inability to intervene in medical issues or effectively activate interventions in order to prevent serious complications or the death of hospitalized patients (Henneman, Gawlinski, & Giuliano, 2012; Subbe & Welch, 2013; Thielen, 2014). However, not all situations of clinical deterioration resulting in patient death (such as end of life or palliative conditions) are FTR situations. Bobay, Fiorelli, and Anderson (2008), examining the factors associated with FTR, conducted a retrospective, descriptive correlational study using chart reviews for patients in five hospital intensive care settings. Their results showed that 60.8% of the patients died despite nursing care that met established guidelines. These patients were "end-stage oncology patients who had elective surgery but died as a results of the cancer and its complications, not as a result of the procedure" (p. 213). In addition, the researchers noted that there were subtle physiological changes in the patients, and that while the overall incidence of actual FTR events in the five hospitals was 0.03%, as many as two-thirds of patient deaths were incorrectly identified as FTR events. The researchers stated

that “despite increasing high-tech care, it may be the tracking of vital signs that nurses have always done that provides the best prediction of impending FTR” (p. 231). They posit that FTR is the result of a number of interrelated factors, including nursing vigilance, expertise, communication between care providers, organizational and environmental support, and the deterioration patterns of patients.

Shever (2011) conducted a cross-sectional analysis study over a four-year period involving a review of health records from nine electronic data repositories for patients over the age of 60 years. These records represented 10,187 hospitalizations. The findings of the study showed that patients who had frequent nursing surveillance, defined as surveillance an average of 12 times per day, had reduced odds of an occurrence of FTR by approximately 50%. Shever (2011) concluded that, in an acute care setting, nurses are in the best position to prevent FTR and that the close observation of significant or subtle changes in clinical status is just one aspect of preventing FTR.

Ashcraft (2004) reported that FTR might occur when a change in patient status is not recognized, when recognition occurs but intervention does not, or when intervention is delayed or ineffective. Further, researchers have identified FTR as consisting of several components, including failure to anticipate the unexpected, to record timely assessments, to recognize early deterioration trends, and to respond or react (Ashcraft, 2004; Subbe & Welch, 2013). Manojlovich and Talsma (2007), in a literature review to identify nursing processes that reduce FTR, stated that while too few nursing studies link FTR and nurse sensitive outcomes, the studies they reviewed did demonstrate that FTR was impacted by two key nursing activities: surveillance and taking action.

Taenzer, Pyke, and McGrath (2011), in their review of emerging approaches to addressing FTR, found that a recent shift has occurred from improving the response to deterioration to improving the detection of deterioration. They concluded that this shift includes surveillance monitoring to promote early detection. Further, they suggested that increased surveillance might increase the likelihood of detecting deteriorating patients; however, other human behavior factors, such as how nurses interpret the information and the timeliness with which they share or act upon it, may affect rescue outcomes.

Researchers have also described the link between the FTR rates and the use of EWS for early detection. Aiken et al. (2003), in a cross-sectional analysis of patient outcomes data and nurse survey data, studied the link between FTR and key nursing activities of surveillance, analysis, and corrective action, positing that nursing surveillance systems and early intervention resulted in lower rates of FTR. The literature also described some limitations with linking EWS and FTR (Henneman, Gawlinski, & Giuliano, 2012; Manojlovich & Talsma, 2007). Manojlovich and Talsma (2007), in their literature review, described FTR as a performance measure of the outcome of a process that is influenced significantly by nursing care.

In contrast to the assumptions described above by Aiken et al. (2003), additional literature has described to the notion that FTR outcomes are linked directly with the monitoring and surveillance of deteriorating conditions and environmental factors that affect nursing surveillance (Henneman, Gawlinski, & Giuliano, 2012; Manojlovich & Talsma, 2007). Henneman, Gawlinski, and Giuliano (2012), in their description of the available nursing surveillance literature, suggested that nursing surveillance and intervention de-

mands that nurses attend to both patient and environmental factors, and they posited that more research is needed to evaluate nursing surveillance practices.

Revisiting their earlier research, Aiken et al. (2011) evaluated conditional circumstances, such as the nurse work environment, as additional factors, beyond nursing characteristics, that contribute to FTR outcomes. In their repeat study using a cross-sectional analysis of patient outcomes and nurse survey data, they included analyses of hospital nurse staffing, nurse education, and work environments. They described "marked improvement in patient outcomes in hospitals with good work environments, slight improvement in hospitals with average environments, and no effect in hospitals with poor environments" (Aiken et al., 2011, p. 2). As such, the findings of Aiken et al (2011) suggest the limitations of the current literature in identifying the many environmental, organizational, and human factors that affect FTR situations and that make it challenging to directly correlate EWS and FTR.

One such environmental factor that is also a medical device technology hazard is alarm desensitization or alarm fatigue. In the patient safety literature, alarm fatigue— defined as sensory overload due to overexposure to an excessive number of alarms, leading to desensitization and missed alarms—is described as a significant concern (Sendelbach & Funk, 2013). Since patient deaths have been attributed to alarm fatigue, the Joint Commission made clinical alarm safety a National Patient Safety Goal in 2014. The Joint Commission's review of event alerts revealed that of the ninety-eight alarm-related events reported between June 2009 and June 2012, eighty resulted in patient deaths (Sendelbach, Wahl, Anthony, & Shotts, 2015). Cvach (2012) conducted an integrative review of alarm fatigue and found evidence in the literature that clinicians may be ex-

posed to as many as 700 types of alarms per day and that 80% to 99% of clinical alarms are false. Alarm fatigue may result in slower response times, ignoring alarms that are triaged as non-critical and overriding alarms due to the burden of desensitized alarms.

Although alarm fatigue is well documented in the literature, the literature is lacking interventions to guide clinicians in reducing the risks associated with alarm fatigue (Cvach, 2012; Sendelbach & Funk, 2013). Sendelbach, Wahl, Anthony, and Shotts, (2015) implemented a quality improvement project for a sixteen-bed adult coronary care unit. They evaluated the data showing that multiple, similar alarms were triggered for a patient's clinical status, such as for low heart rate and bradycardia. In this example, one symptom triggered two separate alarm alerts. By bundling the alarm alerts to delete duplicate alarms, the researchers saw an 88.5% reduction in alarm signals per day. Rayo and Moffatt-Bruce (2015), however, cautioned that reducing the total rate of alarms without clearly understanding the false alarm rate might also risk reducing attention to valid alarms. They also cautioned that evaluating the technology for improvement opportunities while ignoring the human factor of mental workload associated with the memory burden of recalling which alarms signal which events may result in deterioration in alarm response among nurses.

In summary, the literature reviewed focused primarily on a recent shift from improving the response to deterioration to improving nurses' detection of deterioration. The literature described multi-factorial contributions to the phenomenon of FTR that were not limited to the provider characteristics of recognition, response, and rescue but that also included a consideration of work environments. None of literature evaluated how nurses

experience and interact with EWS early detection technology with regard to the two key FTR nursing activities of surveillance and taking action.

Early Warning Systems

Early warning systems (EWS) are described in the literature as comprised of physiological aggregate scores derived from preset parameters that trigger an alert based on the calculation of total individual aggregate patient scores that deviate from the established parameters. The original EWS was designed to collect data from the following physiological parameters: systolic blood pressure, pulse rate, respiratory rate, temperature, and level of consciousness (Mapp, Davis, & Krowchuk, 2013; Page, Blaber, & Snowden, 2008). Since the original EWS was established, it has been modified to include one or more additional physiological parameters, such as oxygen saturation levels, volume of urinary output, blood sugar level, white blood count, and pain score. These adapted EWS items are part of Modified Early Warning Systems (MEWS), and they have additional labels attached to their algorithms that measure for additional triggers (Page, Blaber, & Snowden, 2008; So, Ong, Wong, Chung, & Graham, 2014). In addition to MEWS, other revised EWS versions have been developed, such as the National Early Warning Score (NEWS), Standardized Early Warning Systems (SEWS), Pediatric Early Warning System (PEWS), and Vital Early Warning Scores (VIEWS), all of which were designed to standardize clinical assessments, promote early recognition of deteriorating conditions in patients, and guide clinical decision making (Capan, Ivy, Rohleder, Hickman, & Huddleston, 2015; Gordan & Beckett, 2010).

From a broader research perspective, the primary challenge that variations in the types of EWS systems available poses is that the resulting lack of standardization of ap-

proach and scoring for early detection makes it difficult to measure the effectiveness of these systems for improving clinical outcomes. In a systematic review of the impact of EWS, Alam et al. (2014) revealed that forms of EWS that had been adapted into MEWS had different thresholds and scoring methodologies that made it difficult to compare the contributions of EWS to clinical outcomes. Similarly, in their review of the literature, Kyriacos, Jelsma, and Jordon (2011) also described the limitations that variations in EWS pose. They proposed that patient safety is dependent on nurses' clinical judgment of deterioration in the context of EWS or MEWS scores and other contextual factors. In a Cochrane review study, McGaughey et al. (2009) reported that while the literature supports the view that EWS and MEWS are used widely in many western countries in both paper and electronic documentation forms, there is little evidence of the effect of their use on clinical outcomes, such as mortality rates. McNeill and Bryden (2013) in their systematic review of EWS and their impact on hospital patient survival rates, reported that much of the available evidence has been of poor quality and weak in its support of implementing single parameter trigger systems, such as vital signs monitoring, to reduce rates of cardiac arrest.

Alam et al. (2014) described the United Kingdom's standardized scoring system, called the NEWs, as the most sensitive early warning score currently available. Kolic, Crane, McCartney, Perkins, and Taylor (2015) conducted a prospective observational study of 370 health records of patients admitted to an acute medical unit for the purpose of evaluating the accuracy of NEWS scores. They reported a high rate of a) incorrect calculation (18.9%) and b) inadequate or inappropriate clinical responses to the scores (25.9%) (Kolic, Crane, McCartney, Perkins, & Taylor, 2015).

Patel, Jones, Jiggens, and Williams (2011) conducted a retrospective study of 32,149 patients admitted to trauma and orthopedic units over a period of seven years and found no statistically significant relationship between MEWS and mortality rates in trauma patients. They cautioned that for any tool to be effective it has to be implemented and acted upon appropriately, accurately, and in a timely manner.

Taenzer, Pyke, and McGrath (2011), in their review of approaches to address FTR, found evidence to suggest that improved outcomes may result from improved vital signs monitoring and recognition of clinical deterioration. The effectiveness of EWS was identified as dependent on intermittent vital sign checks by nursing staff. While they found that the contributions of rapid response teams to improved FTR outcomes were inconclusive, the success of such nursing teams was dependent upon their response to early detection. In their review, the researchers further cautioned that patient surveillance using biotechnology should not replace other forms of clinical monitoring so as to avoid a false sense of security regarding patients who are at risk for deterioration.

Schmidt et al. (2015) conducted a retrospective observational study of two acute care hospitals in England undertaken before, during, and after the deployment and ongoing use of an EWS. The EWS was designed to improve the collection and clinical use of vital signs data. The researchers found that there was a strong relationship between the EWS studied and reduced mortality between 2004 and 2011. They described how the EWS was designed originally to prompt nurses to record vital signs on hand held devices, calculate physiological values into an early warning scores, and provide clinical decision-making support based on the EWS value. The researchers reported that while the findings at two hospitals were similar with regard to the relationship between the increased use of

EWS and reduced mortality rates, the "timing of the reductions were different and while we are not able to offer a definite explanation for this latter finding, it may be due to issues not addressed directly by EWS and which have been reported in other hospitals, for example, staff reluctance to call for help with deteriorating patients" (pp. 14-15). This study supports other findings showing that human behaviors such as reluctance to act upon EWS scores made it difficult to directly correlate the EWS' effectiveness and declines in mortality rates.

Taenzer, Pyke, and McGrath (2011), in their literature review of current and emerging FTR approaches, reported that environmental considerations like nurse-to-patient ratio, availability of physician support, alarm fatigue, and such perceptions as lack of acceptance of the benefits of EWS and a false sense of security that EWS technology will catch clinical deterioration may interfere with early detection and the potential for rescue. In a systematic review of EWS literature, Alam et al. (2014) recommended that every EWS should be considered an adjunct system to clinical judgment.

Johnstone, Rattray, and Myers (2007), in their examination of EWS and organization change in the literature, made similar recommendations. They suggested that any EWS is ineffective as an early detection mechanism and may become a potential barrier to patient safety if the significance of what is being recorded and triggered is not recognized, appreciated, and acted upon. For example, an EWS alert may be triggered for signs of hypovolemic shock, but it may have different triggers for early cardiac signs (such as an elevated heart rate) as opposed to the late sign of decreased blood pressure. A review of the literature on EWS by Preston and Flynn (2010) led the authors to caution that a

comprehension of physiological compensatory mechanisms for early signs of deterioration versus late signs is required in the interpretation of EWS alerts.

In summary, the literature reviewed focused primarily on EWS and its scoring methodologies. A limitation associated with these scoring systems is that they require clinical interpretation and decision-making. The literature provided some support for EWS in the areas of clinical assessment, interpretation, and clinical decision-making supported by nursing practice. However, many authors and researchers have cautioned against EWS technology driving nursing practice and suggested that it be utilized, rather, as a secondary adjunct to clinical judgment and other contextual elements that influence practice. None of the literature reviewed, however, evaluated the experience of nurses in using EWS technology and their application of the practical essentials of clinical assessment and critical thinking for clinical decision-making.

Clinical Assessment and Critical Thinking

While authors and researchers have defined critical thinking as it influences clinical decision-making and practice in various ways, common concepts in the literature included the ability to anticipate patient needs, to understand and utilize nursing knowledge, to examine data from multiple sources carefully, to analyze complex information, to navigate and appraise personal assumptions, and to change focus when presented with new information (Berkow, Virkstis, & Stewart, 2011; Chang, Chang, Kuo, Yang, & Chou, 2011; Dickerson, 2005; Riddell, 2007; Swinny, 2010). Clinical assessment was reported to inform critical thinking, which leads to clinical reasoning, judgment, and decision-making (Swinny, 2010). Accurate clinical assessment and critical thinking were identified as equally necessary for patient safety. Tanner (2006) defines the

term clinical judgment as a means in which a nurse interprets a patient's needs or health issues and takes action or modifies approaches based on the patient's response. Nurses use clinical reasoning to make clinical judgments. Good clinical judgment requires an understanding of pathophysiology, disease processes, illness experience for patients and families as well as physical, social emotional, and coping mechanisms. Tanner's Clinical Judgment Model, depicts ways of knowing as noticing, interpreting, responding, and reflecting processes. Knowing is influenced by the nurse's perception of a situation, practical experience, ethical perspectives, theoretical knowledge, and relationship with the patient (Lasater, 2007).

Schubert (2012) described a study evaluating nurses' critical thinking ability through a simulation exercise with pre- and post-knowledge tests given to medical-surgical nurses over a nine-week period in a United States university medical center. The author found that human error, lack of knowledge, and poor performance all interfered with patient safety. According to Schubert (2010), nurses contributed to FTR when they did not recognize, respond to, or report the clinical deterioration of patients. Critical thinking, also identified as significantly important, involved logical reasoning, sound judgment, rational decision-making, appropriate problem-solving, and effective communication with members of the inter-professional healthcare team. Further, anticipating the unexpected through knowledge of the patient's history, current condition, and comorbid disease processes, as well as recognizing changes in patient status, analyzing trends and patterns in clinical changes, and putting the whole picture together, were all necessary components in sound clinical judgment and decision-making. Swinny (2010), in a review of critical thinking definitions as they related to critical care nursing, stated that critical

thinking involves critical reflection for future reference and improving or enhancing nursing practice.

Mapp, Davis, and Krowchuk (2013) conducted an integrative review study that investigated EWS and its effect on predicting patient deterioration. Their results showed an increase in the confidence of nurses in their decision-making processes. However, their review did not reveal evidence supporting the effect of EWS on nurses' ability to clinically assess patients or to think critically about the response or action required.

Researchers have debated whether or not the ability to reason and respond to clinical information is a learned skill, but they have generally agreed that expert nurses collect more situational cues than novice nurses, who detect and interpret clinical data later than experienced nurses (Chang, Chang, Kuo, Yang, & Chou, 2011; Dickerson, 2005; Saintsing, Gibson, & Pennington, 2011; So, Ong, Wong, Chung, & Graham, 2014). Levett-Jones et al. (2010), in their literature review of clinical reasoning and their discussion of a clinical reasoning model, posited that FTR is related to poor clinical reasoning skills, including nurses' ineffectively or insufficiently collecting the right cues and taking the right action for the right patient at the right time and for the right reasons. While EWS was identified as helpful in supporting novice nurses to recognize, respond to, and rescue deteriorating patients at the right time, in the right manner, and in the right sequence, there remained the need for nurses to observe and interpret any significant or subtle changes in clinical status more effectively. The authors provided an example of how early clinical assessment and interpretation was necessary to detect a subtle change, such as respiratory rate patterns, in order to promote the early detection of patient deterioration. In other studies and reviews that evaluated the effects of EWS and MEWS on clinical

observation, respiratory rate was a vital sign significant to detecting patient deterioration, but it was often missing from clinical assessment (Johnstone, Rattray, & Myers, 2007; Kyriacos, Jelsma, & Jordan, 2011; Ludikhuize, Smorenburg, de Rooij, & de Jonge 2012; Preston & Flynn, 2010; So, Ong, Wong, Chung, & Graham, 2014).

In an international exploratory study, Thompson et al. (2007) evaluated the nursing clinical decision-making of 245 acute care registered nurses when presented with clinical scenarios describing patients at high risk for FTR who required assessment under time pressure. Nurses were presented with cues, seven of which were generated from EWS technology and two of which were contextual cues: time and protocol recommendations. Their results revealed that nurses relied on intuition, which contributed little to decision-making accuracy and which underestimated the importance of clinical information and cues. The results also demonstrated that nurses' risk assessments and decisions to intervene were largely inaccurate and were consistently incorrect across a total of fifty clinical scenarios (Thompson et al., 2007). They concluded that when nurses were faced with complex choices about complex clinical situations under time pressure constraints, they tended to value intuition over rational reasoning and nursing experience over evidence-informed decision supports. Other concepts linked to critical thinking and explored in the literature have included whether or not thinking critically leads to clinical competence (Chang, Chang, Kuo, Yang, & Chou, 2011; Riddell, 2007) and the fact that there is a lack of indicators or standardized methods to evaluate critical thinking in practice (Berkow, Virstis, & Stewart, 2011; Riddell, 2007); most commonly, critical thinking, at its core, has been defined to involve manipulating thinking skills and processes.

