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Recognizing Patient Deterioration: A Quantitative Study on Patient Outcomes in the Adult Acute Care Setting

Zachary Krom
University of Connecticut - Storrs, zachary.krom@uconn.edu

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Zachary R Krom, Ph.D.

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The identification of patient deterioration is significant because, in its absence, adverse events may go unnoticed and quickly escalate in severity. Only 17.4% of patients experiencing in-hospital cardiac arrest are seen by medical response teams, such as a rapid response or code blue team (Chan, et al., 2016). The purpose of this secondary data analysis was to determine if the frequency and rationale for RRT and code blue calls are related to nursing staff exposure to a deterioration recognition education program. Eleven medical surgical and five progressive care units at an urban academic medical center were included in the study. RRT and code blue calls were analyzed before and after the education intervention occurred. The data was analyzed using hierarchal negative binomial regressions. The analysis revealed that as the proportion of nurses that were trained in a unit increased over time, the percentage of RRT calls significantly increased (IRR 0.997, [CI 95%: 0.984, 1.010], $p = 0.614$). The analysis also indicated that there were significantly more RRT and code blue calls for the cardiac (IRR 1.08 [1.05,1.11], $p = 0.001$) and respiratory reasons (IRR 1.09 [1.06, 1.12], $p < 0.001$) in the post ALERT period. These findings imply that trained nurses are identifying deterioration before cardiopulmonary arrest. They also suggest that the simulation training may have bearing on knowledge retention that is effectively used later in practice. More research is needed on deterioration education involving multifaceted educational programs involving simulation. Lastly, further scholarly inquiry is encouraged to explore the impact of proactive educational programs on patient outcomes.

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Zachary R. Krom

B.S., Binghamton University, 2001

B.S.N., Binghamton University, 2002

M.S.N., University of Hartford, 2006

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Presented by

Zachary R. Krom, MSN, CCRN, CHSE, NPD-BC

Major Advisor_____

Thomas J. Van Hoof

Associate Advisor_____

Paula McCauley

Associate Advisor_____

Bernice Coleman

University of Connecticut

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Chapter 1: Introduction

Research problem

The recognition of patient deterioration has garnered international attention from accrediting agencies for many years (Australian Commission on Safety and Quality in Health Care, 2017, Institute for Healthcare Improvement [IHI], 2006, National Institute for Health and Care Excellence, 2007). The identification of patient deterioration is significant because, in its absence, adverse events may go unnoticed and quickly escalate in severity. A landmark study published almost 30 years ago found 84% of patients who experienced cardiac arrest expressed signs of deterioration previously documented by hospital staff (Schein, et al., 1990). An expert panel reviewed 118 cases of cardiac arrest and found that 62% of the arrests were avoidable and the odds of arrest were five times more likely in non-acute areas than in critical care areas ($p<0.001$) (Hodgetts et al., 2002). Patient deterioration can occur at any point during a patient's admission and is not specific to critical care areas such as intensive care units (ICUs). In another study looking at 49 ICU patients, the reason for ICU admission was related to monitoring issues by healthcare workers in 46% of the cases (van Galen et al., 2016). Processes are in place to help patients who are experiencing deterioration, yet for these processes to be successful, the appropriate teams must be activated. For example, a study looking at 21,913 patients in 274 hospitals found only 17.4% of patients who had a cardiac arrest were seen by a medical response team, such as a rapid response or code blue team (Chan et al., 2016).

Rapid response teams (RRT) and code blue teams are activated to respond to varying degrees of patient deterioration. Rapid response team use increased in popularity within the United States with the initiation of the 100,000 Lives Campaign (IHI, 2005). The Joint

Commission also recommended that hospitals utilize RRTs which further supported widespread adoption (Joint Commission, 2007). When hospitals have implemented a rapid response team, significant reductions in patient mortality have resulted (RR 0.87, 95% CI 0.81-0.95, $p<0.001$) (Maharaj, et al., 2015). Cardiac arrests in settings outside of the ICU have also decreased in RRT equipped hospitals (RR = 0.62, 95% CI: 0.55-0.69), (Solomon, et al., 2016).

In the United States, the annual number of hospitalized patients treated for cardiac arrest between 2003 and 2007 was estimated to be 211,000 (Merchant, et al., 2011). From 2008 to 2017, that estimation increased to 292,000 (Holmberg, et al., 2018). Intra-hospital cardiac arrest is a significant issue that deserves local and national attention. The volume of patients experiencing intra-hospital cardiac arrest is increasing, however the likelihood of survival has improved. An analysis of the hospitals involved with American Heart Association's Get with the Guidelines-Resuscitation Registry, found an improvement in risk-adjusted survival rates over nine years, including all age ranges (13.7% in 2000 to 22.3% in 2009) (Girotra, et al. 2012). The overall survival rates have improved to 30.4% from 2007 to 2012 in patients, ages 18-64 (Mallikethi-Reddy, et al., 2017). Patients experiencing in-hospital cardiac arrest have reduced odds of full recovery, which is dependent upon individual and environmental characteristics. The overall pooled survival rate looking at studies conducted over the last 33 years was determined to be 13.4% (95% CI: 5.6%-28.8%) (Schluep, et al., 2018). In the same meta-analysis, one-year survival rates for patients experiencing cardiac arrest ranged from 8.9% for patients over the age of 65 to 39.3% for patients on a cardiac floor. As a result of the data presented, many hospitals have taken a preventative approach in preparing staff to prevent arrest and to intervene with appropriate resources in addition to basic and advanced cardiovascular life support training (American Heart Association, 2016).

Simulation and web-based training programs to help nursing staff recognize patient deterioration have been successful in transferring concepts to practice and in building confidence (Bliss & Aitken, 2018; Liaw, Rethans, et al., 2011). High fidelity simulation experiences can be particularly useful when teaching health care providers to identify and manage patient deterioration (Connell, et al., 2016). Classroom-based programs utilizing multiple educational methods, including different degrees of simulation to deliver content, has been well established in the literature. The most well-studied programs are the Acute Life-Threatening Events Recognition and Treatment (ALERT), Multi-Professional Full-scale Simulation (MPFS), Acute Illness Management (AIM), and COMPASS (Liaw, Scherpbier, et al., 2011). However, there are not many studies linking deterioration education to patient outcomes.

Furthermore, many of these programs have been implemented sporadically around the globe with concentrations in Australia and the United Kingdom. The setting for this study currently uses the ALERT program. Evidence shows that intra-hospital cardiac arrest leads to poor patient outcomes, and there is a lack of evidence to support education to prevent deterioration that can lead to intra-hospital cardiac arrest. The relationship between the classroom-based ALERT program that utilizes multiple approaches to educate staff, including simulation, and patient deterioration and patient outcomes, will be explored.

Background and Significance

Patient deterioration has been defined by the nurses that experience it as "an evolving, predictable and symptomatic process of worsening physiology towards critical illness" (Lavoie, et al., 2016, p. 74). Management of a deteriorating patient can involve more frequent or complex assessments or interventions to regain and maintain stability. In the hospital setting, nursing is

the discipline that is most likely to be present when deterioration occurs. It is an expected function of the nurse to recognize the change and to intervene, including obtaining resources and notifying other disciplines to assist with caring for the patient. These resources often come in the form of teams, either rapid response or code blue.

The phase of the rapid response system that results in the activation of the team is referred to as the afferent limb (Winters & Devita, 2017). Teams can be activated by following written protocols, by continuous vital sign monitoring systems, and by concerned family members. Activation criteria can be objective, such as a respiratory rate range, or subjective, such as a concern for the patients' safety (Rao & Devita, 2017). Activations that rely on recorded vital signs are most popularly known as Early Warning Systems (EWS) and more recently, NEWS (National Early Warning Score) that originated in the United Kingdom (McGaughey, et al., 2007; Smith, et al., 2013). These systems produce a value extrapolated from multiple vital signs that fall within or outside of defined ranges.

A RRT is a group of experts who can be summoned to assist with a deteriorating hospitalized patient when critical interventions are thought to be needed (IHI, 2019). The team itself is also known as the efferent limb of the rapid response system (Devita, et al., 2006: Winters & Devita, 2017). Physicians from Australia, the United Kingdom, and the United States, first developed the concept in the 1990s (Winters & Devita, 2017). RRTs are commonly comprised of a multidisciplinary group, such as registered nurses, respiratory therapists, and physician staff. Teams can be nurse-led or physician-led (Duncan, et al., 2017).

Another activation method that has been studied for the past two decades in the adult and pediatric populations is initiated by patients or their families (Albutt, et al., 2017; Brady, et al.,

2015; Bogert, et al., 2010; Gerdik, et al., 2010). Although there are multiple methods to activate an RRT by various people involved with a patient's care (including the patient themselves), if deterioration goes undetected or is overlooked, it can often escalate rapidly.

The relationship between RRT and code blue calls is often a precursory one. If a deteriorating patient can be identified, evaluated, and treated with an RRT call, they may stabilize, and further decline would be prevented. Once stabilized, the team may order a diagnostic test or procedure. The team may also transfer the patient to a higher level of care, such as a progressive care unit (PCU) or ICU. Alternatively, the patient can remain at that level with the consideration of more frequent assessment or monitoring. A code blue activation is indicated when the prevention of cardiopulmonary collapse is not possible, either due to the severity of the patient's symptoms or due to the speed in which they decline.

Code blue is an alert heard in the hospital setting that serves to activate a group of advanced cardiac life support providers (American Heart Association, 2016) to attend to a patient who is experiencing a cardiopulmonary arrest. It results in the swift mobilization of a team to come to the patient's room and provide life-saving measures including basic and advanced life support techniques, such as cardiopulmonary resuscitation, defibrillation, administration of emergency medications, and/or endotracheal intubation. Code teams are multidisciplinary and include members from nursing, respiratory therapy, medicine, pharmacy, chaplaincy, and security, as well as others. The goal of the team is to achieve the return of spontaneous circulation for the patient.

The presumed overarching goal, not only of the teams but of nursing in general, is to prevent deterioration and to maintain or improve all hospitalized patients' current level of health.

To support this goal, nurses would benefit from techniques and methods to identify degradation and therefore stop the progression to cardiac arrest. One option is the use of the ALERT program. This program offers a systematic approach to evaluating a patient who is in distress (Smith, 2016a). The program uses prioritization of assessment by body systems whose deterioration would have the most severe consequences if not addressed rapidly.

The current study is significant to nursing science for multiple reasons. First, assessment is one of the foundations of nursing practice. Assessment is the first step in identifying a patient that is deteriorating. Due to the increased duration and frequency of patient interaction, nurses are in critical positions to detect changes. The success of identification is increased when the nurse is given the knowledge and tools to distinguish deterioration within a complex patient presentation. Currently, in the literature, the best method to impart this knowledge to the nurse is uncertain. The ALERT program uses multiple learning techniques to present a systematic assessment method, which is followed by low fidelity simulated scenarios for the application of the concepts to increase the participant's retention of the material. This study may support the use of programs that have a multi-faceted approach for educating nurses on how to recognize a deteriorating patient. This work may encourage studies focused on investing instructional time on specific patient characteristics related to deterioration.

Furthermore, the training that nurses receive upon hire and on an annual basis is often procedural or intervention based to support competency-based practice. This work may help the integration of deterioration recognition and responses with these competency-based skills that are specific to the patient populations.

This study is unique because the ALERT program is licensed for administration in two medical centers in the United States, one in California and the other in Georgia. Second, the ALERT program has not been studied in the United States hospital system. This study seeks to explore the relationship between educational programs designed to teach deterioration recognition and patient outcomes that have been sparsely studied in the past (Mitchell et al., 2010; Wright et al., 2006), and not at all recently.

Specific Aims and Research Questions

The purpose of this secondary data analysis is to determine if the frequency and rationale for RRT and code blue calls are affected by nursing staff being exposed to the ALERT course at an urban academic medical center. The primary aim of the study is to determine if exposing the nursing staff to the ALERT course impacts the frequency of code blue and RRT calls. The secondary aim is to describe the relationship between course content and reasons for activation of RRT and code blue teams.

This study will address the questions regarding the relationship between the ALERT course and the frequency and reasons for activation of rapid response and code blue teams, with the appropriate nurse or contextual variables selected or controlled.

1. Are there more RRT calls during the ALERT training period then in the period before the education was implemented?

2. Are there less code blue calls during the ALERT training period then in the period before the education was implemented?

3. As more nurses are trained in the ALERT course, does the number of RRT calls increase?

4. As more nurses are trained in the ALERT course, does the number of code blue calls decrease?

5. Will there be an increase in specific reasons for RRT and code blue calls that match the content covered in the simulated content of the ALERT course?

Theoretical Model

Worldview: Positivism

This quantitative study seeks to determine the cause and effect relationship between nursing education and patient outcomes. When focusing on a cause and effect relationship utilizing hypothesis testing and objectified concepts, positivism is often the worldview selected for the study (Polit & Beck, 2016). In addition to the deductive process involved, the researcher's values and biases are controlled, and their involvement in the research is limited (Polit & Beck, 2016).

Theoretical Lens: Ida Jean Orlando: Nursing Process Discipline Theory

Ida Jean Orlando's Nursing Process Theory was selected for this study due to its precise nature in using the nursing process and how the systematic quality of the ALERT assessment complements its structure (Table 1). Five foci comprise the framework of Orlando's theory (May, 2013). Evaluation of the patient and determining how to address their need(s) is the first step. The second is the presentation of the patient that requires attention. The third focus is the reaction of the nurse, that is, their physical, emotional, or psychological response to the patient situation. Fourth, is the nurse's inclusion and use of the patient's presentation, history, and the surrounding environment to guide the nurse's decision making (May, 2013). The final focus is

the resolution of the situation the nurse was addressing and, ideally, improvement in the patient's condition.

Table 1

Theoretical Lens: Stepwise Comparison of Nursing Process Theory and the ALERT Assessment

Steps	Nursing Process Theory	ALERT
1	Patient assessment and addressing the need	Assessment: Airway, Breathing, Circulation, Disability and Exposure
2	Patient presentation that requires attention	Patient needs within the ABCDE assessment are identified, and prioritized
3	Reaction of the nurse: physical, emotional, and psychological	Nurse initiates interventions and resources
4	Incorporation of presentation, history, and surrounding environment	Nurse considers previous knowledge of patient with assessment, and current interventions to determine next steps
5	Resolution of situation	Nurse repeats assessment until needs are resolved, and patient is stabilized

Note. Nursing Process Theory by Ida Jean Orlando; ALERT = Acute Life-Threatening Events Recognition and Treatment

An experienced nurse would use a similar process when presented with a deteriorating patient. The ALERT course teaches deterioration assessment using the mnemonic ABCDE (airway, breathing, circulation, disability, exposure). As the nurse completes each assessment, they activate the stages of the nursing process theory, attending to specific findings, reacting to the data they receive, and assimilating what they know of the patient's history to find a solution. If the nurse can complete the full assessment, they once again engage the nursing process theory

to understand the situation from a broader perspective and possibly synthesize the underlying cause for the patient's deterioration.

Definition of Terms

Patent Deterioration

An operational definition of patient deterioration was recently created in a concept analysis paper, "a dynamic state experienced by a patient compromising hemodynamic stability, marked by physiologic decompensation accompanied by subjective or objective findings" (Padilla & Mayo, 2018, 1365).

Progressive Care Unit

An area of care in which the patients are "moderately stable with less complexity, require moderate resources and require intermittent nursing vigilance or are stable with a high potential for becoming unstable and require an increased intensity of care" (American Assocation of Critical Care Nurses [AACN], 2008, p. 1). The American Association of Critical Care Nurses uses this term to include: step-down units, direct observation units, intermediate care units, telemetry units, and transitional care units (AACN, 2008).

Rapid Response Team

A rapid response team is a "team of designated clinical staff trained to respond rapidly to urgent calls for help when it is suspected or apparent that a patient is experiencing serious clinical deterioration” (Australian Commission on Safety and Quality in Healthcare, 2015).

Code Blue Team

A code blue team is a group of clinical experts that responds to cardiopulmonary arrest within a hospital. The team can include, but is not limited to, a physician, a respiratory therapist, a pharmacist, and a nurse.

ALERT Program

The ALERT program is an educational program designed for healthcare providers to recognize deteriorating patients, prevent multisystem organ failure, and initiate rapid treatment with an emphasis on effective communication techniques (Smith, 2016a).

Chapter 2: Literature Review

Overview

The literature review chapter is made up of six sections and the first section addresses the search strategy. In the second section, the nursing perception of clinical deterioration is explored. The third section explains how deterioration has impacted patients. Educational programs and how participants perceive them is discussed in the fourth section. Educational programs and their relationship to patients' outcomes are covered in the fifth section. Lastly, the literature on the ALERT program is presented.

Search Strategy

An exhaustive review of the literature was conducted using online databases and content-specific journals. Peer-reviewed, scholarly articles were identified using the following databases: PubMed, PsycINFO, CINAHL, Medline, and ProQuest. Articles published in English from 1990 to January 2020 were considered in the search. The keywords that were used in the search included: clinical deterioration, patient deterioration, adverse events, nursing education, and surveillance. Studies that focused on intensive care units, pediatric patients, and patient perspectives were excluded from the results. This literature review consists of relevant studies that have influenced the purpose and aims of this dissertation.

The Concept of Deterioration

Clinical deterioration has the defining attributes a dynamic state, involving decompensation, and having subjective and objective determinants, per a recent concept analysis (Padilla & Mayo, 2018). The authors found that the patient’s clinical state, susceptibility, pathogenesis, and adverse events often lead to an episode of clinical deterioration. Padillo & Mayo (2018, p. 1365) penned this operational definition "a dynamic state experienced by a

patient compromising hemodynamic stability, marked by physiologic decompensation accompanied by subjective or objective findings".

A dimensional analysis was conducted that used the words of acute and critical care nurses in the literature to explore the meaning of deterioration and define the concept (Lavoie, et al., 2016). The characteristics or properties of deterioration were found to be, evolving, physiological, predictable, and symptomatic. Studies supporting the evolving property showed evidence that deterioration was a dynamic process. The properties of physiological and symptomatic were endorsed with examples from the literature involving abnormal vital signs and how they indicated deterioration. The prediction property was supported by studies showing that patients had particular characteristics that the nurses cued in on in order to predict that deterioration would occur. Additionally, the processes associated with deterioration were surveillance, recognition, referral, and response (Lavoie, et al., 2016). Surveillance was described as how nurses obtain data from monitoring and the value of their assessments. Recognition involved the reasoning behind nurse's identification of deterioration and the systems that are sometimes available to assist them. The concerns around communicating, including confidence and timing, with other disciplines were discussed in the section on the referral process. The response process was described using nurses experience with requesting assistance from staff who could provide interventions to treat deteriorating patients.

Patient Deterioration and Nursing Experience

There have been multiple studies that have examined general floor nurse's experiences and observations in situations where a patient is deteriorating. "Recognizing and responding" was the most common theme identified amongst the studies (Allen, et al., 2017; Chua, et al., 2013; Hart, et al., 2016). This finding is expected considering nursing staff has the most time

interacting with patients and the devices used to monitor them. Nurses described deterioration situations as complex events that required technical, cognitive, and behavioral skills (Hart et al., 2016). Intuition was also mentioned as a predictive tool that some nurses utilized in addition to these skills (Hart et al., 2016). Managing deteriorating patients was another commonality. Nurses took responsibility for directing patient care, delegating, and acquiring additional resources and staff as needed in these cases (Allen, et al., 2017; Chua, et al., 2013).

Preparation is as essential to the novice as it is to the most experienced nurse. Many newer nurses were concerned with their lack of experience and potential lack of resources during these situations (Purling & King, 2012). Caring for deteriorating patient changes the dynamic of the nurse's assignment; new nurses also expressed concern about the increased workload a deteriorating patient can cause (Purling & King, 2012). Resources in the form of technology and personnel can be summoned by the nurse to assist with patient care. Tools, such as monitoring systems, are available to nurse on certain floors depending on the acuity and diagnosis of the patient. Some nurses described putting more confidence in the assessments of medical staff or systems which produce warning scores based on vital signs rather than their assessments (Dalton, et al., 2018). One resource that nurses have indicated they value is education relating to the development of deterioration techniques (Chua, et al., 2013).

The research on specialized areas of care outside of the ICU is limited; however, the findings are comparable to floor nurse experiences. As part of the program of study for this author's doctoral degree, a scoping review was conducted on patient deterioration in the progressive care setting (Krom, in press). Three themes were identified in the review of 13 articles: training methods, surveillance, and monitoring systems. Training techniques included team-based experiences with the use of checklists or protocols. Surveillance techniques

mentioned in the literature included physical assessment and technological methods to recognize early signs of patient deterioration. The theme of monitoring systems included work that relied on parameters derived from multiple vital signs to identify patterns in the process of deterioration. The review indicated a need for more research addressing educational methods that focus on a multi-factorial approach to improving nurses' methods of surveillance, given the complexities of a particular patient population.

Deterioration and Patient Outcomes

The literature on deterioration and patient outcomes falls into three categories: predisposing patient characteristics, repeated episodes, and delays. Specific patient characteristics have been shown to increase the risk of cardiac arrest as well as RRT activation. In the cardiac arrest literature, arresting patients were most likely to have respiratory disorders (38%) or multiple disorders (27%) (Schein, et al., 1990). Of the patients having various abnormalities, metabolic, and respiratory problems were most common. In Kause, et al. (2004), 79.4% of patients who experienced cardiac arrest had abnormal physiology preceding the event. Hypotension and decreased Glasgow Coma Scale were the most frequent antecedents to cardiac arrest (Kause, et al., 2004). Similar precursors to ICU admission have also been identified in the literature. Hypotension and tachycardia were the most common precursors in one study (Hillman et al., 2002) and hypotension and decreased Glasgow Coma Scale in another (Kause, et al., 2004).