There have been more than three decades of literature on the topic of nursing intuition, a topic that was polarizing in earlier literature but that has been gaining acceptance in the past decade as a legitimate way of nursing knowing (Robert, Scott Tilley, & Peterson, 2014). While there is no universal definition of nursing intuition in the literature, it has included such descriptions as the non-linear procedure of knowledge, a cognitive ability to assist with assessment, an analytical process of accumulated data resulting in the ability to recognize patterns in specific situations, and a complex decision-making process based on previously learned information or experiences (Benner & Tanner, 1987; Michael et al., 2015; Pretz & Folse, 2011; Robert, Scott Tilley, & Peterson, 2014; Traynor, Boland, & Buus, 2010). Seminal work by Benner (1982, 1984) firmly established a relationship between expert nurses and the use of intuition, yet little is known about how intuition is used by non-expert nurses (King & Macleod-Clark, 2002; Pretz & Folse, 2011; Robert, Scott, Tilley, & Peterson, 2014).

More recently, researchers have studied nursing intuition to better understand how intuition as nursing knowledge is utilized in clinical practice. Traynor, Boland, and Buus (2010) conducted focus groups of nurses to study their autonomy and their use of intuition for decision-making. They found that participants were influenced by both tacit judgment and technical or empirical influences; however, the personal experience of the nurses was the final arbitrator in their decision-making. Michael et al. (2015) conducted a study using an intuition scale to evaluate the levels of intuition in 122 nurses. Their findings revealed that nursing intuition constitutes an integral part of clinical practice and contributes to the formation of nurses thinking and decision-making.

In a systematic literature review, Odell, Victor, and Oliver (2009) concluded that nursing intuition guided decision-making that EWS were interpreted inaccurately often, and that timely intervention was influenced by nurses' level of comfort with or confidence in what they observed. The results of other studies and review papers have also shown that nurses rely heavily on intuition and that unless analytical reasoning is applied, the likelihood of errors in their decision-making processes is increased (Carberry, Clements, & Headley; 2014; Ludikhuize, Smorenburg, de Rooij, & de Jonge, 2012; McDonnell et al., 2012; Odell, 2010; Odell, Victor, & Oliver, 2009; Preston & Flynn, 2010). Pretz and Folse (2011), in their survey of 175 practicing nurses and nursing students, measured their preference for intuition and found that preference for intuition increased with experience. They cautioned, however, that more research is needed to determine whether this increase is due to their expertise, as experience is not equivalent to expertise.

In summary, critical thinking involves complex thinking structures and comprehensive nursing knowledge that are required for anticipating, analyzing, interpreting, and responding to patient data in clinical decision-making. The literature reviewed showed that nursing experience, such as responding to situational cues and human behaviors, influence critical thinking and the decision to act. When relied on for decision-making in the absence of expertise, intuition increases the potential for FTR errors. Little is shown in the literature, however, regarding the perceptions of nurses on the influence of EWS in their critical thinking and decision-making.

Summary and Implications for Research

Much research has been conducted attempting to link FTR to numerous contributing factors in the various human factor analysis (HFA) categories of human behavior

and attributes, organizational culture, and environmental factors. Researchers have conducted or reviewed studies linking or attempting to link FTR and EWS to various contributing factors that are human, environmental, or organizational related. Examples of topics in these research studies and literature reviews include nurse to patient ratios and staffing levels (Needleman, Buerhaus, Mattke, Stewart, & Zelevinski, 2002; Park, Blegen, Spetz, Chapman, & De Groot, 2012), the educational levels of nurses (Aiken et al., 2003; Aiken et al., 2011; Cooper et al., 2010; Schubert, 2012), agency nurses (Aiken, Shang, Xue, & Sloane, 2013), and novice nurses (Levett-Jones et al., 2010; Purling & King, 2012; Saintsing, Gibson, & Pennington, 2011). In addition, research and reviews have focused on hospital work environments (Aiken, Shang, Xue, & Sloane, 2013), the effectiveness of rapid response teams (Subbe & Welch, 2013), ineffective communication, and the attitudes and behaviors of care providers (Classen, 2010; Mackintosh & Sandall, 2010).

There is international evidence suggesting that nurses do not always recognize the clinical deterioration of a patient, but there is little known about the influence of early warning systems on nurses' decision-making (McDonnell et al., 2012; Thompson et al., 2007). A literature review by Schmid, Hoffman, Happ, Wolf, and Devita (2007) revealed that the relationship between FTR and nurses' critical thinking is yet to be understood. Researchers posit that the impact and influence of EWS on nurses' decisions making is unknown and that additional resources are needed to validate and evaluate EWS/MEWS systems in the context of their clinical judgment and decision-making (Kyriacos, Jelsma, & Jordan, 2011; Thompson et al., 2007). The literature examined also yielded no studies or reviews that described or explored EWS and the experience of EWS technology on

nurses' perceptions of their practices and critical thinking processes. Qualitative research to explore how nurses experience and perceive EWS as it relates to their practice has the potential to add an important dimension to existing bodies of evidence regarding EWS and FTR.

In summary, the literature reviewed has described a shift in acute healthcare settings to improve early detection of a patient's deterioration through standardized assessment and communication processes. EWS are monitoring systems that support nursing surveillance and are designed as early detection tools to contribute to the potential reduction of FTR outcomes. However, the effective activation of rescue remains dependent upon the nurse's ability to recognize and respond to EWS data in conjunction with contextual patient and environmental information. Evaluation challenges identified in the literature linking EWS and FTR are the lack of standardization due to many adaptations and variations of systems and scoring methodologies; the requirements for data interpretation, which may be varied across institutions; organizational barriers, such as culture and environmental supports; and human factor attributes influencing clinical judgment, such as intuition, expertise, and experience. None of the literature reviewed evaluated the interaction between monitoring supports like EWS that inform the nursing practice of surveillance. In addition, the experience and perceptions of nurses using EWS technology as it relates to their clinical assessment, critical thinking, and decision-making skills has yet to be undertaken. Based on the evidence reviewed, a qualitative study to increase our understanding of the experience of nurses and their perception of the impact of EWS and related technology on their critical thinking and other practice processes has the potential to contribute to a wider evaluation of EWS systems and to improve patient outcomes.

CHAPTER III: METHODS

This chapter describes the research design for this qualitative study and the related methods employed to address the following research questions:

1. What are the experiences of nurses who use automated early warning systems (EWS) technology in acute care clinical practice settings?
2. What are the perceptions of nurses using automated EWS technology in acute care practice settings regarding its impact on their critical thinking and decision-making processes?

Research Tradition and Study Design

The inductive qualitative research tradition is an appropriate research tradition for answering the research questions for this study, which has an exploratory descriptive design (Sandelowski, 2000; 2009). A qualitative descriptive method of research is "relevant as an empirical method for gaining firsthand knowledge of the perception and experience of a phenomenon," and for answering questions about human behaviours," and it "is suitable if time and resources are limited for a particular study" (Neergaard, Olesen, Anderson, & Sondergaard, 2009, p. 5). The proposed method was appropriate for this research study because the study

> does not involve experimental interventions to modify or control the study environment, is neither constructed of thick descriptions nor theory development but rather allows the researcher to stay closer to the data for the purposes of rich descriptions and low-inference interpretations of meaning." (Sandelowski, 2000, pp. 335-336)

While the expectation of a qualitative descriptive study is that it will yield a descriptive summary of a phenomenon, organizing the data in a way that is relevant to the participants and the audience may produce working concepts and hypotheses for future studies as well (Sandelowski, 2000, p. 338). For this reason, this study's design included a data analysis component with human factor analysis principles incorporated; initially, data descriptions were categorized into groupings of human performance, organizational environment, and the technology system. The conceptual framework in Appendix A provides an overview of this study's theoretical framework.

Setting and Participants

The setting was a large multi-site community acute care hospital in Southern Ontario with over eight hundred inpatient beds. An acute care hospital was the appropriate setting for this study because the organization's two sites both provided a variety of acute care medical-surgical settings and services, including acute general medicine, neurology, respirology, cardiovascular, oncology and cancer care, palliative care, rehabilitation, general surgery, and orthopedic surgery services. The inclusion criterion for the acute care setting was an organization that has implemented EWS for the early identification and intervention of clinical deterioration. Eighteen months before the planned conducting of this study, the organization selected for review had implemented an automated EWS in its medicinal and surgical areas of care. Nurses responsible for carrying EWS electronic devices to alert them to a change in patient status were invited to participate in this study. In addition, nurses at the point-of-care responsible for responding to the alerts were invited to participate.

The EWS used in the selected research setting was an early detection system that does not require the calculation of scores to generate alerts. Rather, it is an early detection system that has built into it population-specific parameters and algorithms that respond to respiratory rates, heart rate, temperature, blood pressure, serum white blood cell count, and a neurological level of consciousness assessments summarized with the acronym AVPU (alert, verbal, pain or unresponsive). For the purposes of this study, FTR refers to undesirable and preventable clinical deterioration in patients. The inclusion criteria for study participants included nurses who practiced in the acute care setting and had a minimum of six months professional experience in an acute care hospital. Nurse participants were recruited from various acute care sub-specialties within the medical and surgical areas of care, including cardiovascular, neurology, respirology, oncology, acute general medicine, general surgery, and orthopedics. Interviews were conducted at the participants' convenience, did not occur during the study participants' working shifts, and took place away from the workplace environment so as to protect participant confidentiality and promote spontaneity.

Sampling and Recruitment

The sample size for this study was projected to include approximately 6 to 12 participants who had used EWS technology with the expectation that recruitment would end once saturation was reached and when no new knowledge emerged from the data (Sandelowski, 1995; 2002). Guided by the supervisory committee, it was projected that this sample would be adequate to illuminate the phenomenon and to answer the research questions within the constraints associated with graduate research. Purposive sampling was used to include nurses from both acute medicine and surgical practice settings in or-

der to achieve better saturation (Creswell, 2013). A criterion sampling strategy was employed to include nurses with experience with EWS technology. A snowball recruitment sampling strategy identified potential recruits by asking clinical leaders and nurses with experience to identify other nurses with information-rich experiences (Cresswell, 2013). Finally, a convenience sample was used since all participants were employed in the same organization (Creswell, 2013).

As the student investigator, I recruited the purposive sample of participants directly. The recruitment strategies used were the active methods listed below. Entry into the field required access to organizational leaders with approval from the Hamilton Integrated Research Ethics Board (HIREB). In addition, before commencing with recruitment, research ethics board approval was granted from the REB at the organization where the study was conducted. To secure entry at the organizational level, the Executive Director of Clinical Programs was approached in writing for permission to conduct the study. To secure entry at the unit level, approval was also sought from the Clinical Directors and Clinical Managers to approach nurses directly as the primary active recruitment strategy. Finally, the student investigator met in person with the Clinical Managers of the medicine and surgical clinical areas to share the study's rationale, purpose, and aims. Once permission was obtained for entry into the field at these levels of clinical leadership, the student investigator selected clinical units for the study by gauging the individual leaders' level of interest in participation. Nurses on units where leadership expressed interest were approached on their respective units. In the plan of the study, it was intended that passive methods would be utilized, such as a presentation at Nursing Grand Rounds and distribution of study information flyers at nursing stations (Gledhill, Abbey, & Schweitzer,

2008). However, active methods were highly successful at recruiting nurses and, thus, passive methods were not required.

Individual nurses who agreed to meet with the student investigator were given a formal invitation letter that included an information sheet outlining the purpose of the study. Those who agreed to be interviewed were contacted to arrange a separate meeting to further explain the study, answer any questions, and obtain written consent (see Appendix B for letter of information and consent). Informed consent, which the student investigator obtained before the commencement of this study, included descriptions of the purpose of the study, the procedures involved in the study, the participant's role, the potential risks and benefits, the assurance of privacy and confidentiality, and the opportunity for the participant to withdraw at any time from the study without penalty, including any negative influence on their present or future employment (Emanuel, Wendler, & Grady, 2000).

As a recruitment incentive, study participants were given a twenty-dollar gift card (paid for by the student investigator) to a national coffee chain outlet. This recruitment incentive was appropriate, as it was a small, reasonably priced token designed to encourage participation and not a form of coercion. In addition, compensation was offered to all participants for travel costs and parking fees incurred from participation in this study. Since all nurse participants met with the student investigator on hospital grounds, either before or after their working shift, the location of the meetings occurred in the place of employment of the participants and the student investigator. The participants all had monthly parking passes; thus, parking fee reimbursement was not required.

Data Collection

The tenants of an exploratory qualitative descriptive design include loosely structured interviews and the coding of data according to conceptual themes derived from the data (Lincoln & Guba, 1985; Thorne, Con, McGuinness, McPherson, & Harris, 2004). In this study, participants were asked for permission to be audio recorded during semi-structured interviews that would include their responses to open-ended questions consistent with the study design. The questions served to initiate and stimulate the conversation and support the flow of the interview process (see Appendix C for the list of questions to guide the interviews and Appendix D for the demographic questionnaire). Probing questions during in-depth interviews were designed to be "developmental so as to pursue a topic or issue to exhaustion or closure before moving onto the next topic of conversation" (Partington, 2001, p. 38). Participants were asked to describe situations when EWS was either useful or not useful to them and their interpretation of the relationship between EWS and their clinical practice, clinical assessment, critical thinking, and clinical decision-making. Depending on the course of the discussion, not all the questions were asked, and the questions were re-examined for potential modification following the first two interviews after an evaluation of their relevance. The questions did not need to be modified after the first two interviews, however; so subsequent interviews followed a similar format throughout the data collection phase. Interview strategies used included active listening, such as "restatement to ensure researcher understanding, clarification, and persistence with rephrasing difficult to answer questions" (Partington, 2001, pp. 39-41). Non-verbal responses were observed as cues to guide the interview, frame the probing questions, and elicit a deeper level of understanding of the experience. Non-verbal

responses were noted and documented in the field notes immediately after each conversation.

The research method included reflexive journaling before and after each conversation to identify any potential biases in the interview questions. "Field notes record what the researcher sees and what is interpreted regarding what is seen, including reflections on emerging themes, ethical dilemmas, points of clarification, the researcher's frame of mind, and reflection of researcher's feelings" (Bogdewic, 1999, p. 50). Field notes were not used as an interview data collection method because what participants have said can be truncated or misinterpreted during such manual documentation.

The experiences and perspectives of nurse participants were explored during the interviews. "Through a process of intuiting with the researcher as the data collection instrument," the student researcher conducted "all the interviews so that she can gain a sense of the whole experience of each participant and stay close to the data" (Streubert-Speziale & Carpenter, 2007, p. 86). Interviews were approximately 45 to 60 minutes in duration and informed consent was reviewed and obtained before them. Participants had the opportunity to discuss the study's purpose, procedures, potential harm, risks, discomforts, and benefits. Participants also had the opportunity to ask questions and were reminded of the withdrawal procedures. Data saturation was reached by the ninth interview, at which point the student investigator, in consultation with the thesis committee supervisor and member, made the decision to end the data collection.

Data Management

The student investigator hired a transcriptionist solely for the purpose of supporting this study. Confidentiality agreements were obtained from the transcriptionist. All

audio recordings and transcription documents remained the property of the student investigator until the completion of the study and will remain so for a period of seven years. Interviews were audiotaped on a digital recorder to which only the student investigator had access. Each participant on the audiotapes was identified with a code name. The recorder was kept in a locked cabinet within a locked office until the transcriptionist transcribed the recordings. The document listing the participants and their code names was housed on a computer requiring a password that was only accessible to the student investigator. Once the audio-recorded interviews were transcribed verbatim, they were encoded, secured with password access, and stored on an encrypted electronic device that was locked in an office to which only the student investigator had access. Audiotapes and paper documents, including artifacts and manual data coding systems, were stored in a locked cabinet to which only the student investigator had access.

All documents associated with the study will be destroyed and audiotapes completely erased once the final research reports are written; no personal identifiers will be shared or published. Demographic data were stored in a locked cabinet to which only the student investigator has access for a period of seven years, after which time the data will be destroyed using a confidential waste collection processes. The coded data were organized using NVivo qualitative data analysis software Version 11 PRO (2015), which had been installed on the student investigator's personal password-protected computer.

Data Analysis and Organization

The student investigator listened to audiotapes repeatedly in order to become familiar with the data and to understand participant tones, inflections, and feelings as communicated during the interviews. Verbatim accounts may not capture the entire essence

of experience, however; thus, attention was also paid to pauses and silences (Laverty, 2003). Data were coded by topic, issues, experiences, and perceptions. The data were re-structured to identify overarching themes with an iterative approach to providing a systematic process for organization. Data collection and analysis occurred concurrently and constant comparison and categorization enabled the verification of the data's themes (Boejje, 202, p. 392).

The student investigator originally planned to apply a rudimentary pre-set coding system using human factor principles, categorizing data descriptions into groupings of human performance, organizational culture, and technological environment (Cafazzo et al., 2009; Cafazzo & St-Cyr, 2012). The student investigator read and reread the transcribed interviews and then highlighted and extracted the most significant statements, formulated their meanings, and clustered them into themes in order to identify common experiences (Wojnar & Swanson, 2007). After the first five interviews, it was determined that the rudimentary pre-set coding system according to human factor analysis (HFA) principles (categorizing data descriptions into groupings of human performance, organizational culture, and the technological environment) would need to be adjusted based on the themes emergent from the data. Once all the transcripts were reviewed in detail, the pre-existing coding system was revised so that the analysis of the data answered the research questions.

The student met several times with one of the supervisory committee members who had extensive expertise in qualitative research to establish and revise the data coding themes. The supervisory committee member confirmed that the initial pre-set data codes were insufficient to answer the research questions. Human factor principles remained rel-

evant to explaining the context of the study, but the pre-set coding categories that reflected these principles, designed before data collection, required revision to fit the data collected and to answer the research questions. In planning this study, it was anticipated that "a templated pre-existing coding system may need to be modified or entirely discarded for the purposes of ensuring best fit to the data" (Sandelowski, 2000, p. 338). Once an exhaustive description using the revised coding system was written, resulting in a prototype for a theoretical model of the experience, the student investigator sought further feedback from a supervisory committee member and her supervisor to confirm the essence of experience that was evolving from the data (Chambers, 1998). Parent nodes in NVivo were recreated into primary themes, each with several sub themes that yielded findings further refining the essence of nurses' experience with EWS technology.