Patient characteristics in relation to RRT calls were also found. One such study found that patients over 75 years old were more likely to experience delays in activations (adjusted odds ratio, 1.79 [1.59-2.94]; $p < 0.001$) and when activations occurred, they were more likely to

be at night (adjusted odds ratio 0.73 [0.62-0.98]; $p < 0.001$) (Fernando, Reardon, McIssac, et al., 2018). In White, et al., (2016), hypotension, oxygen desaturation and decreased level of consciousness were the most common reasons for RRT activation. Hypotension, decreased mental status and clinical concern were the most common triggers for RRT activation across a 12-year period, that included 19000 activations (Herod, et al., 2014).

One study specifically looked at all patients discharged from the ICU and which patients ended up arresting, being readmitted to the ICU, or requiring an RRT activation (Ng, et al., 2018). The authors found that being of advanced age, having a tracheostomy upon discharge from the ICU, and being admitted to the ICU with a subarachnoid hemorrhage or respiratory surgery were risk factors for all three events.

Episodes of deterioration that require RRT activation can occur more than once for a single patient. Patients with liver disease (odds ratio, 1.75; 95% CI, 1.14-2.69; $p = .01$), requiring noninvasive mechanical ventilation (odds ratio, 1.67; 95% CI, 0.94-2.94; $p = .07$), central line insertion (odds ratio, 1.81; 95% CI, 1.02-3.21; $p = .04$), or suctioning (odds ratio, 1.66; 95% CI 1.23-2.25; $p = .001$) were more likely to have repeated episodes (Stelfox, et al., 2013). The authors also found that these patients were more likely to require a higher level of care (43% vs. 13%; odds ratio, 6.11; 95% CI, 4.67-8.00; $p < 0.01$). Also, mortality was increased as well as length of stay in patients with recurrent RRT activations (Chalwin et al., 2019; Fernando, Reardon, Scales, et al., 2018; Stelfox, et al., 2013).

Few studies have addressed the reasons for RRT activation delay, and no study has been specifically designed to answer why delays occur. One study found more delays occurred between the hours of midnight and 8am (Barwise et al., 2016). During this time there could be a

decreased number of staff or resources compared to what is available during the day. One hypothesized reason for delay was that medical and nursing staff are choosing to treat the patient themselves, rather than following the activation criteria (Barwise, et al., 2016). Other authors have attributed the delay to the failure by hospital staff to detect deterioration (Gupta, et al., 2017; Sundararajan, et al., 2016).

While the reasons for delay may be in need of further attention, the consequences for patients are well documented. Delays from 15 minutes to one hour have been associated with multiple adverse outcomes. One example is increased length of stay (Barwise, et al., 2016; Gupta, et al., 2017; Reardon, et al., 2018), with one study noting durations of 32.4 days versus 14.9 days; $p < .001$ (Padilla & Mayo, 2019). These patients have also been found to have higher mortality rates (Barwise, et al., 2016; Gupta, et al., 2017; Chen, et al., 2015; Padilla & Mayo, 2019; Reardon, et al., 2018). Gupta, et al., (2017) found mortality rates of 34.7% in delayed patients versus 21.2% in patients experiencing timely activation ($p = .001$). In addition, two studies found that the likelihood of ICU admission was increased when a delay occurred, adjusted odds ratio = 1.56; 95% CI, 1.23-2.04; $p \leq .001$ and adjusted odds radio 1.72, 95% CI, 1.51-1.96; $p < .001$ (Chen, et al., 2015; Reardon, et al., 2018),

Educational Programs and Nurse Response

Educational programs specifically designed to teach healthcare providers to recognize and respond to patient deterioration were found in the literature from 2004 to 2018 (Appendix A). While the evaluation of these methods by the participants is well documented, the impact on patient outcomes is not. The participants of these programs have included staff and student RNs, physicians, midwifery students, and midwives. Simulation was a method used in all programs,

while e-learning was utilized in only the most recent program from Australia (Duff, et al., 2018). It is important to note that two of the programs used patient "actors" in the simulation sessions, instead of, or in addition to, high fidelity simulation (Buykx, et al., 2011; Featherstone, et al., 2005). The duration of the programs ranged from 3.5 hours to 5 days, most of which were continuous sessions while some were broken up over a few days. The ABCDE (airway, breathing, circulation, disability, exposure) method of assessment was used in six of the ten programs. The TeamSTEPPS approach was another method that has been documented extensively in the literature (Harvey, et al., 2014). Four studies used validated tools to assess nurses' responses to the programs. Participants expressed an increase in knowledge (Bliss & Aitken, 2018; Buykx, et al, 2011), assessment skills (Bliss & Aitken, 2011; Liaw, Rethans, et al., 2011) and deterioration identification or reporting (Fuhrmann, Perner, et al., 2009; Liaw, Rethans, et al., 2011).

Educational Programs, Patient Outcomes, and Nursing Interventions

In 2010, an Australian team examined the COMPASS educational programs effect on patient outcomes (Mitchell et al., 2010). The course was administered to 177 nurses and 28 junior physicians in a medical center. The COMPASS program consists of online learning, lectures, and case study discussion (Australian Capital Territory Health, 2019). The authors found a reduction in unexpected deaths (11/1157 [1.0%] vs 2/985 [0.2%], Rate Risk Ratio 1.57 [1.24-1.00] p = .03) and a reduction in unplanned admissions to the ICUs (21/1157 [1.81%] vs 5/985 [0.5%], Rate Risk Ratio 0.28 [0.11-0.74], p = .005).

A follow-up hospital-based analysis to the Buykx study (2011) was done by comparing nursing charting pre and post-program attendance (Kinsman, et al., 2012). The charts were

audited five times at two-week intervals before and after the program was conducted. The authors found that the frequency of patient observation (β2 = 0.112, $t = -3.57$, d.f. = 7, $p = .009$) and pain assessments (β2 = −0.179, $t = -4.585$, d.f. = 7, $p = .003$) had improved but not the administration of oxygen ($p = 0.143$)

The ALERT Program

The ALERT program has been studied as an educational tool four times between 2004 and 2007. The first study as summarized in Appendix A, consisted of 315 staff members, which included 180 nurses (area of practice not specified) (Featherstone, et al., 2004). The post-test questionnaires showed higher confidence ratings related to identifying increases in patient acuity after completing the course (pre 6.04, post 7.71; t = 11.74; $p < .01$). The program was also used to evaluate the knowledge of acute patient assessment in two groups of physicians and was performed in five hospitals in the United Kingdom (Smith & Poplett, 2004). Physicians who had previously attended the course had higher scores on a questionnaire of ALERT related concepts (9.44 ± 1.63, 7.45 ± 2.32, $p < .05$). In a later study, a group of 16 primary care physicians were trained on the ALERT course (Elliman, et al., 2007). Physicians rated the course as relevant and had positive feedback.

The ALERT program has also been used as part of a curriculum to reduce hospital mortality in the United Kingdom (Wright et al., 2006). In addition to training all clinical staff in the ALERT program, the curriculum included the use of a surveillance system, an early warning system, an infection control program, and a focus on the place of death and medication errors. Mortality ratios significantly fell from 94.5 to 77.5 over four years (95% CIs [73.1, 82.1], [73.1, 82.1]).

Gaps in the Literature

There is a need for more research in specialized areas outside of the ICU, such as the PCU. Patient acuity in these areas is higher, and therefore, the nursing assessment and interventions are more intense. Deterioration has a different connotation in this area and deserves specific attention. Other areas where patients frequent during their hospital stays may benefit scholarly attention. Diagnostic testing areas such as procedural suites, computed tomography, and X-ray rooms should be considered. The relationship between education programs devoted to improving deterioration recognition and patient outcomes is another area in need of further research.

Summary

This chapter presented a literature review on the current and relevant studies on reasons for and outcomes related to clinical deterioration. Nurses' experience with deterioration has been addressed by many studies which have supported further education, improved inter-professional relationships and increasing nurses' confidence in their practice. The literature demonstrates that unrecognized deterioration can have significant detrimental effects on patients such as increased mortality, increased length of stay and readmissions to the ICU. In the next chapter the methodology will be discussed in detail, including data collection methods, the intervention and data management.

Chapter 3: Study Methods

Introduction

The methods and procedures of this study will be presented in this chapter. The collection, preparation, management, analysis of data will be discussed. The intervention in the study, the Acute-Life Threatening Events Recognition and Treatment (ALERT) program, will be presented in detail. Protection of data and human subjects will also be addressed. Five research questions directed this study:

1. Are there more RRT calls during the ALERT training period than in the period before the education was implemented?
2. Are there less code blue calls during the ALERT training period than in the period before the education was implemented?
3. As more nurses are trained in the ALERT course, does the number of RRT calls increase?
4. As more nurses are trained in the ALERT course, does the number of code blue calls decrease?
5. Will there be an increase in specific reasons for RRT and code blue calls that match the content covered in the simulated content of the ALERT course?

Research design

In this quantitative analysis, a retrospective cohort design was used. This design is appropriate when examining interventions that have occurred in the past while focusing on outcomes that are still presently occurring (Polit & Beck, 2016). The ALERT program started in June of 2016 and has continued for the last four years at the study institution. The units in which

the ALERT trained nurses practice represent the cohort. The ALERT program is the intervention, and the RRT and code blue activations represent the outcomes.

The study analyzed RRT and code blue calls occurring from 2015 to 2017, before and after the implementation of an educational program designed to teach deterioration recognition. The relationship between the number of nurses trained in each unit and the number of calls over time was explored. The analysis also explored the reasons for calls related to the simulated ALERT scenarios.

Data collection

RRT and code blue data have been collected at Cedars-Sinai since 2012. An automated process that creates a report using the telecom system, and an event reporting system was implemented in early 2016. Monthly reports for the pre-ALERT period were obtained from December 1, 2015 to June 28, 2016. The first ALERT program was taught on June 29, 2016, which began the post-ALERT period. The post-ALERT period spanned from June 29, 2016 to April 30, 2017. All of the nurses in the medical-surgical and progressive care units were not trained all at once, rather staff participated the program on a bi-monthly or monthly basis. Although participation in the program was rolling and the term post-ALERT was chosen for brevity.

Over the course of this time, three groups of data were extracted from the records. The number of nurses trained from each floor, the counts of the RRT and code blue calls and the reasons for the calls. The intervention (exposure to the ALERT course) and the dependent variable (RRT and code blue counts) were analyzed simultaneously. As a result, the period after the implementation of the ALERT course was named the post ALERT period.

Reasons for RRT were acute hemorrhage, hypotension, respiratory distress, seizures, arrhythmias, acute mental status change, hypertension, concern, syncope, and other. The reasons staff would call a code blue were hypotension, acute hemorrhage, seizures, arrhythmias, cardiopulmonary arrest, and other. The number of nurses trained, and their demographic information was also obtained for the post ALERT period.

Data preparation

Areas of care were combined and recoded to reflect the same patient populations or nursing staff. The reasons for code blue and RRT calls were paired with the ALERT scenario topics by common characteristics. The demographic information of the ALERT attendees was reviewed for accuracy, and nurses in leadership positions were excluded from the analysis. Nurses from the emergency room and the nursing resources department, which includes float and crisis nurses, were also excluded.

Sample

The fundamental unit of analysis in this study was the nursing unit. Eleven medical surgical and five progressive care units were included in the study. Each nursing unit is distinguished by the characteristics of the patients admitted and the training of the nursing staff. Patients admitted to the medical-surgical units have two levels of monitoring, continuous heart rate and rhythm monitoring, with intermittent vital sign monitoring or only intermittent vital sign monitoring. The nurse to patient ratio is 1:4 or 1:5. Nurses working on the medical-surgical units are trained in basic life support techniques and basic electrocardiogram (ECG) interpretation. They also receive training based on the specific patient population.

Patients admitted to progressive care units (PCU) have continuous ECG, pulse oximetry, and respiratory rate monitoring, and the nurse to patient ratio is 1:3. PCU nurses have mandatory training in advanced cardiac life support techniques as well as advanced ECG interpretation and interventions. Patient-specific training also applies for PCU nurses, for example, mechanical circulatory device management, and pulmonary artery catheter management.

ALERT Participant Data Collection

A convenience sample included registered nurses who attended and successfully completed the ALERT program. 196 nurses participated in the program. Nurses in leadership positions such as manager, assistant nurse manager, clinical nurse specialists and nurse educators were excluded. Nurses working in the emergency department and in the nursing resources or the float pool were also excluded.

Patient Data Collection

The demographic information of the patients who required RRT and code blue calls was not analyzed as it was not recorded in the generated code blue and RRT report.

ALERT program

The ALERT program was developed in 1999 as a training system designed to teach inter-professional staff how to identify and manage patients that are actively deteriorating (Smith, et al., 2002). The program takes eight hours to administer, over a single day. A course facilitator monitors the program according to the guidelines established in the ALERT Course and Regulations manual (Smith, 2016b). The course facilitator must have expertise in healthcare and an education-based degree. The course facilitator can also be a certified ALERT Trainer as well.

The ALERT faculty works under the guidance of the course facilitator to deliver the content. Each facility determines how often it administers the course to maintain competence.

All candidates received the course material two weeks before the start date. The packet included the course manual, agenda, location of course, and a letter to participants instructing them to read the course manual in preparation. The course content was delivered in the same order, using the same educational materials, each time it was administered, as outlined in the program manual. In this study, all ALERT programs were delivered in the hospital simulation center. The delivery techniques used in the class were video, case studies, demonstration, group discussion, and simulation. The evaluation of the candidate's knowledge and application of the ALERT assessment was done in the afternoon simulation scenario sessions during which, each candidate led the management of one of the scenarios and rotated roles. The roles were: candidate, patient, assistant, and observer. Candidates broke into groups to participate in the first four scenarios facilitated by one of the faculty. After a short break, the candidates completed another four scenarios with a different instructor. The scenarios are "Pneumonia and Sepsis," "Hypovolemia and GI Bleed," "Hypoglycemia," "Pulmonary Embolism," "Seizures," "Acute Coronary Syndrome," "Reduced Level of Consciousness-Opiates" and "Anaphylaxis" (Smith, 2016a).

For each class, there was a maximum ratio of one instructor to six candidates, which was followed for all classes administered in this study. A multidisciplinary mix of candidates was encouraged in the course regulations. However, the participants in all sessions delivered at Cedars-Sinai were nurses. Candidates received a signed course completion certificate at the end of the course if they demonstrated competence based on the course objectives.

Data analysis procedure

Data were analyzed using StataSE 15 (StataCorp, 2017). Descriptive statistics were used to describe the nursing demographic information. The first two research questions regarding the number of RRT and code blue calls in the pre ALERT and post ALERT periods, were addressed using Fisher's exact test. This analysis identifies non-random associations between two categorical variables (McDonald, 2008). Although the test is applicable to larger samples, Fisher's exact test is commonly utilized with small sample sizes. For this reason, Fisher's exact test was chosen over Pearson's chi-square test, as this study contained comparisons between relatively small counts. This is because the Fisher's exact test calculates the p-value from each permutation of data at least as extreme as the observed association, while the Chi-square test approximates the p-value from the discrepancy between observed and expected counts (Bewick, et al., 2003).

Research questions 3 and 4, pertaining to the number of RRT calls increasing and code blue calls decreasing as more nurses are trained in the ALERT course, were answered using a hierarchal negative binomial regression. The unit of observation was defined as each nursing unit at each month. Meaning that there is a single snapshot every month for the proportion of trained nurses in a unit. Because of this, nurses who completed training in the last third of a month were not considered to have completed training until the following month, as the benefit of their training would primarily be reflected starting the following month. A negative binomial regression was conducted to analyze the number of code blue and RRT calls, as the data represents counts. A negative binomial model was used in favor of a Poisson regression as a result of overdispersion in the data. This model will show greater variation in the data and suggests more extreme observations than what would be predicted by a Poisson distribution

(Hilbe, 2011). If the mean and variance were equal, a Poisson regression would be appropriate. Question 5 was answered by comparing the counts for each reason for the activation of both RRT and code blue in the pre-ALERT and post-ALERT periods, with the scenarios taught in the program. Question 5 was also analyzed using Fisher's exact test.

Data Management

A password-protected computer that is a managed asset of Cedars-Sinai was used to store the electronic files of code blue and RRT calls and the attendance records for the ALERT course. Records of calls were coded sequentially with patient identifiers removed. Any paper records were de-identified of patient and staff information and were locked in the office of the researcher. The primary researcher has been employed at Cedars-Sinai for more than four years and has worked with the staff nurses, and nursing leaders studied in this project. The researcher has had full access to all data collected due to his role as an ALERT instructor and as a member of the hospital's code blue and RRT committee.

Ethical Considerations

The Institutional Review Board (IRB) at Cedars-Sinai reviewed the research proposal and determined the study was not regulated and therefore not subject to the requirements of human subjects' protection. A representative from the University of Connecticut's IRB reviewed the proposal and agreed with Cedars Sinai's recommendation.

Chapter 4: Results

Introduction

In this chapter, the results of this quantitative retrospective cohort design to explore the relationship between an education program designed to improve identification and interventions for deteriorating patients and emergency team calls will be presented. The findings will be related to the five original research questions and the demographic information for the nurses that participated in the Acute Life-Threatening Events Recognition and Treatment (ALERT) program will be shared.

1. Are there more rapid response team (RRT) calls during the ALERT training period than in the period before the education was implemented?
2. Are there less code blue calls during the ALERT training period than in the period before the education was implemented?
3. As more nurses are trained in the ALERT course, does the number of RRT calls increase?
4. As more nurses are trained in the ALERT course, does the number of code blue calls decrease?
5. Will there be an increase in specific reasons for RRT and code blue calls that match the content covered in the simulated scenarios of the ALERT course?

Setting

This study took place in an 886-bed urban academic medical center. At the time of the data collection, the facility had 11 medical-surgical units, five progressive care units (PCU), two pediatric intensive care units and five adult intensive care units. The patients in the medical surgical and PCU areas, which were the focus of this study, were admitted by private medical

and surgical physicians, and by physicians employed by the medical center. The units are differentiated by patient diagnosis, such as medical and surgical, and further distinguished by specialty of medicine or surgery, such as neurology and orthopedics.

Data Analysis

Nursing Unit Summary

Appendix B illustrates the numbers and rate of RRT, and code blue calls for each unit averaged by month during the pre and post ALERT periods. The numbers and percentages of ALERT trained nurses per unit averaged across the post-ALERT training period are also displayed with total nurse and bed numbers by unit. This table does not take into account the variation between the units, however it serves to show the data before higher level of analyses were performed. This simple descriptive table illustrates the average number of RRT calls increased from 7.79 in the pre ALERT period to 8.37 in the post ALERT period. The total average number of code blue calls decreased from 1.08 in the pre ALERT period to 1.05 in the post ALERT period.

Alert Participant Demographic Information

The demographic information for the ALERT trained nurses is displayed in Table 2. In the 11.5-month period that the ALERT program was conducted, 196 nurses attended the 8-hour program. The participants represent 17% of the nursing staff on the units that could have sent staff to the program. The majority the nurses attending possessed a bachelor's degree in nursing (n=162, [82%]). The job categories with the most attendees were Clinical Nurse I (73[37%]) and Clinical Nurse II, (67[34%]). More nurses attended from PCUs (117[60%]), than the medical-surgical units (79[40%]).

Table 2

Degree, Job Category, and Area of Practice of ALERT Participants

Characteristic	Count (%)
Degree	
ADN	12 (6)
BSN	162 (82)
MSN	22 (11)
Job Category	
CN I	73 (37)
CN II	67 (34)
CN III	39 (20)
CN IV	17 (9)
Area of Practice	
Progressive Care Units	117 (60)
Medical Surgical Units	79 (40)
Total Number of Participants	196

Note. ADN = Associate Degree Nurse; BSN = Bachelor of Science in Nursing; MSN = Master of Science in Nursing; CN = Clinical Nurse

Information on the education degrees and job categories of ALERT trained nurses by unit is illustrated in Table 3. The number of nurses attending the ALERT program was divided by the total number of nurses employed in each unit to product the percentage trained. Units that begin with the letter A represent medical-surgical units and units that begin with the letter B represent progressive care units (PCU). There was a total of 11 medical-surgical units and 5 PCUs in the

sample. The number of nurses trained in the PCUs ranged from 14-41 and 0-16 nurses in the medical-surgical units. There were 4 medical-surgical units, (A1, A9, A10, A11) in the sample that had 1 or less nurses trained in the ALERT program. The units that did not have any participants in the ALERT program were kept in the analysis because the effectiveness of the trained ALERT nurses is measured as a proportion. Keeping the proportions of zero helped to inform the estimates used in the analysis.