Ethical Considerations

The procedures for HIREB approval, participant informed consent, and ethical data management, storage, and destruction have been previously described. The student investigator worked within the HIREB requirements to protect participants' rights and safety. Given the sensitive nature of the phenomenon of interest, participants could potentially disclose an FTR situation that may have resulted in a critical incident and/or serious incident of harm to a patient. It was also anticipated that due to the sensitive nature of the phenomenon of interest, participants could become emotionally distraught during the interviews. To address these concerns, the protocol required that the student investigator be supportive of participants, offer short interview breaks if needed, and remain prepared with appropriate resources, such as information regarding the organization's employee assistance program. In addition, participants were reminded that their consent form in-

cluded the ethical consideration that they had the freedom to stop or withdraw from the study at any time. During the data collection period, the student investigator abided by the hospital's codes of ethics to ensure that patient safety was not compromised at any time (CNO, 2009). The student investigator practiced in accordance with the duty to report any incidents of patient deterioration or FTR. However, no such incidents were revealed during the interviews.

It was also anticipated that something could be revealed during the interviews that the student investigator may feel obligated to report to a regulatory body or other authority, such as confession of hidden or unknown harm or an intentional criminal act contributing to a FTR critical incident. The student investigator, before obtaining informed consent, did not promise participants full confidentiality for such reportable disclosures. The student investigator had planned to address self-care while protecting participant confidentiality by debriefing with the student investigator supervisor and with no one else outside the circle of care. No criminal or reportable acts were revealed during the interviews, however.

The student investigator introduced herself to the study participants as a nurse who practices in the organization to build rapport and cement relationships through building a common language (Partington, 2001). Although a close rapport with participants can lead to informed research, effort was made to "reduce non-sampling errors that could arise such as respondent behaviour in which the nurse participants respond in a way that may deliberately try to please the nurse researcher" (Fontana & Frey, 2000, p. 652). The student investigator evaluated her motives and evaluations through daily journaling so as to suspend judgment, avoid the use of leading questions, adopt a listening style that did

not include evaluating the responses, and identify early recognition of signs of the confusing of roles between the student investigator and the nursing leader in the organization where the study was conducted (Fontana & Frey, 2000, p. 653). The study met the ethical principles of value and validity by avoiding exploitation and limiting human and financial costs (Emanuel, Wendler, & Grady, 2000). Trustworthiness of the results was enhanced through a supervisory review of the data.

Rigour

The rigor of this study was established through the following "components of trustworthiness: credibility, authenticity, transferability, dependability and confirmability" (Cresswell, 2013, p. 246). Credibility was enhanced through the presentation of accurate descriptions of participant's perspectives, including the use of their verbatim narratives in the findings chapters.

Authenticity was enhanced through the different voices and perspectives heard and interpreted. "Dependability was achieved and enhanced through 1) data collection until saturation, 2) through an auditing of the research process with regular reviews by the supervisory committee, and 3) conducting data collection and data analysis concurrently" (Cresswell, 2013, p. 246). As a means of promoting credibility through debriefing, the student investigator conducted biweekly telephone meetings with her supervisor during the data collection phase. Transferability from this study to larger populations would be ideal; however, in the tradition of exploratory descriptive qualitative research, transferability is not the ultimate goal. Nonetheless, rich descriptions, methods, context, and analysis contribute to the transferability of these results (Lincoln, 1995). Confirmability was achieved by keeping clear audit trails of decision-making processes and record-

ing the operational details of the data collection and analysis phases through reflexive journaling.

Meanwhile, reflective appraisal—which involved frequent evaluations of the student investigator's preexisting knowledge and experiences as a nursing leader in the organization in which the study was conducted—established confirmability. The student investigator reflected on her reactions following each participant interview in order to identify and remove bias (Lincoln & Guba, 1985). After each interview, the student investigator acknowledged (in her field notes and during her weekly debriefing meetings with her supervisor) any challenges experienced in withdrawing from the role of nursing leader and assuming the role of researcher. Upon review of the early transcripts, it was evident that, at times, the student investigator did step into her administrative role. Adjustments were made in subsequent interviews.

Trustworthiness was achieved through member checking, which was conducted by returning to participants and allowing them the opportunity to validate findings. "Incorporating changes based on participant feedback is essential," according to Cresswell, (2013), "such that if the participants testify that the universal description of experience has captured their personal experience, the study has achieved is aim and promoted credibility" (p. 252). This was accomplished through sending a single e-mail to each of the study participants to elicit their feedback regarding the student investigator's interpretation of the essence of their experiences. The content of the e-mail explained that transcribed and coded data had been clustered into similar categories of experience that were understood to be shared by most of the participants. The common themes were presented

to the participants in a table format. Six out of nine participants confirmed that the themes were reflective of their experiences.

The findings of this study will be presented in Chapter Four, and themes that were identified during the data collection and data analysis phases of the study will be discussed in detail. To support the validity of the themes that emerged from the interviews, demographic detail about the participants and rich descriptions of participant's experiences will be presented.

CHAPTER IV: FINDINGS

The primary purpose of this study was to explore the experiences of nurses who use automated early warning systems (EWS) technology in acute care clinical practice settings. The secondary purpose was to explore their perceptions of the technology's impact on their critical thinking and clinical decision-making processes. This chapter will describe the findings of this qualitative research. This chapter will identify the themes that emerged during the interviews and that answered the research questions through the rich description of nurses' experiences. Findings were evaluated in the following two phases: a) identification of themes and sub themes of experiences and perceptions and b) identification of interdependencies between the themes and sub themes using human factor analysis (HFA) as the guiding theoretical framework for understanding the interdependencies. These phased findings will be presented in Figures 1-2 and discussed in detail in this chapter.

Participants

A total of nine nurse participants completed this study. Participants practiced in various areas including medical and surgical units and had varying levels of nursing experience. There were seven Registered Nurses (RNs) and two Registered Practical Nurses (RPNs) who participated in this study. There were two participants who were in nursing clinical leadership positions as resource nurses and seven participants who were practicing directly at the point-of-care. The two nurses in resource nurse positions were responsible for carrying the technology device on their respective shifts. At the time of the study, they were not involved in direct patient care. EWS alarm alerts came directly to the resource nurses, and their responsibility was to communicate with the point-of-care

nurses in charge of the patient whose symptoms triggered an alert. The seven point-of-care nurses were responsible for direct patient care and did not receive EWS alerts directly. The resource or charge nurse on their units notified them when an alert had been triggered. In some descriptions, the resource nurses reported their experiences as similar and in others there were differences noted in their experiences. The findings are presented from the point of view of both the resource and point-of-care nurses. The primary and secondary themes that emerged were experiences that were common to most or all participants.

Participants' gender and experiences were similar in that all were female and all had worked with EWS technology between 6 and 18 months before being interviewed. See Table 1 for participant demographic details.

The findings of this study are presented according to the following three primary themes:

1. experience with EWS;
2. perceptions with EWS and critical thinking; and
3. perceptions with EWS and clinical decision-making.

Each of the three primary themes yielded findings of positive and negative experiences with EWS and each primary theme had subthemes illuminating how nurses experience and perceive EWS as it relates to their nursing practice. The primary themes and subthemes were those most commonly reported by the participants. EWS was described by participants as "value added," by resource nurses, novice nurses, and nurses whose workloads were heavy. EWS was also described as being redundant and desensitizing at times.

Table 1

Description of Study Participants (N=9) Participating in Interviews

Descriptor	**Number**
Professional Designation	
Registered Nurse (RN)	7
Registered Practical Nurse (RPN)	2
Working Status	
Full Time	6
Part Time	3
Role Description	
Resource Nurse (unit nursing clinical leader role)	2
Point-of-Care Nurse	7
Highest Level of Education Preparation	
RPN Diploma	2
RN Diploma	3
BScN	4
Number Years in Nursing Workforce in Acute Care	
1-5 years	4
6-10 years	1
11-15 years	1
>15 years	3
Number Years Employed at Current Organization	
1-5 years	5
6-10 years	1
11-15 years	1
>15 years	2
Time exposed to Early Warning Technology System	
6-12 months	4
>1 year	5

The systems were perceived as supporting nurses in putting the clinical picture together, but not as able to replace nursing judgment and assist with nurses' accountability, or to enhance communications with physicians. Participants described their perceptions of EWS as contributing to documentation challenges as well. Finally, a concurrent theme that emerged throughout the interviews was the importance of using nursing intuition and clinical assessment when interpreting EWS reporting requirements and alerts. See Figures 1 and 2 for categories of themes and subthemes in the nurses' experiences and perceptions of EWS.

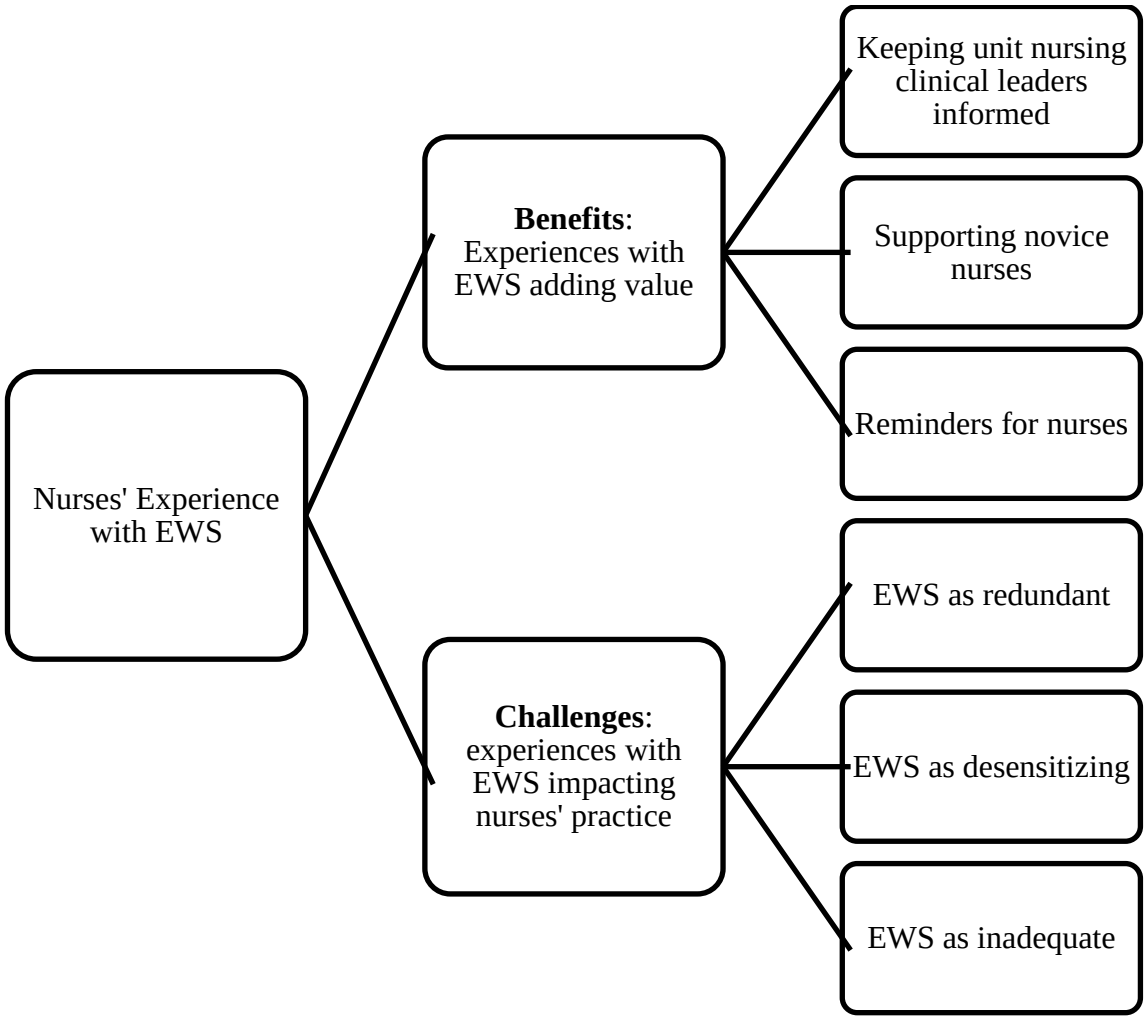


Figure 1. Themes and sub themes of nurses' experiences with EWS.

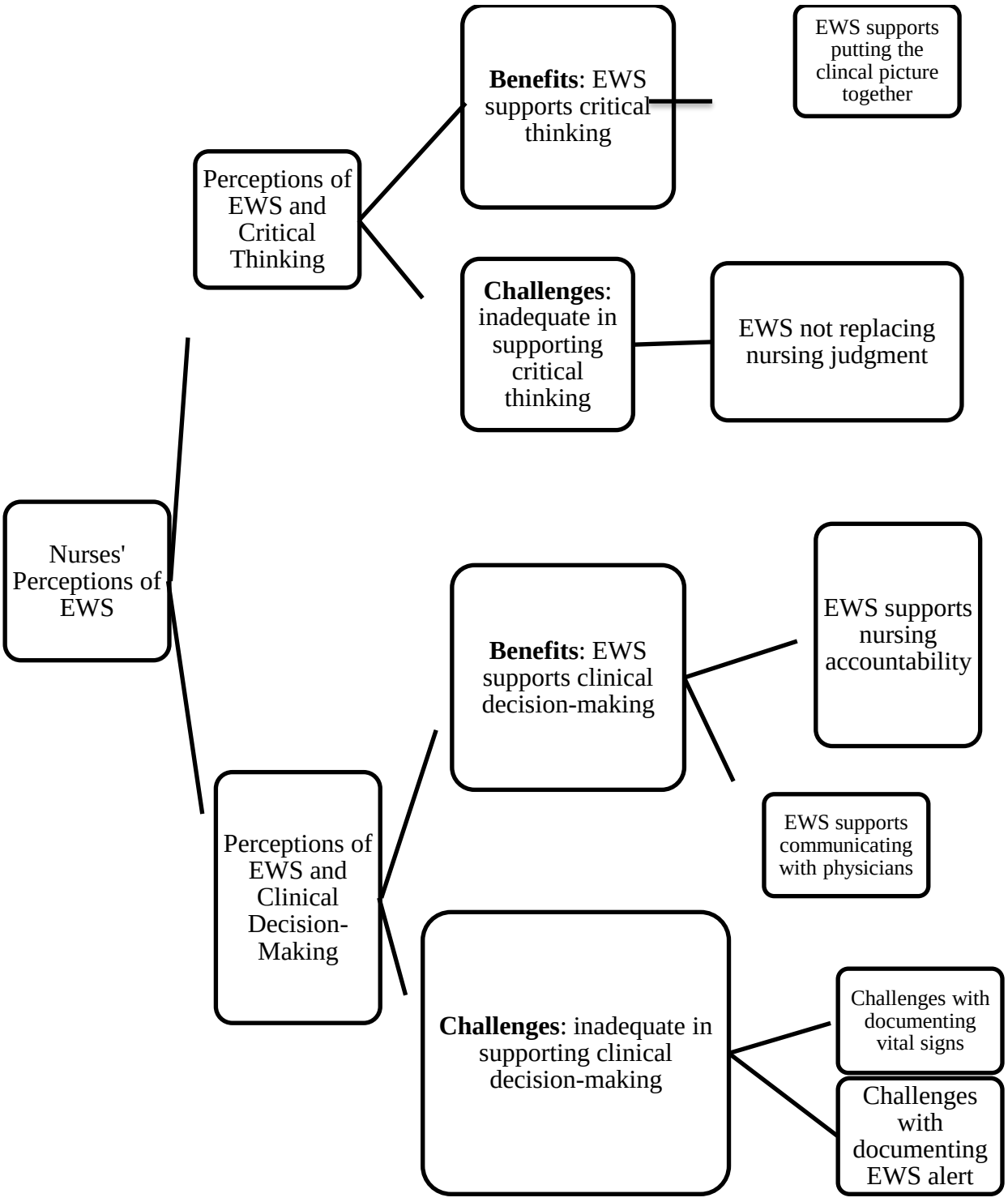


Figure 2. Themes and sub themes of nurses' perceptions of EWS.

The following provides rich descriptions from the point of view of either resource nurses or point-of-care nurses. The similarities and differences in experiences and perceptions that were reported as benefits or challenges are presented below.

Experiences with EWS

Participants shared experiences with EWS technology that included both benefits and challenges. Examples of the benefits of EWS included a) adding value for nurses, b) keeping nursing clinical leaders and novice nurses informed, and c) serving as a valuable reminder at times. Participants' examples of challenges with EWS included a) redundancy, b) desensitization to alerts, and c) inadequacy with clinical decision-making for specific populations. These findings are discussed in greater detail below.

Benefits: Experiences with EWS Adding Value

Study participants reported benefits of EWS adding value to their nursing practice.

Keeping nursing clinical leaders informed. Resource nurses expressed the view that EWS alerts assisted them in being informed about patients at risk for deterioration on their units when they were in charge. Point-of-care nurses reported that having their unit's nursing leader aware of what was happening with their patients was also helpful. A resource nurse described her experience of how the EWS kept her informed of patients on her unit as follows:

> As a resource nurse, I get the alert and then I usually tell the staff and ask, "What's going on with your patient?" and that's when we look into the computer to see the trend. You wouldn't know unless you get the trigger because you won't be able to monitor all 40 or 37 patients on the floor. But because the EWS gives

> you the trigger, you kind of give attention to that patient and know exactly what is going on. (Resource Nurse Interview)

Point-of-care nurses also reported the value of the EWS alerting the resource nurse or charge nurse of patients who were deteriorating:

> It alerts the charge nurse that she can just remind you if you have done something about that high blood pressure; whereas on your own . . . I think that would be why it is helpful. Because is it like a second person is aware of what's going on whereas with yourself, you're just taking care of it on your own. But with the EWS it tells the charge nurse just to make sure that that's being looked at. (Point-of-Care Nurse Interview)

In addition to experiencing the added value of EWS in the support of the resource or charge nurse, participants described how EWS supports novice nurses.

Supporting novice nurses. A common theme that threaded its way throughout the interviews was the positive impact that the EWS technology had in supporting novice nurses. In this context, participants used the term "novice nurse" to describe those nurses who were either new to nursing or new to nursing in the current area or specialty. One nurse stated of EWS, "Sometimes it's very helpful. I think it's helpful for more novice nurses" (Point-of-Care Nurse Interview).