Table 3

The Percentages of Educational Degrees and Job Categories of ALERT Participants in Each Unit

	Degrees			Job Category				RNs Trained, Unit RN Total, (%)
Unit	ADN	BSN	MSN	CNI	CNII	CNIII	CNIV	
A1								
Numbers	0	0	0	0	0	0	0	0, 43, (0)
Percentages	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
A2								
Numbers	1	7	1	6	0	2	1	9, 69, (13.0)
Percentages	0.01	0.10	0.01	0.09	0.00	0.03	0.01	
A3								
Numbers	0	4	1	1	1	2	1	5, 60, (8.3)
Percentages	0.00	0.07	0.02	0.02	0.02	0.03	0.02	
A4								
Numbers	0	2	0	1	0	1	0	2, 65, (3.1)
Percentages	0.00	0.03	0.00	0.02	0.00	0.02	0.00	

	Degrees			Job Category				RNs Trained, Unit RN Total, (%)
Unit	ADN	BSN	MSN	CNI	CNII	CNIII	CNIV	
A5								
Numbers	0	8	1	5	3	0	1	9, 104, (8.7)
Percentages	0.00	0.08	0.01	0.05	0.03	0.00	0.01	
A6								
Numbers	0	11	2	3	2	5	3	12, 110, (11.0)
Percentages	0.00	0.10	0.02	0.03	0.02	0.05	0.03	
A7								
Numbers	1	6	0	0	6	0	1	7, 94, (7.4)
Percentages	0.01	0.06	0.00	0.00	0.06	0.00	0.01	
A8								
Numbers	2	12	2	7	3	5	1	16, 43, (37.2)
Percentages	0.05	0.28	0.05	0.16	0.07	0.12	0.02	
A9								
Numbers	0	0	0	0	0	0	0	0, 40, (0)
Percentages	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
A10								
Numbers	0	1	0	1	0	0	0	1, 40, (2.5)
Percentages	0.00	0.03	0.00	0.03	0.00	0.00	0.00	
A11								
Numbers	0	1	0	0	1	0	0	1, 41, (2.4)
Percentages	0.00	0.02	0.00	0.00	0.02	0.00	0.00	
B1								

Numbers	0	13	1	11	2	1	0	14, 57, (24.6)
Percentages	0.00	0.23	0.02	0.19	0.04	0.02	0.00	
B2								
Numbers	1	18	2	7	10	1	3	21, 62, (33.9)
Percentages	0.02	0.29	0.03	0.11	0.16	0.02	0.05	
B3								
Numbers	1	11	2	5	4	2	3	14, 62, (22.6)
Percentages	0.02	0.17	0.03	0.08	0.06	0.03	0.05	
B4								
Numbers	1	23	3	12	12	3	0	27, 128, (21.1)
Percentages	0.01	0.18	0.02	0.09	0.09	0.02	0.00	
B5								
Numbers	3	31	7	12	21	6	2	41, 113, (36.3)
Percentages	0.03	0.27	0.06	0.11	0.19	0.05	0.02	

Note. A1-11 = medical surgical units; B1-5 = progressive care units.

Research Questions 1:

Are there more RRT calls during the ALERT training period than in the period before the education was implemented?

A comparison of the number and rates of calls between the pre and post ALERT period was done to address research question 1 and 2. These analyses did not consider the variation in the number of nurses employed, number of nurses ALERT trained, or the number of beds across the units. The results from the Fisher's exact test suggest there is a significant increase in the percentages of RRT calls between the pre ALERT, 74.5% (n=924) and post ALERT period,

78.8% (n=2064), $p = 0.007$. The difference in the percentages of the RRT calls between the pre and post ALERT periods is 4.3% (78.8-74.5). This suggests that for every 100 RRT calls that occurred in the post ALERT period, on average, there were 4.3 more that were RRTs rather than code blues, compared to the pre ALERT period. The number needed to treat or the reciprocal of 4.3 (1/0.043) is 23.3. This indicates that 23 calls need to occur before there is one additional RRT then would have occurred in the pre ALERT period. The ratio of post ALERT and pre ALERT percentages of RRT calls is 1.06 (0.788/0.745). This result suggests the rate of RRT calls in the post-ALERT period is 1.06 times that which occurred in the pre ALERT period.

Research Question 2:

Are there less code blue calls during the ALERT training period than in the period before the education was implemented?

A comparison of the number and percentages of code blue calls between the pre and post ALERT periods was done next. The results from the Fisher's exact test suggest there is a significant decrease in the percentages of code blue calls between the pre ALERT 25.5% (n=316) and post ALERT periods, 21.5% (n=556), $p = 0.007$. The number of code blue calls increased between the two periods, however the Fisher's exact test considers the differences in proportions, so the percentages indicate a significant decrease in code blue calls. The difference in the percentages of the code blue calls between the periods is -4% (21.5-25.5). This suggests that for every 100 code blue calls that occurred in the post ALERT period, on average, there were 4.0 less that were code blues rather than RRTs, compared to the pre ALERT period. The number needed to treat or the reciprocal of 4.0 (1/ - 0.04) is 25. This indicates that 25 calls need to occur before there is one additional code blue then would have occurred in the pre ALERT

period. The ratio of post ALERT and pre ALERT percentages of code blue calls, 0.215/.255 = 0.84. This result suggests the rate of code blue calls in the post-ALERT period is 0.84 times that which occurred in the pre ALERT period.

Modeling

In order to address research questions three and four, the analysis proceeded using hierarchical negative binomial regressions. The independent variables were percentage of trained nurses and date (in months). The dependent variables were either rate of RRT calls per bed per month or rate of code blue calls per bed per month. The incidence rate ratio (IRR) is the output of this regression model. The IRR describes how the percentage of the dependent variable (in this case, counts of calls), changes for a category of the independent variable. A value of greater than 1.0 indicates an increasing percentage and a value of less than 1.0, a decreasing percentage. This value is then interpreted with the *p* value to determine if the trend is significant. The unit is considered a random effect in the model because the units in the study are a sample of the larger population of units in the hospital. The differences in unit characteristics were therefore controlled. For example, some units may receive more acute patients than others, and without the random effect in place, this factor could play a role in the interpretation of the results. Total beds per unit was used as an offset in the model, to account for the different sizes of the units studied in the sample. For example, larger units may be more likely to have more activations due to size alone, while smaller units would likely have fewer activations.

Preliminary analyses of the model involved determining if a relationship between the two independent variables, percentage of nurses trained and date (in months), existed. The correlation between the two variables was calculated to be 0.65, which indicated a positive relationship

(Polit & Beck, 2017). In order to further determine the degree of correlation, the variance inflation factor (VIF) was calculated to be 2.3, which indicates a moderate degree, with a value of 5 or more indicating a high degree of correlation (Carney & Surles, 2002). The VIF is a measure of collinearity, which can occur when variables in a model are related. This value can result in an unwanted variance in the regression coefficient (Wheeler, 2010). The correlation and VIF value were within acceptable limits and the analysis proceeded.

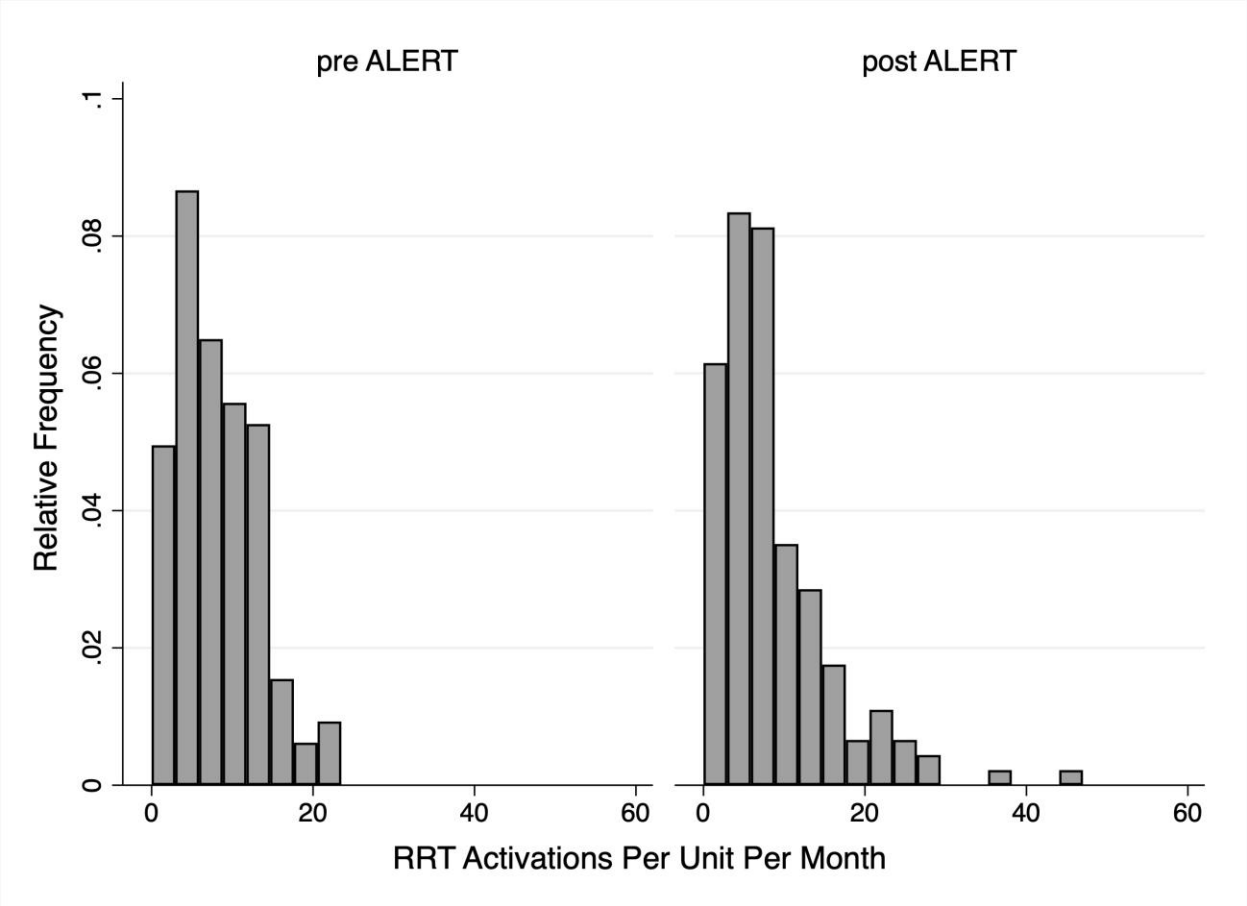
A systematic approach was undertaken to illustrate the progression of arriving at, and supporting the relationships discovered in, the hierarchical negative binomial regressions specifically addressing the third and fourth research questions. To start, the model was first applied to all calls (RRT and code blue) in the post ALERT period, predicted by months and offset by total unit beds. There was a trend that all calls per bed per month were decreasing, although not significantly (IRR 0.993, [CI 95%: 0.981, 1.006], $p = 0.305$). Then the independent variables of date (in months) and percentage of trained nurses were introduced. This analysis showed a significant increase in the number of all calls per bed per month as the rate of trained nurses increased (IRR 1.014, [CI 95% 1.001, 1.027], $p = 0.039$). The model also demonstrated that the rate of all calls per bed per month significantly decreased as time progressed in the post ALERT period (IRR 0.980, [CI 95% 0.963, 0.998], $p = 0.029$).

Below are histograms pertaining to the relative frequency of RRT and code blue calls pre ALERT and post ALERT, per unit, per month. In order to account for more calls occurring in the post ALERT period than in the pre ALERT period, both histograms are displayed in relative frequency. In Figure 1, most units have less than 3 code blue calls a month, in both time periods. In Figure 2, both time periods suggest that most units at each month have very few RRT calls.

There also appears to be a higher density of the relative frequency of RRT calls in the post ALERT compared to the pre ALERT period.