Some of the participants found EWS most valuable when they were novice nurses, either new nurses overall or novices in a new area of acute care. For example, a nurse described her experience as a new nurse working with EWS supporting her:

> In that instance, I was just new to medicine, better yet, new to oncology. I was running; I was very overwhelmed, a lot to adapt to; I didn't notice that this patient

> had a few signs of sepsis; didn't even know that alarm went off until my charge nurse brought it to my attention. (Point-of-Care Nurse Interview)

Another nurse described how EWS supported her transition from being an experienced nurse in mental health to a novice nurse in medicine:

> I feel like I'm in a position where the technology validates what I already know clinically is happening but, at that point, I came from a mental health background where I didn't really use critical thinking to look at those symptoms in place. (Point-of-Care Nurse Interview)

Whether participants were experienced or novice, many shared the common experience that EWS added value during times of high patient volume or high patient acuity.

Reminders for nurses. The majority of the participants spoke of the added value of EWS technology serving as a reminder during times when the unit was busy, when their patient assignment was heavy, or when they were rushed. They reported that the EWS kept them on track when their workloads were heavy with very acutely ill patients or when they had increased volumes of patients on their units. Participants reported that on shifts where their workloads were demanding, they felt that they were rushed in their clinical assessments. On shifts where their workload was increased and there were multiple competing priorities and demands, participants stated that the EWS assisted them to prioritize. As one nurse stated, "When you are rushing, sometimes you don't have the capacity or the time to really stop and think and be mindful of what you are doing and what is happening" (Point-of-Care Nurse Interview).

Another nurse described her experience with competing demands in a busy work environment and how the EWS reminded her to stay on track:

> I have had EWS alerts for sure, and it's just a kind of gentle reminder because I am finding in nursing you're not able to just have a task and do it. You'll start off doing something . . . family will ask you a question, pharmacy will call you to the phone, another nurse is asking for assistance from me which is all fine . . . I'm not complaining . . . but then you get the alert reminder from your charge nurse and you're like, 'Oh right . . . I have to make sure that that's taken care of.' Sometimes, you can be side-tracked, I guess, and it's always nice that that's just a gentle reminder to stay on track. (Point-of-Care Nurse Interview)

In summary, participants reported that EWS added value for specific nurses, such as charge and novice nurses. In addition, they reported that EWS added value during specific situations, such as when they were very busy. While participants reported EWS as adding value, they also articulated several challenges with EWS negatively impacting their nursing practice.

Challenges: Experiences with EWS Impacting Nurses' Practice

The student investigator identified several words and phrases from the interviews that participants used to describe challenges they experienced with the EWS. Participants described the alarm alerts as annoying, repetitive, tedious, and telling them what they already knew. Point-of-care nurses also reported challenging experiences with redundancy and their desensitization to the alarm alerts. The resource nurses reported that EWS was redundant with palliative care patient populations. All participants reported examples of EWS as inadequate in triggering an alert for a patient whose condition was deteriorating.

EWS technology as redundant. The majority of participants gave specific examples of times when the EWS technology was redundant or when they had assessed

their patient to be clinically deteriorating and had taken action before the EWS alerted the charge or resource nurse. One nurse stated, "If there is an alert, I've already identified it and I've already notified the physician" (Point-of-Care Nurse Interview).

Another nurse described her experience with EWS for a patient whose symptoms resulted in an alert on her cardiology unit in the following way:

> For the particular floor I'm on, the cardiology floor, the person's heart rate is 45, which is outside of the acceptable level, but the person is waiting for a pacemaker so we know that it's going to be 45. But the EWS will tell us that this person's at 45, which is too low, but we know that because they're going for a pacemaker. (Point-of-Care Nurse Interview)

Another nurse described her experience with repeat alerts:

> The alert is going to an iPod for the resource nurse, and when she gets it, she will be writing it in a paper and will be handing it over to us so that we document whether the doctor was informed or whether the medication was given. When I'm documenting it, I know it's going to be the alert because it's little bit critical status, but that's the history of the patient. The doctor is aware of it, and there is no new action to be taken. I have to let her know so she don't have to take the pain of writing it and bringing to me. So I just say, "Ignore it; it's a repeat alert." (Point-of-Care Nurse Interview)

Many participants gave examples of alerts being redundant for palliative care patient populations. According to one resource nurse, "The EWS will still give us an alert even when the patient is palliative, so with those cases, we actually know. Some nurses will actually let me know" (Interview Resource Nurse). Another point of care nurse

shared their experience with EWS and palliative patients similar to the resource nurse's experience:

> We've had patients on the floor whose blood pressure is deteriorating. It's dropping, and the EWS keeps alarming us and telling us, but we know and we are aware that the person's palliative. We still enter the vitals, and it keeps telling us we need to do something. The most responsible physician is aware, the family is aware; so, in that particular case, it's not helpful. (Point-of-Care Nurse Interview)

Overall, participants described EWS as redundant in situations where they have already anticipated the alert, particularly for palliative care populations. They also described how redundant alerts can lead them to being desensitized.

EWS technology as desensitizing. Participants conveyed concern with the EWS technology alerting them repeatedly about what they already knew was a potential or actual clinical situation of deterioration for their patients. One nurse reported her frustration with repeated alarm alerts that she described as desensitizing to her clinical practice:

> Depending on, I think, the amount of exposure you've had with patients or with certain experiences, you might become desensitized to not have that sense of urgency. That sometimes goes away when you see it so much, like that alarm fatigue. (Point-of-Care Nurse Interview)

Another nurse described an experience with redundant alerts that resulted in her becoming desensitized to EWS:

> I feel that if it keeps being redundant, the more nurses are inclined to ignore it because it just becomes this automatic thing. I feel like, after a while, it just

> becomes desensitizing; like, I understand the system that's trying to alert you, but when it's happening so much, all the time . . . I feel like I kind of become desensitized to that. (Point-of-Care Nurse Interview)

In addition to participants describing their negative experiences with EWS being redundant and desensitizing, they gave testimony to the frequency with which EWS was inadequate in detecting patients with deteriorating conditions.

EWS technology as inadequate. During the interviews, many participants reported on the technology not identifying and alerting the nurse to patients who were clinically deteriorating. According to one nurse, "The alert wouldn't even come up because all her vitals are fine, but she's just unresponsive" (Point-of-Care Nurse Interview).

Participants shared multiple examples of patients who were clinically deteriorating and suffered unexpected and undesired outcomes, including an admission to an ICU for a patient who did not have a preceding EWS alert trigger. One resource nurse described her experience with patients who had only had one symptom that did not result in an alert but who still needed to be transferred to ICU:

> Well, we send some patients to ICU because they de-sat, but heart rate was fine, blood pressure was fine, so that's why they keep on reviewing the EWS and all the transfers to ICU; they review it and then they see whether they missed some part of it. There were a couple where O2 sat de-satting was the main complaint of the patient and why we sent the patient to ICU, and there was no alert for that one. When the patient is just de-satting, there's no alert for just de-satting. I hope that someone will be able to evaluate what the triggers are that weren't captured by

> EWS so that we can improve the EWS, because we can always improve the parameters. (Resource Nurse Interview)

In summary, a number of commonly-reported experiences with EWS were shared among the participants. The reported benefits of EWS included nursing clinical leaders being better informed about patients on their units who were potentially declining clinically. In addition, novice nurses were better supported in terms of understanding when a patient was deteriorating clinically. Finally, nurses working in busy clinical environments were reminded to prioritize their patients, take action, and respond to declining patients in a timely manner.

Participants also shared the common experience of EWS being redundant, as they had anticipated situations and acted upon them where patients were potentially or actually deteriorating and the repeat alarms desensitized them to the multiple alerts that followed. For some of the themes identified, the experiences with EWS reported by the two resource nurses differed from those reported by nurses providing direct patient care. An example of such a difference was the point-of-care nurses' description of EWS as redundant. Point-of-care nurses reported instances when the resource nurse or charge nurse received an alert, and they, as point-of-care nurses, had already anticipated and acted upon the alert. Resource nurses and point of care nurses described scenarios in which the EWS was redundant for palliative care patients. However, in general, resource nurses did not describe EWS as redundant. Resource nurses and point-of-care nurses described other reported themes, such as the experience of EWS supporting novice nurses, similarly. Finally, most participants shared examples in which the EWS was inadequate for alerting

nurses to patients with deteriorating conditions, as the system's parameters or algorithms were not adequate for triggering an alert in those situations.

In addition to exploring their experiences with EWS, participants were asked about their perceptions of EWS in their workplace and its impact on their critical thinking and clinical decision-making. As with the nurses' experiences, their perceptions were categorized into themes that were reported as benefits and challenges. Perceived benefits that were commonly reported were the following: the EWS a) supported putting the clinical picture together, b) assisted nurses' ability to respond, and c) enhanced communications with physicians. Perceived challenges were that the EWS could not replace nursing judgment and that the system had documentation barriers.

Perceptions of EWS and Critical Thinking

During the interviews, participants were asked about their perceptions of how the EWS impacted their critical thinking. Their perceptions included both benefits and challenges. An example of a positive perception was that EWS supported their ability to put the clinical picture together. A reported perceived challenge was that the EWS was inadequate to support critical thinking and that the technology did not replace nursing judgment in effective clinical decision-making. The perceived benefits and challenges experienced with EWS with regard to critical thinking are described in detail below.

Benefits: Perceptions that EWS Supports Critical Thinking

Several participants shared a common positive perception that EWS supported nurses in putting the clinical picture together.

EWS supports putting the clinical picture together. Sharing their perceptions of how EWS assisted nurses with understanding the whole clinical picture, participants

reported that it had the potential to help them think critically about what was happening to the patient and to anticipate what to expect next. One resource nurse described this finding.

> It kind of puts the pieces together. A nurse may not put a temperature, pulse, and respiration together and say that a patient is at high risk of developing sepsis. She may just understand that an elevated white count may be a sign of infection, but she may not understand that there are many pieces in identifying a patient who could have shown signs of systemic inflammatory response syndrome (SIRS), or sepsis. So it helps her understand that there is more than one type of signal, where a patient may be developing signs of SIRS or sepsis. (Resource Nurse Interview)

While the participants' perceptions of EWS were that it was helpful in putting the clinical picture together, participants also shared the common experience that EWS did not interpret the clinical picture for them. It was the nurses' responsibility to interpret what was happening with the patient and what was the most appropriate response to the alert.

Challenges: Perceptions that EWS was Inadequate in Supporting Critical Thinking

Many participants shared a common negative perception of EWS as inadequate to support critical thinking and held that EWS could not replace nursing judgment.

EWS not Replacing Nursing Judgment. Participants expressed that EWS was inadequate to support their critical thinking, particularly with regard to its inability to replace the nurse's need to think critically. For example, one nurse stated, "I know there are things out there that we put in place—for example EWS—but that can't really replace your nursing judgment" (Point-of-Care Nurse Interview).

Another nurse described the difference between an alert for an abnormal vital sign and a nurse's clinical assessment:

> It doesn't help with the clinical assessment. You have to be able to do your assessment. You have to be able to do head-to-toe assessment and you have to be able to know what you are looking for. Let's say you do the patient's vital signs and you check the machine. The blood pressure machine will give you the rating but it won't' tell you if their pulse is racy or rapid or thready or weak. You have to be able to know your critical skills and your assessments and what you're looking for and be able to put it together. (Point-of-Care Nurse Interview)

Another nurse stated that the EWS was not a stand-alone system and that it was up to the nurse to interpret what the alert meant. She described her perception as follows:

> It doesn't stand-alone; it also has to be coupled with the nurses assessment as well. Just because you get an alert doesn't mean it means anything; you have to do your own assessment and come up with some sort of idea whether it's significant or not. It's just an alert; it's a flag, and the nurse actually has to go back and do her own assessment to determine whether it's significant or not. So it's not a stand-alone system. (Point-of-Care nurse Interview)

In being interviewed about their perceptions of EWS and critical thinking, participants were asked about their perceptions of EWS and how they perceived it to impact their clinical decision-making.

Perceptions of EWS Technology and Clinical Decision-Making

During the interviews, participants were asked about their perceptions of how EWS impacts their clinical decision-making processes. Their perceptions included both benefits and challenges. For example, EWS assisted nurses' accountability for their clinical assessments and interpretations of what they assessed. Participants also stated that they perceived EWS as supporting their communications with physicians. A significant perceived challenge with EWS was meeting documentation requirements. The perceived benefits and challenges of EWS experienced by nurses using EWS with regard to clinical decision-making are described further below.

Benefits: Perceptions that EWS Support Clinical Decision-Making

There were two primary themes in participants' positive perceptions of how EWS supports clinical decision-making. The first was that it holds nurses accountable for responding to their assessments. The second was that it supports nurses when communicating with physicians about patients with deteriorating conditions.

EWS supports nursing accountability. Participants reported that EWS supports their clinical decision-making and holds them accountable for what they are assessing and the actions they will take in response to their interpretations. One nurse described her perception of accountability to EWS alerts in the following words:

> Well, it holds you accountable, of course, because when your charge nurse is saying 'Hey, I got this notification do you know?' And you have to say, 'This is what I've done.' So, it's holding you accountable to your actions. And then, of course, every time an alert goes off, you have to document the alert. (Point-of-Care Nurse Interview)

In conjunction with the responsibility to communicate their assessment of patients with deteriorating conditions to physicians, participants described the requirement of communicating all EWS alerts to physicians as one of the major benefits of these systems.

EWS as Supporting Nurses Communicating with Physicians. Several participants shared that the EWS alerts assisted them with reporting to physicians. For example, one nurse described how EWS alerts assisted her telephone reports to physicians: "Some physicians are aware about the EWS alerts as well, so when you call them they actually know what you're talking about because they're familiar with alerts so it kind of help you, you know stream the conversation" (Point-of-Care Nurse Interview).

A resource nurse shared that the EWS assisted her with communicating with the physician, a benefit that she described as leading to timely clinical decision-making and more positive patient outcomes:

> Usually, when the physicians are in bullet rounds, that's when the iPod starts ringing. The alert came through and we were discussing the alert. I said that this person has a SIRS alert and I explained what the white count was, and he kind of hemmed and hawed and then he decided that based on the alert he was going to send off the urine. So the next day, the urine came back positive. If that patient had not had an alert or a SIRS alert, we would not have diagnosed a UTI, which would not have been treated early, and the patient could have ended up getting a more severe infection. Probably (it was an elderly patient) could have a delirium and probably would have had a likelihood of staying longer in hospital. So because it was an early warning system, we were able to treat the patient earlier for

> the UTI and the patient probably went home earlier and went home well. (Resource Nurse Interview)

Another resource nurse explained that the EWS supports a standardized approach to communicating with inter-professional health care team members and their response as follows:

> When the alert comes through, it comes through to the charge nurse, and we know what SIRS or sepsis means, so when the charge nurse says to the primary nurse "You have an alert," we have a general understanding what that means. Then, when the nurse communicates that to the physician, that's also an understood way of communicating—that the patient has an alert, and then there's a little more discussion about what that alert actually is. It's become common in terms of how we communicate. The pharmacist understands what that means because we have conversations with the pharmacist as well as do a med review to see if there's a suggestion of a treatment for SIRS or sepsis. So, a lot of the health care professionals understand what the terminology means, and the responsiveness is pretty much the same. We understand what the goals are of the warning system. (Resource Nurse Interview)

While the participants' perceptions of EWS were that it was helpful in holding nurses accountable and in simplifying their communication with physicians, they reported challenges with documentation requirements, particularly challenges with timely documentation.

Challenges: Perceptions of EWS as Inadequate in Supporting Clinical Decision-Making

There were two negative perceptions with regard to EWS as being inadequate to support clinical decision-making. They were both centered on documentation requirements. Participants stated that the EWS was inadequate in meeting the need for or facilitating the timely documentation of vital signs. Timely documentation is required in order to trigger an EWS alert. Participants also stated that the EWS as inadequate to support timely clinical decision-making in the absence of timely documentation. In addition to the challenge of the timely documentation of vital signs, several participants described challenges with the timely documentation of the EWS alerts and their responses to the alerts. They reported that their priority was to care for the patient in response to the alert and to intervene appropriately. They reported that timely documentation of the alert and their response interfered with their nursing care.

Documentation of vital signs. Many participants spoke to the challenge of untimely or delayed documentation practices and their impact on EWS alerts. The EWS they used pulled information together into an algorithm that was dependent upon the nurse's timely documentation of the vital signs. A delay in documentation meant a delay in EWS triggers. One resource nurse described this challenge as follows:

> Currently, the system is very dependent on the nurses entering the vital signs into the electronic chart, and so we don't have a system where, currently, the vital signs go right into the electronic medical record. The nurse being very busy in the inpatient unit may be doing the vital signs and writing them on a piece of paper and time is elapsing where we're not identifying those alerts because he or she

> hasn't entered them into the medical record and they haven't got into the algorithm to shoot out the alert. So, within the environment, if the nurse is not entering them in a timely manner, it does impede the early warning system. (Resource Nurse Interview)

Another nurse stated that it would be easier and timelier if the vital signs went directly into an electronic chart instead of the nurse documenting them manually:

> Something that would be great is if the blood pressure machine and all the vitals could be connected to that and go automatically into the chart. Of course, that would be a big help for us so that it alerts us quickly, like the blood sugar machine automatically goes into the computer so the documentation is there. (Point-of-Care Nurse Interview)

Documentation of EWS alert. In addition to the documentation challenge, participants described the challenge of the required timely documentation of the EWS alert and the subsequent responses. The challenge that participants spoke of was that of not wanting to leave the patient during a time when they needed nursing care in order to document the alert in the computer. One nurse explained this specific negative perception of EWS as follows: "I mean, if I have to draw blood cultures I am not going to sit down and document that a EWS alarm went off" (Point-of-Care Nurse Interview).

Another nurse also explained her challenge with the timing of alert documentation:

> The EWS alert comes when we document it, so normally when things happen, I go into action rather than sitting with the chart to interpret it. When I see a patient

> is tachycardic, I don't have time to get it documented. I'll be looking at what medications, any PRNs which I can give, or what I should do now, right away, such as call the SUPORT (rapid response team), I call the most responsible physician, and I have the other patients also. So this alert comes only after documentation, which comes later. I don't blame nurses; they don't have time to sit, open up the computer, and do chart comparing. We have to take action. (Point-of-Care Nurse Interview)

While participant interviews focused on nurses' experiences with and perceptions of EWS as described above, the concept of nursing intuition emerged as a concurrent theme within the primary, secondary, and sub themes.