Figure 1

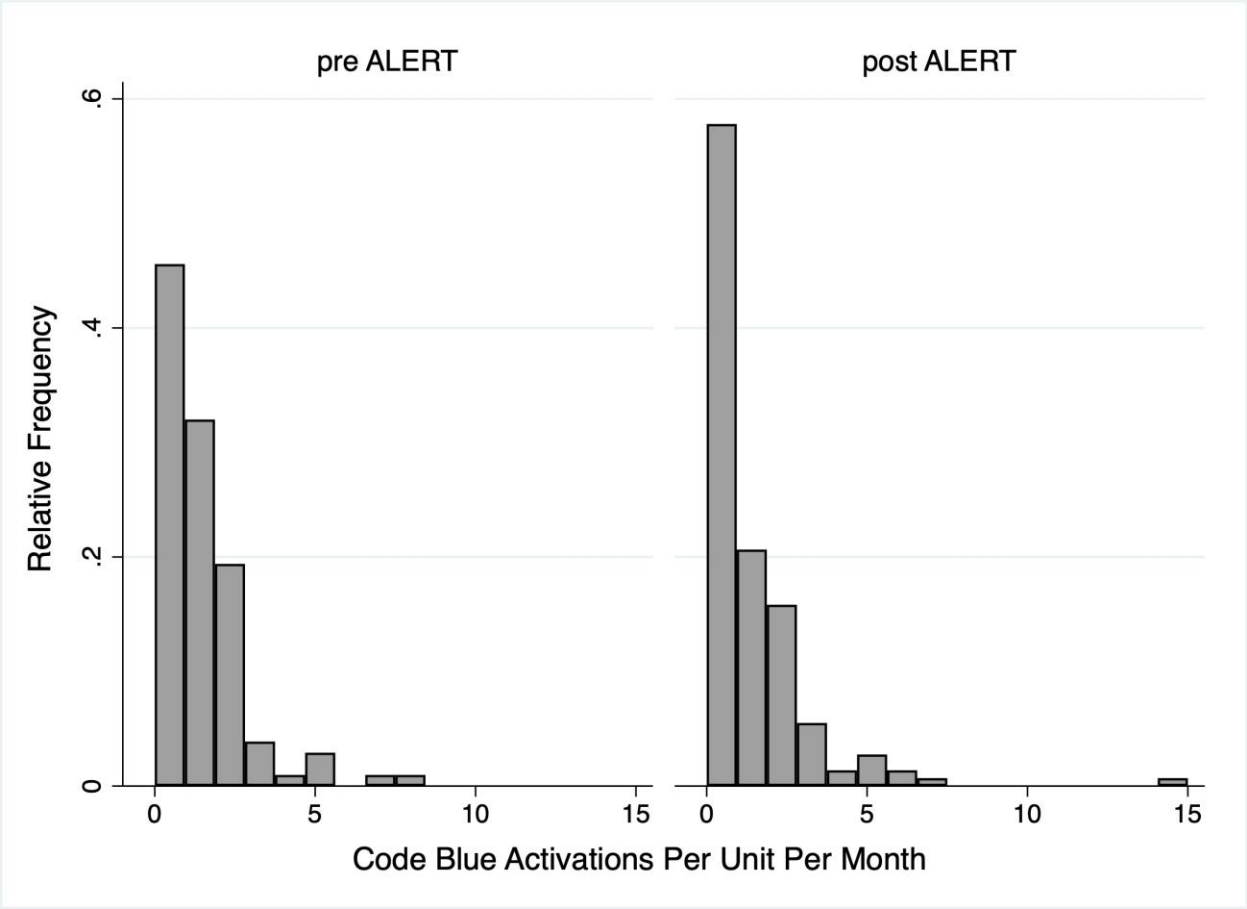
Relative Frequency of RRT Calls per Unit per Month



Note. Values are based on 16 units between December 2015 and April 2017.

Figure 2

Relative Frequency of Code Blue Calls per Unit per Month



Note. Values are based on 16 units between December 2015 and April 2017.

Research Question 3:

As more nurses are trained in the ALERT course, does the number of RRT calls increase?

To determine how date (in months) was related to the rate of RRT calls per bed per month, a hierarchical negative binomial regression was done with the two variables. A decreasing trend of RRT rates was revealed, IRR 0.997, [CI 95%: 0.984, 1.010], $p = 0.614$. Then the percentage of nurses trained was introduced to predict RRT call rates (Table 4). As the percentage of trained nurses increased, the rate of RRT calls significantly increased (IRR 1.015 CI [1.002, 1.029], $p = 0.027$). This suggests that controlling for time helps to explain the association of training and the rate of RRT calls. Table 4 also illustrates a downward trend in the number of RRT calls when looking at the variable of date in months, independent of percentage of trained nurses, that was not significant (IRR 0.982 CI [0.965, 1.00], $p = 0.056$).

The relationship of predicted RRT calls per unit beds and percentage of trained nurses is listed in Table 5. These values were determined by using the value at 0% nurses trained (.2073892) and multiplying it by the coefficient 1.015 and then taking the power of the result in increments of 5. Figure 3 illustrates an increase of approximately 7% (0.885 to 0.95) in the relative proportion of RRT calls for every 5% increase in trained nurses.

Table 4

Hierarchical Negative Binomial Regression Predicting Incidence Rate Ratios (IRR) of RRT Calls

Variable	IRR	95% CI	*p*
Percentage Trained	1.015	[1.002, 1.029]	0.027
Date (in months)	0.982	[0.965, 1.000]	0.056

Note. *Predicted by percentage of trained nurses in each unit, offset by total beds; CI = confidence interval.

Table 5

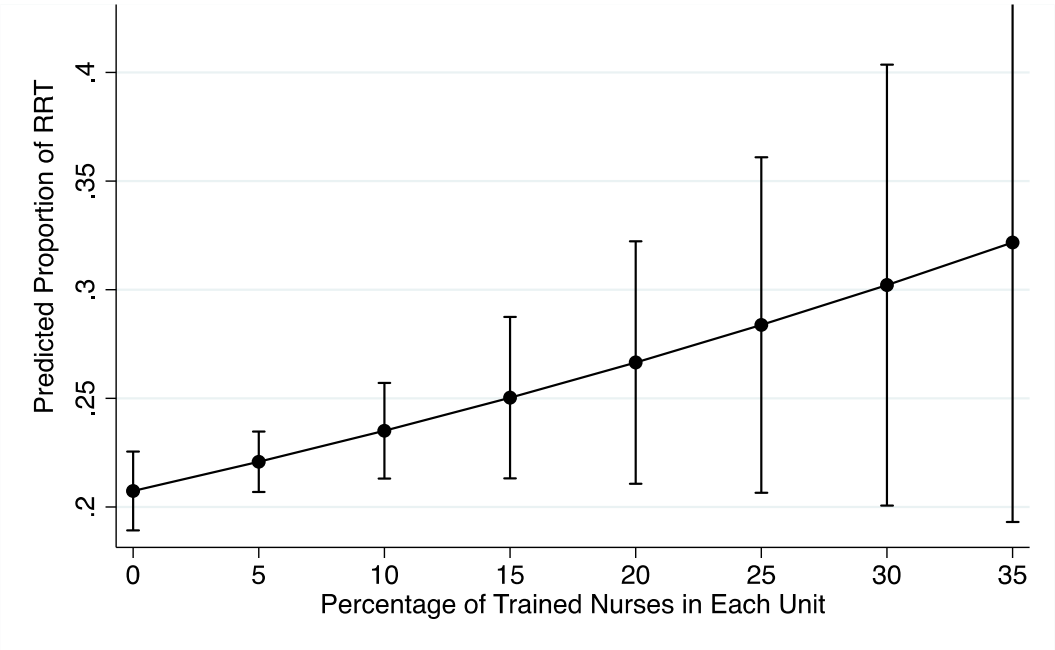
Predicted Percentages of RRT Calls by Percentages of Trained Nurses and Date

% of Trained Nurses	Predicted RRT Calls/Unit bed	95% CI
0	.2073892	.1892587 - .2255197
5	.2208171	.2068912 – .2347431
10	.2351145	.2130774 - .2571517
15	.2503376	.2131505 – .2875247
20	.2665464	.210749 – .3223438
25	.2838047	.2065759 - .3610334
30	.3021804	.2007133 - .4036474
35	.3217458	.1930777 - .4504139

Note. CI = confidence interval.

Figure 3

Percentage of RRT Calls by Percentage of Trained Nurses and Date



Research Question 4:

As more nurses are trained in the ALERT course, does the amount of code blue calls decrease?

An initial hierarchical negative binomial regression was done using the date in months as the independent variable and the rate of code blue calls per bed per month, as the dependent variable. This analysis was done to illustrate how time effects code blue call rate. There was decreasing trend in the rate of code blue calls, IRR 0.970, [CI 95%: 0.941, 1.001], $p = 0.055$.

In the next step of the analysis, a hierarchical negative binomial regression was done to assess the relationship of percentage of trained nurses to code blue call rate. Table 6 shows as the percentage of trained nurses increased, the rate of code blue calls did not significantly decrease (IRR 1.02 CI [0.99, 1.05], $p = 0.244$). Conversely, there was an upward trend in the number of code blue calls. Table 6 also shows the number of code blue calls significantly decreasing when considering date in months as an independent variable (IRR 0.95 CI [0.91, 0.99], $p = 0.030$). When the percentage of nurses trained is introduced to predict code blue activation rates, the decrease of the rate over time became statistically significant. This suggests that controlling for the percentage of trained nurses helps to show the association of date in months and the rate of code blue activations.

Table 7 shows how the predicted code blue calls per bed per month changed as the percentage of trained nurses increased. The predicted code blue calls are determined by using the value at 0% nurses trained (.0263734) and multiplying it by the coefficient 1.018 and then taking the power of the result in increments of five. Figure 4 is an illustration of these values. This figure indicates that the relative proportion of code blue calls will increase approximately 1% (0.027 to 0.03125), with every 5% increase in trained nurses.

Table 6

*Hierarchical Negative Binomial Regression Predicting Incidence Rate Ratios (IRR) of Code Blue Calls**

Variable	IRR	95% CI	*p*
Percentage Trained	1.018	[0.988, 1.049]	0.244
Date (in months)	0.952	[0.911, 0.995]	0.030

Note. *Predicted by percentage of trained nurses in each unit, offset by total beds; IRR = incidence rate ratio; CI = confidence interval.