Nursing Intuition and EWS

During the data collection phase, the student investigator utilized HFA principles and listened for interdependencies between humans and the technology they use in the clinical environment. Though the concurrent theme of nursing intuition was unanticipated, once it emerged, the student investigator paid attention to when participants used the term "nursing intuition" to describe their experiences and perceptions. Participants used the term "gut feeling" when describing situations in which they used their nursing intuition. One nurse stated,

> A lot of times, nurses will say, 'Can you come and see my patient?' I'll walk in and sometimes it's with somebody who has a lot of experience . . . it's a gut feeling . . . it's an inner sense that something's not quite right. And somebody who is a novice and very new may not pick up on something that's very subtle. (Point-of-Care Nurse Interview)

A resource nurse used the term "gut feeling" when describing expert resources that validated her suspicions about a patient's condition: "I work only in the day time, so I do have a lot of supports in terms of, you know, whether I'm thinking that my gut is correct or not" (Resource Nurse Interview).

Another nurse, when describing a clinical situation that included an EWS alert, used the term "nursing intuition" to describe anticipating the clinical events based on her past experience with similar deteriorating patients:

> There are things that, I guess, based on experience, you're able to identify. That's the intuition piece, because that nurse was fairly new, so she wasn't able to maybe catch that as fast. Whereas, coming from that experience and having the extra years before her, I felt it gave me that peace to help me understand the progression of the patient. Because I knew that there would be a chest x-ray done, I knew that there would be respiratory problems, I knew that potentially that person you know could pass. (Point-of-Care Nurse Interview)

Whether participants were describing experiences or perceptions, benefits or challenges, critical thinking or clinical decision-making, nursing intuition was often part of the conversation. The concurrent theme of nursing intuition will be explored further in Chapter 5.

Summary of Findings

This chapter has presented this study's findings through rich descriptions of the themes and sub themes of experiences and perceptions shown in Figures 1 and 2. The collective narratives of the study participants' experiences with EWS yielded both

benefits and challenges, and they had both positive and negative perceptions of EWS. The participants' experiences with EWS were value added for resource nurses and novice nurses. In addition, for nurses experiencing heavy workloads, EWS alerts served as reminders. However, EWS were also described as redundant, particularly with palliative care patient populations, as inadequate, and as desensitizing when repeat alerts occurred.

There were six identified themes associated with nurses' experiences with EWS. The perceived benefits and challenges with EWS included its assisting nurses to put the clinical picture together while supporting but not replacing nursing judgment regarding clinical assessment findings. Participants also perceived EWS to support nurses' accountability for their response to alerts, to assist them in communicating with physicians, and to present documentation challenges. Finally, a concurrent theme that emerged was the importance of nursing intuition when interpreting EWS and clinical assessments. Participants described how they integrated what the EWS alert identified in terms of patient risk with their clinical assessments and used their "gut feeling" to support their critical thinking and clinical decision-making.

Commonly, participants described positive experiences and benefits with EWS, ascribing particular helpfulness to EWS when their workloads were heavy or their units were busy. They also described negative experiences and perceived challenges with EWS, particularly when it created redundancies and alarm fatigue. EWS was also described as inadequate in identifying the potential for FTR in some clinical scenarios.

The findings of this study support several concepts regarding early warning technology and failure to rescue (FTR) as outlined in the background and literature review chapters. Using HFA, the study yielded three primary results. The first result was that

there were specific ways in which the participants experienced EWS technology as adding value to nursing decision-making and practice, particularly for novice nurses. The second result revealed that under certain conditions in the clinical environment, such as high volume of patients and/or the high acuity of patients, the EWS served as a trigger that reminded nurses that there was potential for a patient to be at risk for clinical decline and FTR. The third result was that there were specific situations in which the EWS technology was redundant, duplicating a prior identification of risk by the assigned nurse. In other situations, the EWS was inadequate for detecting problems in specific patients with recognized chronic and deteriorating conditions that result in expected abnormal vital signs within the EWS parameters for alarm. The specifics of these findings will be discussed in detail in Chapter Five, where a discussion of the research results as they relate to current evidence and understandings, limitations of the study, and implications for nursing practice, education, policy, and future research will also be presented.

CHAPTER V: DISCUSSION AND IMPLICATIONS

Introduction

This study explored nurse participants' experiences with and perceptions of early warning systems (EWS) in acute care practice settings. EWS were developed based on evidenced-based physiological and clinical observations known to identify patients at risk for progressive clinical deterioration that, if not addressed promptly, can lead to death (McGaughey et al., 2009). The lack of medical intervention into such deterioration has been coined "FTR" (failure to rescue) in the literature. The literature reviewed in Chapter Two suggested FTR outcomes might be a consequence of the relationship between healthcare provider's behaviours and attitudes, organizational factors, and environmental factors that, when occurring simultaneously, can threaten patient safety and impact on the efficacy of EWS and other rescue efforts (Harrison, Koppel, & Bar-Lev, 2007; Reason, 2004).

Human Factor Analysis (HFA) is the study of how people interact physically and psychologically with products, tools, procedures, and processes (Reason, 1995). The principles of HFA provided the framework for this study. In high-risk industries such as nuclear power generation and aviation, HFA principles have been used to prevent and reduce errors; yet healthcare organizations lag behind in applying HFA principles when researching and designing systems used by point-of-care providers (Carayon, 2006; Grosbee, 2002; Karsh, Holden, & Alpen, 2006; Mahlmeister, 2010; Reason, 1995). Since this qualitative exploratory study describes humans (nurses) using technology (EWS) in a complex environment (acute care practice settings), using the HFA as the guiding framework for analysis and evaluation was especially helpful for organizing the data. Through-

out data collection and analysis, the student investigator evaluated the interdependencies of the three components of HFA: a) the human, b) technology, and 3) the environment. For this study, the technology was EWS, the humans studied were nurses who used the technology, and the environments were acute care clinical practice settings in which the EWS was implemented. During the first phase of data analysis and evaluation, themes and sub-themes of participants' experiences and perceptions were identified. The second phase of data analysis and evaluation included a more thorough application of HFA in which themes and sub themes were evaluated to better understand the interdependencies of the three components of the human, technology, and the environment. Applying HFA principles assisted the student investigator with answering the research questions of how nurses working in acute care settings experience EWS and how they perceive EWS impacting their critical thinking and decision-making processes. While the initial pre-set coding systems were revised during the iterative and concurrent phases of the data collection and data analysis, the student investigator applied HFA to further explore the participants' described experiences and perceptions. Finally, using HFA assisted with discerning the three primary findings introduced in Chapter Four. This study's findings and further discussion points will be presented below using HFA principles.

Discussion

HFA as the Theoretical Framework

Participants spoke about how they interacted with the EWS technology in their clinical work environments. Understanding the limitations and variable capabilities of humans—such as personal perceptions, judgment, years of experience, and nursing intuition—was the first step in applying HFA principles. Comparing human elements with the

limitations and capabilities of existing EWS technology such as its contribution to alarm fatigue or triggering helpful reminders, was the second step. The third step in applying HFA principles was to explore the barriers that occurred in the environment, such as high volume and acuity of patients, which intersected with humans using the technology. Appendix A categorizes HFA as the guiding framework for this study. HFA made the student researcher cognizant of the interaction and interdependency of the three components, giving insight into the complexity of nurses using EWS technology in acute care practice settings. Applying HFA, this study allowed nurses to describe their experiences and perceptions using EWS in acute care settings. The analysis would be incomplete if the focus was just on the EWS technology, as the literature reveals the technology is not standardized and that there are many variations in the global healthcare environment. The analysis would also be incomplete if the focus was just on nurses, as the literature speaks to both novice nurses and expert nurses involved in FTR situations in which early intervention of clinical deteriorating patient conditions has occurred. It was necessary, therefore, to analyze and interpret this information in conjunction with environmental analysis, especially in the case of very busy clinical practice environments in which nurses describe having heavy assignments of very complex patients.

As introduced in Chapter Four, this study had three primary findings: a) EWS added value to nursing and nursing practice, particularly for novice nurses; b) EWS served as the trigger that alerted nurses or reminded them of patients at risk for FTR under environmental conditions, such as a high volume of patients or high acuity patients; and c) EWS technology was redundant and inadequate, in some situations, for detecting patients with deteriorating conditions. These three findings are discussed in detail below.

EWS and Novice Nurses

Participants described scenarios in which the unit was very busy, with multiple competing priorities, and they experienced the benefits of EWS. Participants stated it was beneficial, in these situations, to have the EWS in order to a) keep their nursing clinical leader on the unit informed, b) be triggered with reminders to take action, and c) assist with holding them accountable for an appropriate response to an alert. They also described the benefits of the EWS putting the clinical picture together, particularly for novice nurses. Finally, participants described the EWS as beneficial in helping their communication with physicians.

Four of the study's participants had practiced nursing for a period of between one and five years at the time in which the EWS was implemented, though none of them identified themselves as a novice to nursing at the time of the study. Two participants who identified themselves as new to their area of nursing practice during the EWS's implementation described the technology benefitting them. Benner's seminal research on novice-to-expert nurses (1982) defined novice nurses as nursing graduates within their first year of professional practice. Novice nurses transition to new practice settings and are required to make consequential clinical decisions with limited orientation or experience. Clinically focused critical thinking in an environment that is busy, demanding, and complex is a challenge for novice nurses (Ebright, Urden, Patterson, & Chalko, 2004).

At the time of this study, none of the participants fit Benner's pure definition of novice nurses. Pretz and Folse (2011), in their survey of 175 practicing nurses and nursing students, measured these nurses' preference for intuition and found that preference for intuition increased with experience. They cautioned, however, that more research is

needed to determine whether this increase is due to actual nursing expertise, since experience is not equivalent to expertise. Nurses who move from one area of practice to another may still be experienced, but they may not be expert nurses to their new area of practice. While the pure definition of novice nurse may not have applied to the demographics of this study's participants, two of the participants described themselves as experienced with nursing but not expert to their new area of nursing practice, suggesting that there are components within Benner's novice nurse definition that applied to the experiences of these two participants. The refining of skills, knowledge, and attitudes that comes with experience extends over several years of practice (Ebright, Urden, Patterson, & Chalko, 2004).

As described above, two participants defined themselves as having been new to their current area of nursing practice within the past eighteen months, the time in which the EWS was implemented on their unit. Many participants spoke of the benefits of EWS supporting novice nurses in putting a clinical picture together of a patient who is clinically deteriorating. The literature reviewed supported these benefits and indicated that EWS have a positive impact on rescue efforts and may reduce FTR (Ashcraft, 2004; Subbe & Welch, 2013). Ashcraft (2004) reported that FTR might occur when a change in patient status is not recognized, when recognition occurs but intervention does not, or when intervention is delayed or ineffective. Further, researchers have identified FTR as consisting of several components, including failure to anticipate the unexpected, to record timely assessments, to recognize early deterioration trends, and to respond or react (Ashcraft, 2004; Subbe & Welch, 2013).

Researchers have debated whether or not the ability to reason and respond to clinical information is a learned skill, but they have generally agreed that expert nurses collect more situational cues than novice nurses, who detect and interpret clinical data later than experienced nurses (Chang, Chang, Kuo, Yang, & Chou, 2011; Dickerson, 2005; Saintsing, Gibson, & Pennington, 2011; So, Ong, Wong, Chung, & Graham, 2014). The study participants articulated EWS as assisting novice nurses and those in new areas of clinical practice with critical thinking and clinical decision-making, as supported in the literature.

Participants described the value of EWS in assisting novice nurses to review the parameters triggered with the EWS alert, reassess the patient, critically consider the patient's condition, and anticipate the most appropriate response. EWS were designed to standardize clinical assessments, promote early recognition of deteriorating conditions in patients, and guide clinical decision-making (Capan, Ivy, Rohleder, Hickman, & Huddleston, 2015; Gordan & Beckett, 2010). Levett-Jones et al. (2010), in their literature review of clinical reasoning, suggested that while EWS were identified as helpful in supporting novice nurses to recognize, respond to, and rescue deteriorating patients at the right time, in the right manner, and in the right sequence, there remained the need for nurses to observe and interpret any significant or subtle changes in clinical status more effectively. Study participants demonstrated, in their descriptions, the interdependencies between EWS (technology) and novice nurses (humans) working on a busy clinical unit (environment).

Overall, however, the study findings suggested that the HFA interdependencies between EWS technology and nurses, including novice nurses, could have had a negative

impact on FTR intervention efforts when the EWS alerts were redundant or provided inadequate information for clinical decision-making. The literature describes EWS as primarily designed for surveillance use in general hospital clinical settings to reduce FTR events and avoid morbidity and mortality (Alam, Hobbelink, van Tienhoven, van d Ven, Jansma, & Nanayakkara, 2014; Kyriacos, Jelsma, & Jordan, 2011; Schmidt et al., 2015). Ebright, Urden, Patterson, and Chalko (2004) studied the human performance factors of novice nurses in near miss or adverse event situations in acute care settings and found that while novice nurses reported using critical thinking, they did not do so at the level required to intervene before the occurrence of a near miss or adverse event.

Participants in the present study also described EWS alerts as giving credibility to their nursing assessments when sharing the alert findings with physicians. The literature shows that nurse-physician communication is a major determinant of the quality of the practice environment, as poor communication between nurses and physicians is one of the most common causes of adverse events for hospitalized patients (Manojlovich, 2013; Siedlecki & Hixson, 2015). The Joint Commission reported that many sentinel events were associated with breakdowns in communication between health care providers (The Joint Commission, 2008). Effective communication with the accurate and timely exchange of information minimizes misunderstanding and reduces the risk of handover errors and incidents (Accreditation Canada, 2016).

This study's finding regarding novice nurses may be informative for other organizations implementing EWS. Study participants who were resource nurses described scenarios in which they struggled with understanding the bigger picture, such as the onset of sepsis. The study found that EWS can support less experienced nurses by keeping their

nursing leaders informed, reminding them about clinical priorities when the unit is busy, assisting them with putting the clinical picture together, and facilitating their communication with physicians. Based on these findings and the literature reviewed, organizations that implement EWS could benefit from using the technology as an adjunct tool for nursing education and training to assist novice nurses and nurses to new areas of care in developing with critical thinking and decision-making skills.

EWS as a Reminder for Nurses Working in Busy Clinical Environments

The second finding of this study was that the EWS served as a reminder to nurses when there was potential for a patient to be at risk for clinical deterioration and FTR during situations of high patient volume or high acuity. For this second finding, the HFA framework (Appendix A) was used to evaluate the intersection between the three HFA components of the human, technology, and the environment.

The role of EWS in reminding nurses of potential risk was evident in all the participant interviews, with both point-of-care nurses and resource nurses. When describing their experiences with EWS during busy shifts, participants also described how EWS's impacted on their critical thinking and clinical decision-making. While participants reported that an EWS cannot replace nursing judgment, several acknowledged that during times when their clinical environment was busy or their workload was heavy, they did not always have the time to be mindful and think critically about the bigger picture of what was happening with their patients. Further, they articulated the challenge of timely documentation when they were busy or when they were given an acute patient assignment. Though challenged, they recognized that timely documentation of vital signs into the electronic chart was essential in receiving timely EWS alerts, to inform timely re-

sponses. Taenzer, Pyke, and McGrath (2011), in their review of approaches to using FTR, found evidence to suggest that these improved outcomes may result from improved vital signs monitoring.

In dynamic clinical environments, nurses gather and interpret complex assessment data, which may affect how they interpret EWS data (Johnstone, Rattray & Meyers, 2007). Taenzer, Pyke, and McGrath (2011) reported that EWS outputs are dependent on intermittent vital sign checks by nursing staff. Patel, Jones, Jiggens, and Williams (2011) cautioned that for any such tool to be effective it has to be implemented and acted upon appropriately, accurately, and in a timely manner.

In addition to the challenges with documentation, participants described the potential for EWS to be desensitizing, describing how repeated alarms could result in alarm fatigue, leading to nurses becoming desensitized and a reduction in their urgency to respond. Patient safety literature defines alarm fatigue as sensory overload due to overexposure to excessive numbers of alarms, leading to desensitization and missed alarms (Sendelbach & Funk, 2013). They further identify alarm fatigue as a significant patient safety concern.

Reducing alarm fatigue became a Joint Commission National Patient Safety Goal in 2003 and was revived as a goal in 2014. Alarm fatigue was on the top ten hazards list published by the Emergency Response Centre International (ERCI) Institute in 2012 and 2013 and identified as the number one medical device technology hazard in that same year. However, interventions to guide clinicians in reducing the risks associated with alarm fatigue is lacking in the literature (Cvach, 2012; Sendelbach & Funk, 2013).

The application of HFA principles serves to encourage design efforts to reduce human desensitization to alarm systems such as EWS. An integrated review of the evi-

dence on the safety concern of alarm fatigue conducted by Cvach (2012) reported published evidence to support that clinicians may be exposed to as many as 700 types of alarms per day and that 80% to 99% of those clinical alarms are false. Research has shown that, in general, usability testing for technologies is rarely done in healthcare before implementation of a technology or device. As a result, it is proposed that alarm systems that were developed to improve patient safety have become a patient safety concern (Cvach, 2012; Graham & Cvach, 2010; Sendelbach & Funk, 2013).

Paradoxically, in this study, even though point-of-care nurses did not carry the EWS device that triggered an alert for a patient with a potentially clinically deteriorating condition, it was the point-of-care nurses who spoke of alarm fatigue, redundancy in relation to alarm fatigue, being desensitized to redundant alarms, and the potential to ignore alerts. Reason (2004) identified latent conditions in an organization, such as technology design, as one factor behind human failure in a system. Alarm fatigue literature evidence reviewed reported the desensitization of alarms for nurses who were exposed to an overwhelming number of alerts, many of which were false. For the point-of-care nurses in this study, being desensitized to alarms was somewhat vicariously reported and experienced as point-of-care nurses did not actually hear or receive the alarm directly. The resource nurses received the alarm on an iPod that they carried, and reported it to the point-of-care nurse for the patient whose symptoms triggered the alert. Resource nurses who received all the alarm alerts and followed up with the point-of-care nurses did not perceive the technology as redundant or that they had experienced alarm fatigue. This would be an interesting phenomenon to explore further in future research.

The finding that EWS served as reminders when units and nurses were busy is highly informative because the organization where the study was conducted was not unique in its patient volume and patient flow challenges. At the time of the study, the Centre for Disease Control (2015) and the Public Health Agency of Canada (PHAC) (2015) had reported that the influenza season that year had been the worst in five years. Many organizations across the province of Ontario had reportedly experienced a high volume of acutely ill patients (Infection Prevention and Control (IPAC) Canada and PHAC, 2015). In addition, the Canadian Federation of Nurses Unions (CFNU) reported in 2015 that the rate of absenteeism for registered nurses working in Ontario in 2014-2015 was 7.2%, and the overtime rate was 22.6%. While the absenteeism and overtime rates at the organization where the study was conducted were not as high as the national averages, rates had increased for both indicators in fiscal year 2014-15 from the previous year.