Table 7

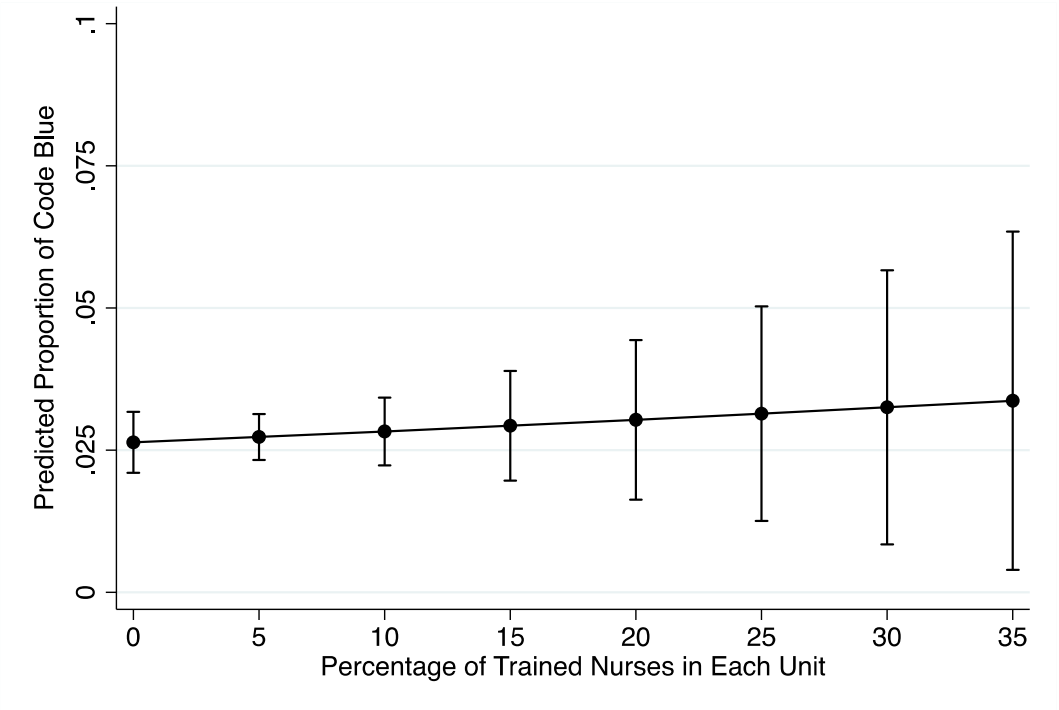
Predicted Percentages of Code Blue Calls by Percentage of Trained Nurses and Date

% of Trained Nurses	Predicted code blue calls/unit bed	95% CI
0	.0263734	.210316 - .0317151
5	.0273119	.0232613 - .0313624
10	.0282837	.0223204 - .0342471
15	.0292902	.0196466 - .0389338
20	.0303325	.016306 - .044359
25	.0314119	.0125449 - .0502789
30	.0325297	.0084232 - .0566361
35	.0336872	.0039533 - .0634212

Note. CI = confidence interval

Figure 4

Percentages of Code Blue Calls by Percentage of Trained Nurses and Date



Research Question 5:

Will there be an increase in specific reasons for RRT and code blue calls that match the content covered in the simulated content of the ALERT course?

Table 8 is a descriptive table of the average counts of each reason for calls per unit, per month for both RRT and code blue calls. To reduce the chance of a Type I error due to having multiple comparisons in the RRT and code blue categories, reasons were grouped together by category. Arrhythmia, acute hemorrhage, hypotension and hypertension were all labeled "cardiovascular" for both RRT and code blue. Another grouping labeled "mental status change" was created that included code brain, syncope, and acute mental status in the RRT category. Unable to contact PMD (primary medical doctor), call per PMD, and other, were grouped as "communication" in the RRT category. In the code blue category, able to contact and other were

labelled as “communication” as well. This reduced the number of reasons for calling an RRT from 17 to 10 and code blue from 12 to 4.

To analyze whether a difference existed in the rate of each call type, for each time period, a negative binomial regression was performed (Table 9). This analysis was offset by total unit beds. The number of RRT calls significantly increased for cardiovascular reasons (IRR 1.08 [1.05, 1.11], $p = 0.001$) and respiratory distress/failure (IRR 1.09 [1.06, 1.12], $p < 0.001$). There was a significant increase in the rate code blue calls for cardiovascular and respiratory distress/failure reasons as well (IRR 1.07 [1.02, 1.12], p = 0.004), (IRR 1.09 [1.05, 1.14], $p < 0.001$). The scenarios that are part of the ALERT curriculum are Pneumonia and Sepsis, Hypovolemia and GI Bleed, Hypoglycemia, Pulmonary Embolism, Seizures, Acute Coronary Syndrome, Reduced Level of Consciousness-Opiates and Anaphylaxis. The ALERT scenario that relates to the cardiovascular reason group is Acute Coronary Syndrome. The ALERT scenarios that relate to the respiratory distress/failure reason is Pulmonary Embolism and Pneumonia and Sepsis.

Table 8

Comparison of Call Reason and Call Type by Pre and Post Alert periods

	RRT		Code Blue	
Reason	pre ALERT	post ALERT	pre ALERT	post ALERT
Cardiovascular				
Numbers*	0.25 (1.04)	3.06 (3.25)	0.01 (0.10)	0.14 (0.46)
Percentages	0.26	0.41	0.33	0.45
Communication				
Numbers	0.21 (0.59)	0.62 (1.20)	0.01 (0.10)	0.03 (0.21)
Percentages	0.21	0.08	0.33	0.10
Respiratory Distress/Failure				
Numbers	0.25 (0.73)	2.16 (2.40)	0.00 (0.00)	0.12 (0.42)
Percentages	0.26	0.29	0.0	0.39
Seizures				
Numbers	0.05 (0.28)	0.30 (0.79)	0.01 (0.10)	0.02 (0.18)
Percentages	0.05	0.04	0.33	0.06
Hypoglycemia				
Numbers	0.00 (0.00)	0.05 (0.24)	---	---
Percentages	0.00	0.01	---	---
Mental Status Change				
Numbers	0.11 (0.46)	1.12 (1.35)	---	---
Percentages	0.11	0.15	---	---
Worry or Concern About Patient				
Numbers	0.03 (0.16)	0.10 (0.35)	---	---
Percentages	0.03	0.01	---	---
Pain Uncontrolled				
Numbers	0.02 (0.13)	0.05 (0.27)	---	---
Percentages	0.02	< 0.01	---	---
Anaphylaxis				
Numbers	0.03 (0.16)	0.03 (0.20)	---	---
Percentages	0.03	<0.01	---	---
Poor Response to Treatment				
Numbers	0.03 (0.16)	0.02 (0.14)	---	---
Percentages	0.03	< 0.01	---	---

Note. * Average number per unit per month; (SD) = standard deviation

Table 9

Comparison of Call Reason and Call Type by Percentage of Trained Nurses

Reason	RRT			Code Blue		
	Percentage Trained		*p*	Percentage Trained		*p*
	IRR	CI 95%		IRR	CI 95%	
Cardiovascular	1.08	[1.05, 1.11]	0.001	1.07	[1.02, 1.12]	0.004
Communication	1.05	[1.01, 1.10]	0.019	1.03	[0.98, 1.09]	0.209
Respiratory Distress/Failure	1.09	[1.06, 1.12]	<0.001	1.09	[1.05, 1.14]	<0.001
Seizures	1.07	[0.99, 1.15]	0.073	1.01	[0.92, 1.11]	0.794
Hypoglycemia	1.04	[0.88, 1.24]	0.615		---	---
Mental status change	1.05	[1.02, 1.09]	0.006		---	---
Concern or Worry about patient	1.07	[1.01, 1.14]	0.032		---	---
Pain Uncontrolled	0.86	[0.62, 1.19]	0.350		---	---
Anaphylaxis	0.95	[0.79, 1.14]	0.550		---	---
Poor response to treatment	0.97	[0.89, 1.06]	0.117		---	---

Note. To account for multiplicity, significance is reduced to p-value 0.005 for RRT and 0.0125 for code; IRR = incidence rate ratio; CI = confidence interval.

In Chapter 4, the results of the study were presented. The descriptive statistics for the nurses trained in the ALERT programs and their units were shown. The RRT and code blue call numbers in the pre ALERT and post ALERT period were displayed to address the first two research questions. There were significantly more RRT calls and less code blue calls in the post

ALERT period then the pre ALERT period. Hierarchical negative binomial regression models were fit with the variables in a sequential manner to provide a thorough approach to answering research questions three and four. The rate of RRT calls per total unit beds significantly increased as the percentage of nurses trained increased over time in the post ALERT period. The rate of code blue calls per total unit beds did not significantly decrease and an increasing trend was observed. The last research question was also addressed with regression modeling and there was a significant increase in both calls for reasons related to cardiovascular and respiratory issues. In the final chapter, the results will be discussed and related to relevant literature. The implications for nursing and health professions will also be addressed.

Chapter 5: Discussion

Introduction and Primary Aim

This study aimed to explore the relationship of an educational program designed to improve nurses' identification of deterioration by looking at the number of RRT and code blue calls before and after an education program. Medical-surgical and progressive care units (PCU) were the focus of the study. Intensive care units (ICU) and the emergency department were not studied because they do not follow the same protocols for activating emergency teams. These data were obtained from monthly records created from an event reporting system at the institution studied. In this final chapter, the significant findings from Chapter 4 will be discussed along with the implications to nursing practice and research.

Significance of the Study

This study is one of the few longitudinal studies that have focused on the relationship between a deterioration recognition education program and emergency team calls. This study adds to the body of literature on prevention of patient deterioration rather than on the consequences of deterioration. The research questions below will guide the discussion in this chapter.

1. Were there more rapid response team (RRT) calls during the ALERT training period than in the period before the education was implemented?
2. Were there less code blue calls during the ALERT training period than in the period before the education was implemented?
3. As more nurses are trained in the ALERT course, did the number of RRT calls increase?

4. As more nurses are trained in the ALERT course, did the number of code blue calls decrease?
5. Was there be an increase in specific reasons for RRT and code blue calls that matched the content covered in the simulated content of the ALERT course?

Discussion of Findings

Nursing Demographic Information

One hundred ninety-six (17%) of the total number of nurses (1131) in the medical-surgical and PCU areas attended the program. This relatively low percentage may have been due to staffing constraints on the units and the lack of staff to cover those attending the program. Another explanation could be the availability of instructors. If some of the instructors were not available, ALERT classes may have experienced limited enrollment in order to maintain the 4:1 student to instructor ratio set in the course guidelines. In this institution studied the instructor staff participated voluntarily, in addition to their unit-based duties and other educational responsibilities.

Two units in the study had zero staff attend the ALERT program. These units remained in the analysis to inform estimates in measuring the effectiveness of the ALERT trained nurses. The author had no knowledge of any systemic influences. One such example could be leadership purposefully not allowing their staff to attend the program. The author believes the training was adequately advertised across the institution studied and all units were given equal opportunity to attend.

The sample in this study consisted of medical-surgical units and PCUs within the medical center. Sixty percent of the nurses who attended the program worked in PCUs, while 40%

worked in medical-surgical units. When the ALERT program was introduced in the summer of 2016, all medical-surgical and PCU units were encouraged to enroll in the program. The leadership of all the units was notified, and the instructors who were ICU, PCU, medical-surgical nurse educators, and clinical nurse specialists, advertised the program. PCU patients tend to have more labile vital signs and sometimes straddle the border between PCU and ICU care. The higher number of PCU nurses in this study could be explained by the perception that the patients for whom nurses care are more likely to deteriorate.