Study participants reported that they were working short staffed and over time on units that were over census with highly acute patients. Applying the HFA framework to this scenario, these clinical environments were extremely demanding on the human component, nurses were overextended, and the EWS technology itself was still in its post implementation evaluation phase. Individually, these HFA components had the potential to increase the risk of FTR. Ebright, Urden, Patterson, and Chlako (2004) stated that healthcare environments can inhibit the development and application of expertise during periods of overwork and understaffing in complex acute care settings. The study results and literature reviewed suggest that organizations considering implementing EWS would

benefit from evaluating alert parameters to ensure that alerts are meaningful to reduce the potential of alarm fatigue.

EWS as Inadequate and Redundant

The third major finding of this study was that EWS was perceived as inadequate or redundant at times. One of the common experiences reported by the participants was that the EWS was inadequate, in some cases, to prevent a patient admission to ICU. Participants made this claim based on two criteria not included in the current EWS: peripheral capillary oxygen saturation (SpO2) and level of consciousness. Deterioration in respiratory status or level of consciousness rarely occur in isolation of other vital sign changes, but both can be significant indicators requiring immediate response. These two measures in the context of the EWS were reported by participants to have been, at times, inadequate in the early detection of clinical deterioration necessary to avert ICU admission. In addition to describing the EWS as inadequate at these times, participants described the EWS technology as redundant in monitoring patient populations with chronic disease and expected deterioration for patients receiving palliative care.

Participants described clinical scenarios that involved patients who had the single, subtle, clinical symptom of SpO2 de-saturation that signaled clinical deterioration. In the scenarios given by participants, clinical deterioration exhibited by a single abnormal clinical parameter would go undetected as the monitoring system in EWS technology is designed with algorithms that include multiple symptom parameters. EWS were initially designed to collect data from various physiological parameters and were developed as early detection systems in response to difficult-to-detect disease processes such as sepsis (Elliot et al., 2015; Mapp, Davis, & Krowchuk, 2013; Page, Blaber, & Snowden, 2008).

The initial signs of sepsis are subtle and easy to miss, and its early diagnosis and intervention is dependent upon early recognition of subtle changes in clinical status. The respiratory system has been reported to be the most common origin for sepsis; the initial symptoms in the early stages of sepsis development include increased respiratory rates and decreased SpO2 (Funk, Sebat, & Kumar, 2009; Gauer, 2013; Wesphal et al., 2011). Altered level of consciousness may also be present as an early sign of sepsis (Funk, Sebat, & Kumar, 2009; Gauer, 2013; Wesphal et al., 2011).

The early management of sepsis requires respiratory stabilization and supplemental oxygen, but the early onset clinical signs of sepsis often go undetected by nurses (Elliot et al., 2015; Johnstone, Rattray, & Meyers, 2007; Kyriacos, Jelsma, & Jordan, 2011; McNeill & Bryden, 2013; Morris & Davies, 2010). Given the evidence regarding the importance of respiratory and related level of consciousness monitoring to avoid sepsis and FTR, the likelihood of risk for FTR could have been increased for the two identified areas in which EWS was inadequate in this study: 1) the SpO2 desaturation and 2) level of consciousness. Deterioration in both of these areas was described by participants as being a patient's only symptom on critical care admission; both of which were undetected by the EWS. Complexity in the clinical environment could be compounded by EWS technology that inadequately monitors patients who experience a symptom or collection of symptoms that are known to contribute to detection of early clinical deterioration.

While EWS are designed to alert clinicians when two or more subtle physiological changes occur, they are not designed to detect deterioration based on one subtle symptomatic change. Funk, Sebat, and Kumar (2009) reported that, typically, sepsis is

suspected when a collection of abnormal clinical parameters are evaluated in combination; however, early evaluation for a differential diagnosis of sepsis may be made based on one significant abnormality in one of the conventional seven vital signs. These signs were listed as respiratory rate, oxygen saturation of arterial blood (SaO2), blood pressure, level of consciousness, capillary refill, urinary output, and central venous oxygenation saturation (ScvO2) deficit. Westphal et al. (2011) cautioned about the low accuracy of diagnostic criteria for systemic inflammatory response syndrome (SIRS) response and sepsis. Based on the findings of their study of screening protocols for patients at risk for sepsis, they adjusted their screening criteria to include clinical manifestations of organ dysfunction. The researchers added oliguria, need for oxygen supplementation, and an altered level of consciousness to their early screening criteria. The examples given by the participants in this study also suggest that EWS are, at times, inadequate in early the detection necessary for early intervention and early management of clinical deterioration, particularly when prompted by a breach of one clinical parameter, such as oxygen saturation or level of consciousness. Another example given by some participants of EWS being inadequate to prevent FTR were failures of early detection of patients experiencing altered levels of consciousness as the primary criteria for ICU admission. Altered level of consciousness may also be present as an early sign of sepsis (Funk, Sebat, & Kumar, 2009; Gauer, 2013; Wesphal et al., 2011).

Study participants provided examples to support that EWS was, at times, inadequate in detecting the need for timely intervention and management of clinical deterioration when specific, isolated clinical parameters were the primary presenting symptoms. Instances of patients who required ICU admission were described. These patients were

admitted to the ICU based on primary and isolated symptoms of oxygen desaturation and/or decreased level of consciousness; not adequate detected in the EWS.

The identification of EWS physiological thresholds that are sufficient to avert patient mortality and morbidity has challenged the development of the technology. The identification of measurement process and outcome measures has posed similar challenges. Acute care organizations measure the success of EWS with indicators such as number of ICU admissions. Alam et al. (2014) cautioned against drawing general conclusions about the correlation between EWS and ICU admissions. In their systematic review of the impact of EWS on clinical outcomes, including patterns of ICU admission, the researchers identified a limitation with benchmarking EWS and their impact on outcomes due to a lack of standardization with modified versions of EWS. According to the researchers, forms of EWS that are adapted into modified early warning systems (MEWS) had different thresholds and scoring methodologies, making it difficult to compare the overall contributions of EWS to clinical outcomes.

EWS have adapted forms from other systems with different thresholds and parameters for triggers; current systems do not have an established single standardized scoring system and continue to be used differently with various patient populations. Researchers have suggested that there are a number of environmental and human factors that influence whether or not a patient is admitted to an ICU, including high occupancy rates, low bed availability, varying admission criteria, and physician practices of patient transfers to general wards (Alam et al., 2014; Taezner, Pyke, & McGrath, 2011). Similarly, Kyriacos, Jelsma, and Jordon (2011) described, in their review of the literature, limitations with variations in EWS. They proposed that patient safety is dependent on nurses'

clinical judgment of deterioration in the context of EWS or MEWS scores and other contextual factors. This evidence is consistent with participants' descriptions of instances where patients were admitted to intensive care settings with a deterioration of a symptom or symptoms undetected by EWS. As discussed in the literature review, the challenges with variations in the types of EWS, including a lack of standardization of approach and variations in scoring for early detection, made it difficult to measure effectiveness in improving clinical outcomes.

In addition to describing the EWS as inadequate, participants described EWS technology as redundant for monitoring certain patient populations, such as patients receiving palliative care. Failure to rescue (FTR) has been conceptualized in the literature as the inability to intervene or effectively activate interventions to prevent serious complications in or the death of hospitalized patients (Henneman, Gawlinski, & Giuliano, 2012; Subbe & Welch, 2013; Thielen, 2014). However, not all situations of clinical deterioration or patient death are the result of FTR, such as expected and managed end of life or palliative conditions (Bobay, Fiorelli, & Anderson, 2008). In this study, both the resource nurse and point-of-care nurse groups gave examples of these situations and described the redundancy of EWS alarm alerts for patients receiving palliative care. They noted that using nursing judgment regarding when to communicate with the physician for such patients was a necessary part of their critical thinking, as was using nursing judgment and critical thinking to select an appropriate action.

Critical Thinking

During interviews, study participants were asked to define critical thinking. All participants struggled with articulating an accurate definition of critical thinking, though

they were able to describe scenario examples of how it was used in practice. While authors and researchers have used various ways to describe critical thinking as influencing clinical decision-making and practice, common concepts included in the literature include the ability to anticipate patient need, understand and utilize nursing knowledge, carefully examine data from multiple sources, analyze complex information, navigate and appraise personal assumptions, and change focus when presented with new information (Berkow, Virkstis, & Stewart, 2011; Chang, Chang, Kuo, Yang, & Chou, 2011; Dickerson, 2005; Riddell, 2007; Swinny, 2010).

Participants, whether point-of-care or resource nurses, all described their clinical environments as busy ones in which they were challenged to think critically about their patients. Aiken et al. (2011) evaluated conditional circumstances, such as the nurse work environments, as additional factors, beyond nursing characteristics, contributing to FTR outcomes. These researchers suggested that the limitations of the current literature in identifying the many environmental, organizational, and human factors that affect FTR situations make it challenging to directly correlate EWS and FTR. In applying HFA principles to the concept of critical thinking, busy clinical environments do not always allow nurses adequate time to be mindful and to think critically. In busy acute care practice environments, novice nurses balancing multiple priorities may not take the time to detect and interpret clinical data in a manner that is required for early intervention. If this level of environmental distraction is compounded by an EWS that may be inadequate in identifying important parameters or redundant in repeatedly alerting risk, it may inadvertently contribute to a greater risk of FTR.

Participants described documentation challenges around the timing of recording the vital signs in the electronic record and documenting their response to the alert. They reported that if the vital signs were not documented in a timely manner, the alarm alert would be delayed, resulting in the potential for a subsequent delay in early intervention for the patient. Further, nurses reported that while they were responding to their clinical assessment based on critical thinking and acting upon their findings, in some scenarios they were unable to leave the patient in order to document. They suggested that if a vital signs monitor could import the vital signs directly into the electronic patient chart, there would be no delay in an alert and they would not need to leave the patient. Taezner, Pyke, and McGrath (2011) reported timeliness of clinical documentation for EWS as a significant factor in preventing FTR.

Bobay, Fiorelli, and Anderson (2008), in their retroactive study of actual FTR events in five hospitals, posited that nursing documentation of vital signs may be the best predictor of effectively intervening in FTR. The researchers also stated that FTR is a result of a number of interrelated factors, including nursing vigilance, expertise, communication between care providers, organizational and environmental support, and the deterioration patterns of patients. The literature reviewed supports the participants' described experiences and perceptions, particularly their suggestion regarding electronic and automated options to improve documentation challenges.

EWS was described as inadequate in detecting certain populations of patients who required transfer to ICU. These patients were described as having experienced a) poor oxygenation leading to respiratory deterioration or altered level of consciousness or b) for palliative care patients whose deterioration was anticipated and managed, redundancy in

triggering alarms. This inadequacy and redundancy intersected with the human component of novice and other nurses who would benefit from EWS to support their critical thinking in busy clinical environments. The study results, supported by the literature, suggest that organizations implementing EWS might benefit from designing systems using standardized criteria that are sensitive to early detection of critical situations such as sepsis and that have adequate detection criteria for respiratory parameters. This study showed that organizations that have already implemented EWS could benefit from evaluating all admissions to ICU for deteriorating patients not captured by EWS and from reducing the potential for redundancy by identifying certain patient populations who should be excluded from triggering EWS alerts. Finally, the challenges with timely vital signs documentation identified in this study has been confirmed in the literature as contributing to the potential for delayed alerts leading to delayed early intervention.

Nursing Intuition

Nursing intuition emerged as a concurrent theme, either used directly by the participants or implied through their described experiences and perceptions. During the interviews, many participants used the term "intuition" or "gut feeling" when recounting clinical scenarios and their experience with EWS. They reported that, in spite of what the EWS alerted or failed to alert, their intuition preceded the alert indicating that something was not right with the clinical presentation of their patient. They also equated the term "nursing intuition" with being experienced nurses.

In addition to the HFA guiding principle of studying the interplay between technology and humans in the work environment, the literature reviewed highlighted that critical thinking and the decision to act are influenced by nursing experience, including rely-

ing on nursing intuition (Carberry, Clements, & Headley; 2014; Ludikhuize, Smorenburg, de Rooij, & de Jonge, 2012; Mahlmeister, 2010; McDonnell et al., 2012; Odell, 2010; Odell, Victor, & Oliver, 2009; Preston & Flynn, 2010; Reason, 1995; Thompson et al., 2007). There is no universal definition of nursing intuition in the literature, although it has been described as a non-linear procedure of knowledge, a cognitive skill to assist with assessment, an analytical process of accumulated data resulting in the ability to recognize patterns in specific situations, and a complex decision-making process based on previously learned information or experiences (Benner & Tanner, 1987; Michael et al., 2015; Pretz & Folse, 2011; Robert, Tilley, & Peterson, 2014; Traynor, Boland, & Buus, 2010).

Odell, Victor, and Oliver (2009) reported that nurses use intuitive processes when recognizing patient deterioration and activating a response, though they cautioned that reliance on intuition without analytic reasoning could increase the likelihood of decision-making errors. Benner and Tanner (1987) reported on expert nurses whose intuition influenced clinical judgment and proposed that the intuitive judgments and perceptions of expert nurses allowed them to shift from identifying salient issues to taking action were different from those of novice nurses, who may view intuition as mystical knowledge (Benner & Tanner, 1987). Robert, Tilley, and Peterson (2014), in their review of the nursing literature, posited that nursing intuition has been identified by early nursing theorists, nursing researchers, and the Institute of Medicine as important nursing knowledge and a valid way of knowing in clinical practice. They analyzed the concept of intuition and the decision-making processes of novice nurses and recommended that, since intuition is gaining legitimacy as a way of knowing in clinical practice, intuitive concepts be included in nursing curriculums using intuitive skill application as an adjunct to clinical decision-making (Robert, Tilley, & Peterson, 2014). With nursing intuition as a concur-

rent theme, this study has highlighted the need to further explore how nurses use nursing intuition for decision-making in response to EWS alerts. More research is needed to illuminate the interdependency between nursing intuition and EWS alerts as it relates to interpreting clinical information, using nursing knowledge, and clinical decision-making.

Implications

Summary

This chapter has discussed findings that identified three informative findings about how nurses experience and perceive EWS in busy acute care settings. They were as follows:

1. EWS has added value to nursing and nursing practice, particularly with novice nurses or nurses new to practice settings,
2. EWS provides benefits to nurses working in acute clinical environments that experience high volumes and high acuity of patients by alerting or reminding them about potential FTR situations, and
3. Existing EWS may require modification to improve adequacy, reduce redundancy, and reduce alarm fatigue.

In addition, participants described or gave examples of situations in which nursing intuition played a role in their critical thinking and clinical decision-making in early recognition of patient physiological deterioration and prevention of FTR. The literature reviewed identified little data to provide an understanding of the experience of nurses using EWS technology to enhance their clinical practice and decision-making. In studying and describing nurses' experiences with and perceptions of EWS, this study may represent the first of its kind. The findings of this qualitative descriptive study validate the po-

tential for EWS in today's acute care environments. EWS were perceived by nurses to support critical thinking and to reduce the risk of FTR, particularly for those nurses recently transferred to acute care units and novice nurses practicing in highly complex and demanding acute care clinical environments.

Implications for Organizations

While the literature regarding EWS and the impact of related technologies on clinical outcomes is inconclusive, this study suggests that there is evidence to support the view that organizations would benefit from understanding nurses' experiences with and perceptions of EWS. This study reveals several implications for organizations implementing EWS. In summary, to potentially reduce the risk of FTR when implementing EWS in acute care settings, the following key recommendations related to nurses' experiences of EWS are provided:

1. Organizations implementing EWS should design the system using evidence-informed, comprehensive, and standardized physiological parameters that are sensitive to early detection of critical conditions such as sepsis.
2. Organizations considering implementing EWS should carefully evaluate the parameters so that alerts are adequate to identify patient deterioration and meaningful enough to reduce the potential of alarm fatigue.
3. Prior to the implementation of EWS, organizations should include point-of-care nurses in the design, development, and testing phases of the system.
4. Organizations implementing EWS should reduce the potential for redundancy by identifying and excluding specific patient populations with expected and

managed deterioration, such as palliative care patients and those with chronic illness impacting specific vital signs parameters.

5. Organizations that implement EWS should use them as an adjunct tool for education regarding clinical assessment, clinical intuition, critical thinking, and clinical decision-making, particularly for nurses new to acute care areas and novice nurses practicing in highly acute care settings.
6. Organizations who have already implemented EWS should review all admissions to ICUs to evaluate the effectiveness of the technology by identifying and debriefing nurses on any patients who are admitted based on clinical deterioration and FTR that were not captured by EWS.
7. When planning for the implementation of EWS, organizations should consider the need for point-of-care electronic vital signs monitoring devices with built in interfaces to electronic health record documentation systems to eliminate the effect of late documentation, reduce nursing burdens, and ensure that alarms reflect the immediate risk.

Implications for Nursing Practice and Education

This study's findings have the potential to contribute to the broader culture of safety in acute care environments. Further, an expanded understanding of the essential structure and common truths about these experiences has the potential to inform nursing leaders in their support of nurses experiencing EWS, particularly in the area of promoting critical thinking, clinical judgment, and clinical decision-making. Since the participants could articulate the use of critical thinking when describing patient scenarios but could

not define critical thinking in the abstract, nursing leaders and nursing educators who implement EWS could consider using the technology as an adjunct tool for simulation. They could consider including scenario-based nursing education strategies regarding clinical assessment, critical thinking, clinical judgment, and clinical decision-making, particularly for nurses new to acute care areas and novice nurses practicing in highly acute care areas. This recommendation is also applicable to educators in Schools of Nursing responsible for developing and revising the nursing curriculum. Integration of competencies in clinical assessment, particularly vital signs assessment, critical thinking, clinical judgment, and clinical decision-making are critical for novice nurses entering practice.

Implications for Future Research

There is little understanding of the experiences of nurses using EWS technology to enhance their clinical practice and decision-making. Understanding the experiences and perceptions of nurses with regard to automated EWS and related technologies in acute clinical practice settings will help to address a gap in the current body of literature and offer important information to guide nursing practice, education, and future research. In particular, more research is needed to illuminate the relationship between nursing intuition and EWS alerts as it relates to interpreting clinical information, nursing knowledge, and clinical decision-making. Further research is also needed in the area of novice nurses who use nursing intuition when interpreting clinical patient data and in the area of the potential for EWS to create alarm fatigue.

An area of interest for future research could include studying different nursing groups that are exposed to EWS alarm alerts to better understand their experiences with real or perceived alarm fatigue, especially nurses who are not directly exposed to alarm

alerts yet experience vicarious alarm fatigue. Future research is needed, as well, to study patients transferred from clinical units to intensive care areas where EWS was ineffective in triggering an early warning for early intervention, particularly in light of the fact that EWS are not standardized. Further research identifying how EWS affect and improve communication between nurses and physicians would be beneficial to enhancing the culture of safety in practice environments. Finally, potential future research could build on the findings from this exploratory descriptive study to examine how nursing leaders can support nurses who use EWS and related technologies.

Limitations of Design

This study had limitations that should be noted. First, the convenience sample was recruited from one organization, which could have constrained the findings of the study. In addition, it was more challenging to recruit participants from the smaller of the two sites of the organization, so the majority of the participants were recruited from the larger site. The use of the snowball recruitment sampling strategy was more effective at the larger site, but this could have been at the expensive of adequate representation from the smaller site, as recruits were more readily available at the larger site. This may have limited the representativeness of the sample. However, there were nurses with various levels of experience included in the study that represented various medical and surgical practice settings. In addition, both RN and RPN nursing groups, and nurses in clinical leadership and point-of-care nursing roles were represented.

Second, the student investigator was a nursing leader (Clinical Director) at the organization where the study was conducted. The study participants may have experienced the student investigator in her professional role, which could have influenced the study

participants' contributions in the interview process. To minimize this influence, the student investigator evaluated every interview transcript and audio recording for any researcher bias and adjusted her style of interviewing for each subsequent interview to remove any potential influences.

Third, since the total number of nurse participants was low (nine), there were a limited number of resource nurses (two) who participated in the study. This limited the ability of the study to determine differences between point-of-care nurses' experiences and resource nurses' experiences. However limited, small differences in the experiences of both nursing groups were identified. Future research could explore this further, particularly to determine how different nursing roles experience EWS alarm fatigue.

Finally, since the study participants were a relatively homogenous group of nursing professionals, the findings of this study may not have encapsulated the views of other healthcare professionals as user groups of the EWS technology, such as physicians or other professional practice staff. However, lessons from nurses as a homogenous group are relevant, as they are the group of professionals who are accountable for documenting vital signs and are first to receive EWS alerts and initiate a response.

Dissemination

A realistic combination of multimodal approaches toward knowledge translation will be chosen strategically so as to ensure success of dissemination. An initial plan will include sharing the results of this study with participant nurses as the primary target of dissemination. Information in the form of a study summary and presentation will be made available to the leadership group at the organization as well as the Nursing Advisory Committee and the Nursing Governance members of the organization. In addition, pre-

senting the findings of the study at a professional conference venue will be pursued. Finally, the opportunity to publish in a medical and/or nursing journal will be pursued.

Conclusion

Failure to rescue outcomes may be one consequence of the relationship between healthcare provider behaviors and attitudes, organizational factors, and environmental factors that intertwine to threaten patient safety and impact the efficacy of EWS and rescue efforts (Harrison, Koppel, & Bar-Lev, 2007; Reason, 2004). This study adds to the body of EWS and FTR literature by providing some understanding of nurses' experiences and perceptions of EWS. This may be helpful for acute care organizations implementing EWS, as it has the potential to contribute to the broader culture of safety in acute care environments.

REFERENCES

Accreditation Canada, Required Organizational Handbook (2016), 19, retrieved from https://accreditation.ca/search/site/rop%20handbook

Aiken L., Cimiotti J., Sloane D., Smith H., Flynn L., & Neff D. (2011). The effects of nurse staffing and nurse education on patient deaths in hospitals with different nurse work environments. *Medical Care, 49*(12), 1047-53.

Aiken, L., Clarke, S., Cheung, R., Sloane, D., & Silber, J. (2003). Educational levels of hospital nurses and surgical patient mortality. *Journal of American Medical Association, 290*(12), 1617-1623.

Aiken, L., Shang, J., Xue, Y., & Sloane, D. (2013). Hospital use of agency-employed supplemental nurses and patient mortality and failure to rescue. *Health Services Research, 48*(3), 931-948.

Alam, N., Hobbelink, E., Tienhoven, A., vande Ven, P., Jansma, E., & Nanayakkara, P. (2014). The impact of the use of early waning score (EWS) on patient outcomes: A systematic review. *Resuscitation, 85*, 587-594.

Ashcraft, A. (2004). Differentiating between pre-arrest and failure-to-rescue. *MedSurg Nursing, 13*(4), 211-216.

Askew, T., Trotter, T., Vacchiano, S., Garvey, P., & Overcash, J. (2012). Avoiding failure to rescue situations: A simulation exercise for oncology nurses. *Clinical Journal of Oncology Nursing, 6*(5), 530-532.

Baker, R., Norton, P., Flintoft, V., Blais, R., Brown, A., Cox, J., Tamblyn, R. (2004). The Canadian adverse events study: the incidence of adverse events among hospital

patients in Canada. *Canadian Medical Association Journal (CMJA)*, *170*(11), 1678-1686.

Benner, P. (1982). From novice to expert. *American Journal of Nursing*, *87*, 402-407.

Benner, P., & Tanner, C. (1987). Clinical judgment: How expert nurses use intuition. *American Journal of Nursing*, *87*(1), 23-31.

Berkow, S., Virkstis, K., & Stewart, J. (2011). Assessing individual frontline nurse critical thinking. *The Journal of Nursing Administration*, *41*(4), 168-171.

Bobay, K., Fiorelli, K., & Anderson, A. (2008). Failure to rescue: A preliminary study of patient-level factors. *Journal of Nursing Care Quality*, *23*(3), 211-215.

Bogdewic, S. P. (1999). Participant observation. In B. F. Crabtree & W. L. Miller (Eds.), *Doing qualitative research* (2nd ed., pp. 47-69). Thousand Oaks, CA: Sage Publications.

Cafazzo, J., & St-Cyr, O. (2012). From discovery to design: The evolution of human factors in healthcare. *Healthcare Quarterly, 15*, 24-29.

Cafazzo, J., Trbovich, P., Cassano-Piche, A., Chagpar, A., Rossos, P., Vicente, K., & Easty, A. (2009). Human factors perspectives on a systemic approach to ensuring a safer medication delivery system. *Healthcare Quarterly*, *12*, 70-74.

Canadian Federation of Nurses Unions. (2015). Trends in own illness or disability-related absenteeism and overtime among publicly-employed registered nurses: Quick Facts 2015. Retrieved from https://nursesunions.ca/factsheet/absenteeism-and-overtime-fact-sheet-2015

Capan, M., Ivy, J., Rohleder, T., Hickman, J., & Huddleston, J. (2015). Individualizing

and optimizing the use of early warning scores in acute medication care for deteriorating hospitalized patients. *Resuscitation*, *12*(32), 1-6.

Carayon, P. (2006). Human factors of complex sociotechnical systems. *Applied Ergonomics*, *37*, 525-535.

Carberry, M., Clements, P., & Headley, E. (2014). How helpful are early warning scores? *Nursing Times, 110*(1-3), 12-14.

Centers for Disease Control and Prevention. (2015). What you should know for the 2014-2015 influenza season. Retrieved from http://www.cdc.gov/flu/pastseasons/1415season.htm

Chambers, N. (1998). We have to put up with it don't we? The experience of being the registered nurse on duty, managing a violent incident involving an elderly patient: A phenomenological study. *Journal of Advanced Nursing, 27*, 429-436.

Chang, M., Chang, Y., Kuo, S., Yang, Y., & Chou, F. (2011). Relationships between critical thinking ability and nursing competence in clinical nurses. *Journal of Clinical Nursing*, *20*, 3224-3232.

Classen, J. (2010). Is failure to rescue really failure to communicate? *Nursing Management*, *July*, 38-41.

College of Nurses of Ontario. (2009). Practice Standard: Ethics. Retrieved from www.cno.org

Cooper, S., Kinsmen, L., Buykx, P., McConnell-Henry, T., Endacott, R., & Scholes, J. (2010). Managing the deteriorating patient in a simulated environment: Nursing students' knowledge, skill and situation awareness. *Journal of Clinical Nursing*, *19*, 2309-2318.

Creswell, J. W. (2013). Five qualitative approaches to inquiry. In *Qualitative Inquiry and Research Design: Choosing Among Five Traditions* (3rd ed., p. 83). Thousand Oaks, CA: Sage Publications.

Cvach, M. (2012). Monitor alarm fatigue: An integrative review. *Biomedical Instrumentation and Technology*, *July/August*, 268-277.

Day, T., & Oxton, J. (2014). The national early warning score in practice: A reflection. *British Journal of Nursing*, *23*(19), 1036-1040.

Dickerson, P. (2005). Nurturing critical thinkers. *The Journal of Continuing Education* in Nursing, *36*(2), 68-72.

Ebright, P., Urden, L., Patterson, E., & Chalko, B. (2004). Themes surrounding novice nurse near-miss and adverse-event situations. *JONA*, *34*(11), 531-538.

Elliot, D., Allen, E., Perry, L., Fry, M., Duiffield, C., Gallagher, R., Roche, M. (2015). Clinical user experiences of observation and response charts: Focus group findings of using a new format chart incorporating a track and trigger system. *BMJ Quality and Safety*, *24*, 65-75.

Emanuel, E. J., Wendler, D. W., & Grady C. (2000). What makes clinical research ethical? *JAMA*, *283*, 2701-2711.

Fontana, A. & Frey, J. H. (2000). The interview: From structured questions to negotiated text. In *Handbook of qualitative research* (2nd ed., 645-672). Thousand Oaks, CA: Sage Publications.

Funk, D., Sebat, F., & Kumar, A. (2009). A systems approach to the early recognition and rapid administration of best practice therapy in sepsis and septic shock. *Critical Care*, *15*, 301-307.

Gauer, R. (2013). Early recognition and management of sepsis in adults: The first six hours. *American Family Physician*, *88*(1), 44-53.

Gledhill, S. E., Abbey, J. A., & Schweitzer, R. (2008). Sampling methods: Methodological issues involved in the recruitment of older people into a study of sexuality. *Australian Journal of Advanced Nursing, 26*(1), 84-94.

Gordan, C., & Beckett, D. (2010). Significant deficiencies in the overnight use of a standardized early warning scoring system in a teaching hospital. *Scottish Medical Journal, 56*, 15-18.

Gosbee, J. (2002). Human factors engineering and patient safety. *Quality Safety Healthcare, 11*, 352-354.

Harrison, M., Koppel, R., & Bar-Lev, S. (2007). Unintended consequences of information technologies in health care—An interactive sociotechnical analysis. *Journal of American Medical Information Association (JAMIA), 14*, 542-549.

Hamilton Integrated Research Ethics Board (HiREB). (2016). Consent Template. Retrieved from https://www.hireb.ca/forms-downloads/

Henneman, E., Gawlinki, A., Guiliano, K. (2012). Surveillance: a strategy for improving patient safety in acute and critical care units. *Critical Care Nurse, 32*(2), 9-18.

IPAC Canada. (2015). Seasonal influenza, avian influenza and pandemic influenza. Retrieved from http://ipac-canada.org/infections-influenza.php.

Johnstone, C., Rattray J., & Meyers, L. (2007). Physiological risk factors, early warning scoring systems and organizational changes. *British Association of Critical Care Nurses, Nursing in Critical Care*, *12*(5), 219-224.

The Joint Commission (2008). Improving America's hospitals: The Joint Commission's

report on quality and patient safety 2008. Retrieved from https://www.jointcommission.org/PatientSafety/NationalPatientSafetyGoals.

Karsh, B., Holden R., & Alper, S. (2006). A human factors engineering paradigm for patient safety: Designing to support the performance of the healthcare professional. *Quality Safety Healthcare, 15*, 59-65.

Kendall-Gallagher, D., Aiken, L., Sloane, D., & Cimiotti, J. (2011). Nursing specialty certifications, inpatient mortality, and failure to rescue. *Journal of Nursing Scholarship, 43*(2), 188-194.

King, L. & Macleod Clark, J. (2002). Intuition and the development of expertise in surgical ward and intensive care nurses. *Journal of Advanced Nursing, 37*(4), 322-329.

Kolic, I., Crane, S., McCarney, S., Perkins, Z., & Taylor, A. (2015). Factors affecting response to national early warning score (NEWS). *Resuscitation*, *2*(9), 1-6.

Kyriacos, U., Jelsma, J., & Jordan, S. (2011). Monitoring vital signs using early warning scoring systems: A review of the literature. *Journal of Nursing Management*, *19*, 311-330.

Lasater, K. (2007). Clinical judgment development: using simulation to create an assessment rubric. *Journal of Nursing Education, 46*(11), 496-503.

Laverty S. M. (2003). Hermeneutic phenomenology and phenomenology: A comparison of historical and methodological considerations. *International Journal of Qualitative Methods, 2*(3), 1-29.

Levett-Jones, T., Hoffman, K., Dempsey, J., Jeong, S., Noble, D., Norton, C., … Hickey, N. (2010). The 'five rights' of clinical reasoning: An educational model to en-

hance nursing students' ability to identify and manage clinically 'at risk' patients. *Nurse Education Today, 30,* 515-520.

Lincoln, Y.S. (1995) Emerging criteria for quality in qualitative and interpretive research. *Qualitative Inquiry, 1*, 275-289.

Lincoln, Y. S. & Guba, E. G. (1985). Naturalistic Inquiry. Newbury Park, CA: Sage Publications.

Ludikhuize, J., Smorenburg, S., de Rooij, S., & de Jonge, E. (2012). Identification of deteriorating patients on general wards: Measurement of vital parameters and potential effectiveness of the modified early warning score. *Journal of Critical Care, 27*(424), 7-13.

Mackintosh, N., & Sandall, J. (2010). Overcoming gendered and professional hierarchies in order to facilitate escalation of care in emergency situations: The role of standardized communication protocols. *Social Science and Medicine, 71,* 1683-1686.

Mahlmeister, L. (2010). Human factors and error in perinatal care: The interplay between nurses, machines, and the work environment. *Journal of Perinatal Neonatal Nursing*, *24*(1), 12-21.

Manojlovich, M. (2013). Reframing communication with physicians as sensemaking: Moving the conversation along. *Journal of Nursing Care Quality, 28*(4), 295-303.

Manojlovich, M., & Talsma, A. (2007). Identifying nursing processes to reduce failure to rescue. *Journal of Nursing Administration, 37*(11), 504-509.

Mapp, I., Davis, L., & Krowchuk, H. (2013). Prevention of unplanned intensive care unit admissions and hospital mortality by early warning systems. *Dimensions of Critical Care Nursing*, *32*(6), 300-309.

Massey, D., Aitken, L., & Chaboyer, W. (2010). Literature review: Do rapid response systems reduce the incidence of major adverse events in the deteriorating ward patient? *Journal of Clinical Nursing*, *19*, 3260–3273

McDonnell, A., Tod, A., Bray, K., Bainbridge, D., Adsetts, D., & Walters, S. (2012). A before and after study assessing the impact of a new model for recognizing and responding to early signs of deterioration in an acute hospital. *Journal of Advanced Nursing*, *19*, 41-52.

McGaughey, J., Alderice, F., Fowler, R., Kapila, A., Mayhew, A., & Moutray, M. (2009). Outreach and early warning systems (EWS) for the prevention of intensive care admission and death of critically ill adult patients on general hospital wards (review). *Cochrane Database of Systematic Reviews 2009, 1*, CD005529.

McGaughey, J., Blackwood, B., O'Halloran, P., Trinder, T., & Porter, S. (2010). Realistic evaluation of early warning systems and the acute life-threatening events: Recognition and treatment training course for early recognition and management of deteriorating ward-based patients: Research protocol. *Journal of Advanced Nursing*, *66*(4), 923-932.

McNeill, G., & Bryden, D. (2013). Do either early warning systems or emergency response teams improve hospital patient survival? A systematic review. *Resuscitation*, *84*, 1652-1667.

Michael, R., Areti, S., Nektaria, K., Michael, S., Despoina, S., Manolis, L., & Nikolaos, R. (2015). Evaluation of intuition levels in nursing staff. *Health Science Journal, 9*(3:4), 1-7.

Morris, A., & Davies, K. (2010). Early warning scoring systems observation in care in

practice. *British Journal of Nursing, 19*(18), 1180-1184.

Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevnsky. K. (2002). Nurse-staffing levels and the quality of care in hospitals. *New England Journal of Medicine, 346*(22), 1715-1722.

Neergaard, M., Olesen, F., Anderson, R., & Sondergaard, J. (2009). Qualitative description: The poor cousin of health research? *BMC Medical Research Methodology, 9*(52), 1-5.

Odell, M. (2010). Are early warning scores the only way to rapidly detect and manage deterioration? *Nursing Times, 106*(8), 24-26.

Odell, M., Victor, C., & Oliver, D. (2009). Nurses' role in detecting deterioration in ward patients: Systematic literature review. *Journal of Advanced Nursing, 65* (10), 1992-2006.

Page, M., Blaber, I., & Snowden, P. (2008). Implementing a modified early warning system for critically ill patients in an acute private hospital. *The World of Critical Care Nursing, 6*(3), 57-64.

Park, S., Blegen, M., Spetz, J., Chapman, S., & De Groot, H. (2012). Patient turnover and the relationship between nurse staffing and patient outcomes. *Research in Nursing & Health, 35*, 277-288

Partington, G. (2001). Qualitative research interviews: Identifying problems in technique. *Issues in Educational Research, 11*(2), 32-44.

Patel, M., Jones, M., Jiggens, M., & Williams, S. (2011). Does the use of a "track and trigger" warning system reduce mortality in trauma patients? *Injury, International Journal Care Injured, 42*, 1455-1459.

Preston, R., & Flynn, D. (2010). Observations in acute care: Evidence-based approach to patient safety. *British Journal of Nursing, 19*(7), 442-447.

Pretz, J., & Folse, V. (2011). Nursing experience and preference for intuition in decision making. *Journal of Clinical Nursing, 20*, 2828-2889

Purling, A., & King, L. (2012). A literature review: Graduate nurses' preparedness for recognizing and responding to the deteriorating patient. *Journal of Clinical Nursing, 21*, 3451-3465

Rayo, M., & Moffatt-Bruce, S. (2015). Alarm system management: Evidence-based guidance encouraging direct measurement of informativeness to improve alarm response. *BMJ Quality Safety, 24*, 282-286.

Reason, J. (2004). Beyond the organizational accident: The need for "error wisdom" on the frontline. *Quality Safety Health Care, 1*(1), 40-44.

Reason, J. (1995). Understanding adverse events: Human factors. *Quality in Health Care, 4*, 80-89.

Riddell, T. (2007). Critical assumptions: Thinking critically about critical thinking. *Journal of Nursing Education, 46*(3), 121-126.

Robert, R., Tilley, D., & Peterson, S. (2014). A power in clinical nursing practice: Concept analysis on nursing intuition. *MedSurg Nursing, 23*(5), 343-349.

Sandelowski, M. (2000). Whatever happened to qualitative description? *Research in Nursing and Health, 23*, 334-340.

Sandelowski, M. (2009). What's in a name? Qualitative description revisited. *Research in Nursing and Health, 33*, 77-84.

Sandroni, C., Nolan, J., Cavallaro, F., & Antonelli, M. (2007). In-hospital cardiac arrest:

Incidence, prognosis and possible measures to improve survival. *Intensive Care Medicine, 33,* 237-245.

Saintsing, D., Gibson, L., & Pennington, A. (2011). The novice nurse and clinical decision-making: How to avoid errors. *Journal of Nursing Management*, *19*, 354-359.

Schmid, A., Hoffman, L., Happ, B., Wolf, G., & Devita, M. (2007). Failure to rescue: A literature review. *Journal of Nursing Administration, 34*(4), 188-198.

Schmidt, P., Meredith, P., Prytherch, D., Watson, D., Watson, V., Killen, R., Smith, G. (2015). Impact of introducing an electronic physiological surveillance system on hospital mortality. *BMJ Quality and Safety, 24,* 10-20.

Schubert, C. (2012). Effect of simulation on nursing knowledge and critical thinking in failure to rescue events. *The Journal of Continuing Education in Nursing*, *43*(10), 467-471.

Sendelbach, S., & Funk, M. (2013). Alarm fatigue: A patient safety concern. *AACN Advanced Critical Care*, *24*(4), 378-386.

Sendelbach, S., Wahl, S., Anthony, A., & Shotts, P. (2015). Stop the noise: A quality improvement project to decrease electrocardiographic nuisance alarms. *Critical Care Nurse, 35*(4), 15-22.

Shever, L. (2011). The impact of nursing surveillance on failure to rescue. *Research and Theory for Nursing Practice: An International Journal, 25*(2), 107-126.

Siedlecki, S., & Hixson, E. (2015). Relationships between nurses and physicians matter. *The Online Journal of Issues in Nursing, 20*(3), 1-6.

Silber, J., Williams, S., Krakauer, H., & Schwartz, J. (1992). Hospital and patient

characteristics associated with death after surgery: A study of adverse occurrence and failure to rescue. *Med Care*, *30*(7), 615-629.

So, S., Ong, C., Wong, L., Chung, J., & Graham, C. (2015). Is the modified early warning score able to enhance clinical observation to detect deteriorating patients earlier in an accident and emergency department? *Australian Emergency Nursing Journal*, *18*(1), 24-32. http://dx.doi.org/10.1016/j.aenj.2014.12.001

Streubert-Speziale, H. J., & Carpenter, D. R. (2007). Phenomenology as method. *Qualitative research in nursing: Advancing the humanistic imperative* (4th ed., pp 86). Philadelphia, PA: Lippincott, Williams and Wilkins.

Subbe, C., & Welch, J. (2013). Failure to rescue: Using rapid response systems to improve the care of the deteriorating patient in hospital. *Clinical Risk, 19* (1), 6-11.

Swinny, B. (2010). Assessing and developing critical-thinking skills in the intensive care unit. *Critical Care Nursing Quarterly*, *33*(1), 2-9.

Taenzer, A., Pyke, J., & McGrath, S. A review of current and emerging approaches to address failure to rescue. *Anesthesiology*, *115*(2), 421-431.

Tanner, C. (2006). Thinking like a nurse: a research-based model of clinical judgment in nursing. *Journal of Nursing Education, 46*(6), 204-211.

Thielen, J. (2014). Failure to rescue as the conceptual basis for nursing clinical peer review. *Journal of Nursing Care Quality*, *29*(2), 155-163.

Thompson, C., Bucknall, T., Estabrookes, C., Hutchinson, A., Fraser, K., de Vos, R, Binnecade, J., & Saunders, J. (2007). Nurses' critical event risk assessments: A judgment analysis. *Journal of Clinical Nursing*, *18*, 601-612.

Thorne, S., Con, A., McGuinness, L., McPherson, G., & Harris, S. (2004). Health care communication issues in multiple sclerosis: An interpretive description. *Qualitative Health Research*, *14*(1), 5-22.

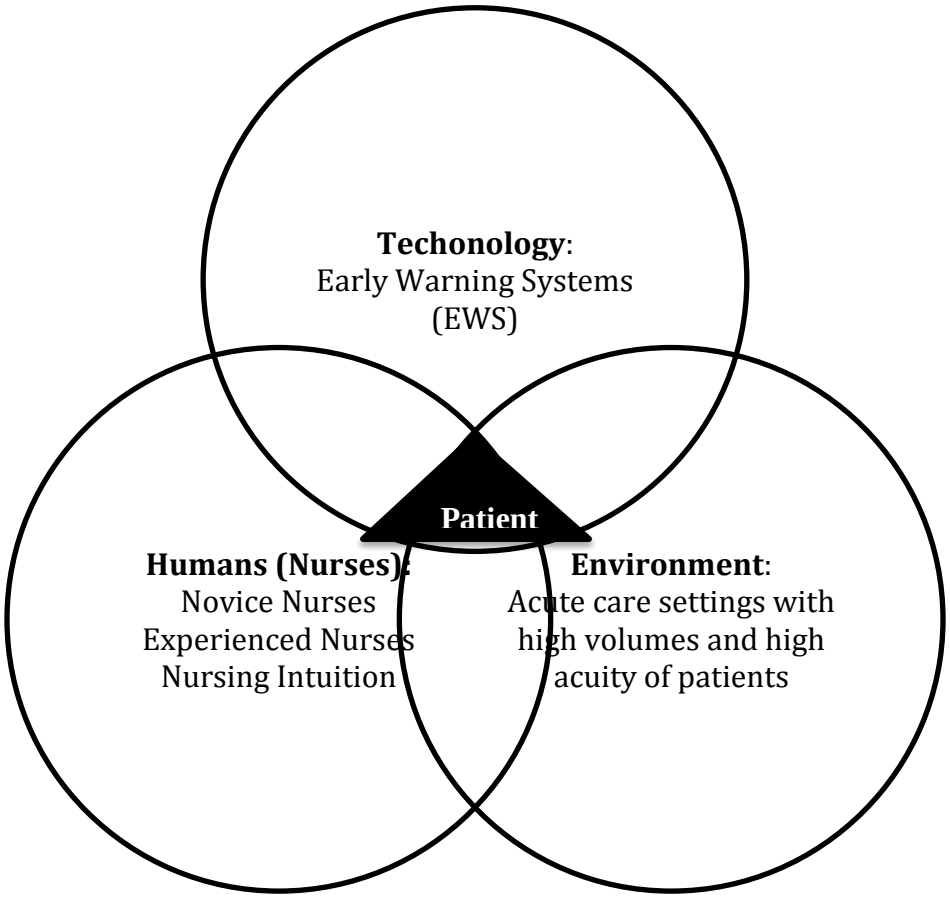
Traynor, M., Boland, M., & Buus, N. (2010). Autonomy, evidence and intuition: Nurses and decision-making. *Journal of Advanced Nursing, 5*, 1584-1591.

Westphal, G., Koenig, A., Filho, M., Feijo, J., de Oliveira, L., Nunes, F., ... & Goncalves, A. (2011). Reduced mortality after the implementation of a protocol for the early detection of severe sepsis. *Journal of Critical Care, 26*, 76-81.

Wojnar, D. & Swanson, K. (2007). Phenomenology: An exploration. *Journal of Holistic Nursing, 25*(3), 172-180.

APPENDIX A

Human Factor Analysis as the Framework for this Study



Adapted from James Reason, 1995

APPENDIX B

Letter of Information / Consent

Study Title: The Experience of Nurses who use Automated Early Warning Technology Systems in Clinical Practice

Investigators:

Local Principal Investigator:
Dr. Colleen McKey, RN. Ph.D. CHE. FACHE
Department of Faculty of Health Sciences
School of Nursing
McMaster University
Hamilton, ON, Canada
(905) 525-9140 ext. 22409
E-mail: mckeyc@mcmaster.ca

Student Investigator:
Patricia Geerlinks
Department of Faculty of Health Sciences
School of Nursing
McMaster University
Hamilton, ON, Canada
E-mail: geerlipl@mcmaster.ca

Purpose of the Study

Hospitalized patients may experience abnormal vital signs and subtle physiological changes 24-48 hours before a serious harmful event. The need to enhance and support early assessment of risk and timely clinical responses to patients who are deteriorating physiologically has led to the development of early warning systems (EWS). EWS are simple algorithms with specific criteria that are designed to identify patients at risk for clinical deterioration. How nurses experience EWS technology and how they perceive the impact of EWS on nursing practice including critical thinking is not well researched, understood or explained in the literature. The overall aim of this study is to understand and describe the experience of nurses using EWS technology to inform the impact of EWS on nursing practice and its effect, if any, on critical thinking and clinical decision-making. I am conducting this qualitative research study for a Master's thesis.

You are invited to take part a study evaluating how nurses experience EWS technology. If you have utilized the technology in your clinical practice I would like to have a one on one conversation with you. I am hoping to learn about how you experience the technology as it relates to clinical assessment and clinical decision-making. I also hope to understand what your perceptions are of the early warning system technology and how you perceive it impacts or relates to your nursing practice. There is a gap in research describing such experiences and perceptions, which makes this study valuable to expand knowledge regarding EWS.

In order for you to decide whether or not you want to be part of this research study, it is important that you understand what is involved as well as the risks and benefits to you as

a study participant. The study details are outlined in the next section and will be discussed with you in person. Once you understand the study, you will be asked to sign this consent form to confirm if you agree to participate. You are encouraged to take your time in making your decision.

It is important that you are reassured that the McMaster School of Nursing, the Local Principle Investigator, Dr. McKey, and the other Thesis Committee members, Dr. Ireland and Dr. Carter will not have access to any information containing participant identifiers.

Procedures involved in the Research

This section will describe the study. If you volunteer to participate in this study you will have a conversation with me, the student investigator that last between 60 to 90 minutes. It will be an interview-like dialogue where I ask you a series of pre-determined questions and based on your answers, more questions may be asked to further clarify. For example, I will be asking you questions related to the early warning system technology that you use in your nursing practice. I will ask you some questions about clinical assessment and critical thinking. I will ask you some questions about the technology itself. And I will ask you to share with me your thoughts and ideas about how you believe the technology is related to your nursing practice. We will have this discussion away from your workplace and at a mutually agreeable time and place.

The conversation will be audiotaped and everything you say will be confidential. I may also take some hand-written notes. No personal identifiers will exist whether in the notes or the tapes, as you will be given a confidential code name during the conversation. You will not be identified during the information collection period or when I transcribe our conversation. I may use some direct quotes when I am writing up the research study but none will be linked to you directly and you will not be indefinable in the write-up.

Once the interviews have been completed with all the participants, a transcriptionist will transcribe all the interviews verbatim and I will look for themes that are common among all the interviewees. No personal identifiers will be available to the transcriptionist as your name will be coded to preserve your privacy. I may come back to you to seek further clarification. At some point I will also follow up with you with the themes and the study findings to verify with you that our conversation was captured correctly in the analysis and that the findings are accurate representations of the thoughts you shared during our conversation.

Potential Harms, Risks or Discomforts:

Are there any risks to participating in this study? Since you are participating in one to one interviews with only me as the student investigator and since I will be removing personal identifiers from all aspects of the study, the risks are minimal. You may feel uncomfortable talking about specific cases in which you experience the early warning technology in which case you can stop and take breaks anytime. You may worry about how your infor-

mation will be interpreted but as I mentioned in the procedures section. You do not need to answer questions that you don't want to answer or that make you feel uncomfortable and you may certainly withdraw (stop taking part) in the study at any time. I will make sure that your privacy is maintained (see details in the Confidentiality section below). It is unlikely that there will be any harms or discomforts from or associated with participating in this study.

Potential Benefits

Are there any benefits to participating in this study? The research will not benefit you directly. What I hope to learn is how nurses experience early warning technology and if there is any impact on nursing practice, clinical assessment and critical thinking of nurses. In learning more about such experiences and perceptions I hope to better understand early warning technology in the practice environment and how it contributes to a culture of safety. The study findings have the potential to inform how nursing leaders can support nurses who experience early warning system technology in the practice setting.

Payment or Reimbursement

Participation in this study is voluntary and no compensation or payment will be made to you as a participants. However, as a recruitment incentive, you will be given a twenty-dollar Tim Horton's gift card as a token of appreciation for participating. In addition, if there are any additional parking fees incurred to you when we meet for the interview, you will be reimbursed for those fees.

Confidentiality

You are participating in this study confidentially. I will not use your name or any information that would allow you to be identified. No one but me will know whether you participated unless you choose to tell others. Every effort will be made to protect your confidentiality and privacy. I will not use your name or any information that would allow you to be identified. However, we are often identifiable through the stories we tell. For that reason, I will disguise your identity with a code name if I am using part of your story as a direct quote.

Any information that you provide that is captured with audiotapes or hand written notes will be kept in a locked desk/cabinet where only I will have access to it. Information kept on a computer will be protected by a password. Once the study has been completed, the data will be destroyed after a period of ten years.

If the results of the study are published, your name will not be used and no information that discloses your identity will be released or published without your consent for that disclosure.

Legally Required Disclosure

Although I will protect your privacy as outlined above, if the law requires, I will have to reveal certain personal information. An example of such a legal obligation would be if you were to disclose any criminal activity associated with patient harm or intention to harm, which would be considered a reportable offense.

Participation and Withdrawal

What if you change your mind about being in the study? Your participation in this study is voluntary. It is entirely your choice to be part of the study or not. If you decide to be part of the study, you can decide to stop (withdraw), at any time, even after signing the consent form or part-way through the study. If you decide to withdraw, there will be no consequences to you. Information provided up to the point where you withdraw will be kept unless you request that it be removed. If you do not want to answer some of the questions you do not have to, but you can still be in the study. There will be no negative consequences for individuals who choose not to participate or who withdraw from the study at any time during the course of the research.

Information about the Study Results

How do you find out about what was learned in this study? I expect to have this study completed by approximately December 2016. If you would like to receive the summary personally, please let me know.

This study has been reviewed by the Hamilton Integrated Research Ethics Board (HiREB). The HiREB is responsible for ensuring that participants are informed of the risks associated with the research, and that participants are free to decide if participation is right for them. If you have any questions about your rights as a research participant, please call the Office of the Chair, HiREB, at 905.521.2100 x 42013.

CONSENT

Participant:

I have read the information presented in the information letter about a study being conducted by Patricia Geerlinks, of McMaster University.

I have had the opportunity to ask questions about my involvement in this study and to receive additional details I requested.

I understand that if I agree to participate in this study, I may withdraw from the study at any time. I have been given a signed copy of this form. I agree to participate in the study.

I would like to receive a summary of the study's results. *Yes* *No*

If yes, where would you like the results sent:

Email: _____

Mailing address: _____

_____

_____

_____ _____ _____

Name of Participant (Printed) Signature Date

Person obtaining consent:

I have discussed this study in detail with the participant. I believe the participant understands what is involved with this study.

Consent form explained in person by:

_____ _____ _____

Name and Role (Printed) Signature Date

Appendix C: Semi-Structured Interview Questions

Clinical Assessment

I am interested in how nurses anticipate change in patient status. Perhaps you could start by describing a clinical situation where you knew a patient's condition was going to change.

Probes:

Describe how you anticipate changes in patient status

What informs that anticipation?

Prompt: if you cannot think of a clinical scenario on their own I have one for you to consider:

Fred is a 72 year old male with a medical history of COPD, hypertension, Parkinson's, and is a Type II diabetic. He was admitted with a new right sided chest pain that increases with inspiration. He has a harsh productive cough producing yellow sputum. You are on a 12 hour shift and since you came on this am his vitals have been as follows:

	0800	**1200**	**1600**	**1800**
Temp C	38.3	37.7	36.5	35.7
HR	106	126	128	135
RR	22	24	26	32
BP	125/88	102/68	96/65	90/62
SpO2	93% R/A	95% RA	93% RA	91% RA

At your 1800 assessment you notice that Fred appears confused and he is somewhat combative.

What do you think is happening to Fred?

What assessments would you make?

What do you anticipate will be the clinical decision-making for Fred?

Critical Thinking

Now I am going to ask you some questions about critical thinking:

What is your understanding of critical thinking?

How would you define critical thinking?

Can you describe a time when you believe you applied critical thinking skills to a clinical situation?

How confident are you in your ability to recognize a patient on your unit who is deteriorating clinically?

What supports are in place for you to enhance that ability?

What barriers (if any) are in place preventing you from activating a response? (prompt: fear of reprisal?)

EWS Technology

I am now going to switch the focus to ask you some questions about your experience using the EWS technology:

Can you describe for me EWS technology?

Can you describe a situation when EWS was useful to you?

Probes: If so, in what way?

Can you tell me more about….

How did that make you feel?

Why is that important to you?

Can you describe a situation when EWS was not useful to you?

Probes: If so, in what way?

Can you tell me more about….

How did that make you feel?

Why is that important to you?

What in your opinion is the relationship between the EWS and your clinical pracitise?

How is EWS technology related to your clinical assessment?

How does your work environment support/impede your ability to collect, interpret, analyze, utilize the information you receive from the EWS?

Ending Questions:

1. Is there anything that you might not have thought about before that occurred to you during this interview?
2. Is there anything else that you think I should understand better about your experience or perspective?
3. Is there anything else that you wish to share that has not been addressed?
4. Do you have any questions for me?

Appendix D: Demographic Questionnaire

Demographic data

Circle best answer:

Male Female

RPN RN NP

Educational Preparation:

RPN RN diploma BScN MN NP

Number of years in the nursing workforce in acute care:

Less than 1 year 1-5 years 6-10 years 11-15 years Greater than 15 years

Number of years working in this organization:

Less than 1 year 1-5 years 6-10 years 11-15 years Greater than 15 years

Time exposed to Early Warning Systems and technology

Less than 1 month 1-6 months 6-12 months greater than 1 year

Employee working status: Full time Part time Causal Retired

Note: rationale for demographic data is for thick description of participants for this study as well as relevance and reference for future studies.