As previously mentioned, patient deterioration in the PCU has been sparsely studied (Krom, 2019). Two studies measured nursing confidence following educational programs (Disher et al., 2014; Harvey, et al., 2014). Another study focused on patient outcomes such as RRT calls and the incidence of failure to rescue events (Young-Xu et al., 2013). Medical-surgical nurses are well represented in other studies that demonstrate an increase in assessment skills and confidence, as discussed in Chapter 1 and 2 (Bliss & Aiken, 20; Duff, et al., 2018; Featherstone, et al, 2004; Furhman et al., 2009; Gordon & Buckley, 2009; Wehbe-Janek et al., 2012). Future studies that focus on specific areas of care, like PCU and medical-surgical units, are encouraged to explore the differences in practice and the training in these areas that may affect the nurses' perception of the education and related patient outcomes.

Bachelor prepared nurses (BSN) represented the largest group of ALERT participants. One explanation for this could be specific to the study setting and related to the institution's Magnet recognition from the American Nurse Credentialing Center (American Nurses Credentialing Center, 2019). One component of the Magnet designation and subsequent re-designations is an institution's effort to increase its percentage of BSNs. Another influential factor is The Future of Nursing Report, which recommends 80% of the nursing workforce acquiring baccalaureate degrees by 2020 (Institute of Medicine, 2011). The institution studied has achieved a fifth consecutive Magnet Designation and implemented strategies to achieve an 80% BSN rate, likely explaining the high BSN representation. Blegen and colleagues (2013)

found failure to rescue hospital events, which often have a component of patient deterioration, decrease ($r = -0.399$) when more nurses have advanced degrees. In a landmark study involving 665 hospitals, failure to rescue events decreased by 4% for every 10% increase in bachelor prepared nurses (Aiken, et al., 2012). Wynn et al. (2009) found that nurses who chose to activate an RRT were five times more likely to have a BSN and four times more likely to have at least three years of experience than those nurses who were asked to initiate a call. The research suggests there may be a component of the educational experience in a baccalaureate program that better prepares nurses to identify a deteriorating patient when they begin to practice professionally. The majority of the nurses in this study may have had a baseline level of skills and knowledge related to deterioration that the ALERT program reinforced and honed. The demographic data collected in the study did not include years of experience; however, this can be estimated using information obtained on the level of professional advancement or level of clinical nurse.

Nurses with Clinical Nurse I and Clinical Nurse II titles represented the two largest groups on the clinical ladder to attend the ALERT course. These groups represent nurses with the least amount of experience, either in years at the institution studied or in years of nursing overall. Education on deterioration may be especially beneficial to some of these nurses as they are novice clinicians, still relatively new to their clinical environments and beginning to develop their practice. Soon after the study period ended, all new graduate nurses were required to attend the ALERT program as part of their residency.

Clinical Nurse III and Clinical Nurse IV nurses are less represented, likely because they are considered experts and resources on their respective units. They may have personally felt, or it may have been the opinion of their leaders, that these nurses' practice already reflected the concepts addressed in the ALERT program. In a recent systematic review investigating nursing experience, authors found that it did not correlate with a reduction in adverse events such as

failure to rescue (Audet, et al., 2018). It still may beneficial for experienced staff to participate in the ALERT program to reinforce concepts they already know. Future studies should ask experienced nurses to attend that believe the content would be beneficial to their practice rather than make attendance mandatory for all levels of experience.

Research Question 1: Were there more RRT calls during the ALERT training period than in the period before the education was implemented?

A simple comparison of the number of RRT calls in the pre-ALERT and post-ALERT periods found that there was a significant increase in RRTs (74.5% [n=924], 78.8% [n=2064], p=0.007). Since the duration of each period was unequal, the Fisher's exact test was chosen to control for this heterogeneity. The purpose of these analyses addressing research questions 1 and 2 was to provide a baseline for the number of RRT and code blue calls and to provide background for research questions 3 and 4. It is important to note that these findings did not control for factors or events that could have influenced the number of calls in either the pre or post ALERT period. As a result, potential, influential elements will be discussed below.

Two institutional factors that could have had a bearing on the results are changes in the process of activating RRTs (afferent limb) or the functioning of the RRT (efferent limb). Regarding the afferent limb, the institution studied maintained the same protocol that included signs and symptoms that would trigger a nurse to activate an RRT. The membership of the team was unchanged, and the geographic span of its response was not altered. To this researcher's knowledge, during the post-ALERT period, there was no change in the activation or functioning of RRTs at the institution studied. One change that occurred that could have affected the afferent

limb was the implementation of the ALERT course. The discussion of research question 3 will address the influence of the ALERT course.

Research Question 2: Were there less code blue calls during the ALERT training period than in the period before the education was implemented?

A similar comparison was done focusing on code blues, the results indicated that less were called in the post ALERT period (25.5% [n=316], 21.5% [n=556], p =0.007). The researcher was also unaware of changes in the activation process, or the functioning of the code blue team during the pre and post ALERT periods.

Three influential factors that may be related to the decrease in code calls to consider are the changing characteristics of admitted patients, admission trends, and nurses' attrition during the study period. There may also be a relationship between these factors and the increase in RRT calls. Patient characteristics have been shown to impact RRT and code blue outcomes (Fernando, Reardon, McIssac, et al., 2018a; Mallikethi-Reddy, et al., 2017; Piscator, et al., 2016). Two-thirds of clinical experts agreed that patient characteristics are a significant factor related to deterioration (Allen, et al., 2018). Patient characteristics were not captured, and therefore not controlled, in this study.

One admission trend to consider is the yearly influenza season. The pre-ALERT and post-ALERT periods span across multiple influenza seasons. If the severity of the flu season varies from year to year, the acuity of the patients admitted would be inconsistent. Acuity changes could have a bearing on the number of RRT and code blue calls. Future studies should consider seasonal changes in patient acuity by measuring illness severity using scoring systems such as the APACHE II (Knaus et al., 1985) on patients that require emergency team activation. Another secular factor is the attrition of ALERT trained nurses. Records pertaining to the transfer of ALERT prepared nurses to other areas of the hospital or outside of the hospital were not available for this study. One change that occurred that could have been related to the increase

in code blue calls was the implementation of the ALERT course. The discussion of research question 4 will address the influence of the ALERT course.

Implications for Nursing Practice

The nursing practice implications for research question 1 and 2 will be discussed in this section. The increase in RRTs and the decrease in code blues between the pre and post ALERT periods could have been due to several factors discussed above. Sharing simple analyses like these with nursing staff may benefit their practice, just as National Patient Safety Goal metrics, such as handwashing compliance and central line infection rates, are shared (The Joint Commission, 2019). Some hospitals may have the means to obtain data and to present it to nurses, in a digestible manner, to improve the connection to their practice on a broader level. Nurses would know how their unit or division was performing and how their call rates compared to other areas of the institution. This knowledge and awareness could spur their interest in improving or maintaining favorable call rates. Many institutions are currently tracking their RRT and code blue calls and have inter-professional committees that analyze and discuss the data. In addition to local tracking, national programs have been used by some institutions. The Get With the Guidelines-Resuscitation (GWTG-R) program offers benchmarking and data sharing to participating hospitals (American Heart Association, 2019). Using these repositories to measure the effectiveness of programs designed to educate staff on deterioration recognition should be considered.

Implications for Nursing Research

The implications for nursing research for research questions 1 and 2 will be discussed in this section. Determining the number of RRT and code blue calls in an institution provides a baseline for exploring process of patient deterioration, emergency team functioning and nursing assessment. A more comprehensive study that involves patient characteristics, temporal admission trends, and a close record of nurse employment is recommended. If these variables

were considered, the degree of the impact of the intervention (the ALERT program) could be better exposed. In lieu of such a study, this secondary analysis considered the variables of time and the ALERT program to determine the potential impact on RRT and code blue rates. Further research is also recommended on nurses' awareness of local RRT and code blue call counts, and how that knowledge may influence their practice.

Research Question 3: As more nurses were trained in the ALERT course, did the number of RRT calls increase?

As the proportion of nurses that were trained in a unit increased over time, the percentage of RRT calls significantly increased (IRR 1.015, [CI 95%: 1.002, 1.029], $p = 0.027$). This finding indicates that the ALERT program led to nurses making independent assessments of when to initiate an RRT. ALERT trained nurses are recognizing deterioration in early stages and are requesting appropriate resources to manage the patient. A similar study that examined the effect of the implementation of improved documentation, an electronic early warning system, and an education program, had comparable results (Mitchell, et al., 2010). The authors found a significant increase in the frequency of RRT activations (25/1157 [2.2%] vs. 38/985 [3.8%], Relative Risk Ratio 1.79 [1.09–2.94], $p = 0.03$) in a 4-month post-intervention period.

Implications for Nursing Practice

Two implications for nursing practice can be gleaned from this finding. First, nurses were able to apply the concepts learned in the program to assess patients more effectively. Nurses are intimately involved in patient care, performing assessments and interventions, administering medication and treatments, and collaborating with physicians and interprofessional team members. The complexity of the nurses' role may be a factor that causes them to miss indicators

of declining health. It appears that the ALERT training increases the speed and accuracy of the nursing assessment to identify deterioration proactively.

Second, nurses called for support from the RRT more often, after they have received the training. The ALERT program may have reinforced the transition in the nurse thinking this is something that "I can handle" to "I need a crisis nurse, physician, or nurse practitioner to assist me." This may involve the need for interventions such as obtaining an arterial blood gas, starting a vasoactive medication to support blood pressure, or accessing a central vein for fluid boluses. These interventions can be more easily facilitated by an RRT. This awareness of when to call for assistance may have stopped some patients from deteriorating to the point of needing a code blue team.

The ALERT program may provide bedside nurses with some of the assessment and prioritization skills of staff, whose role it is to respond to emergency situations. The nurses at the bedside have adopted some of the characteristics of the crisis nurse. A crisis nurse, often with critical care or emergency nursing background, participates in RRTs, code blues, and high-risk patient transports. However, they can also provide advice by phone or in person to address a nurse's concern about a patient before a team is activated. A recent study has shown that nurse-led consult services have been effective in reducing cardiac arrests (MD = 0.9, 95% CI: 0.3-1.5, p = 0.009), length of stay (MD = 294.4, 95% CI: 260.9-328.7, p <_ 0.001) and ICU admissions (MD = 95% CI: 0.7-5.2), (Pirret, et al., 2015). In the institution where this study was conducted, the crisis nurses encourage staff nurses to consult their team if they perceive the patient to be deteriorating, even if the patient does not meet the criteria for an RRT call. If staff nurses are acting as a consult crisis nurse due to the ALERT training, they would decide independently if an RRT was warranted or not. The consult nurse would have more opportunities to assist with other

patients around the hospital where the staff nurses are less comfortable or have less experience with making that decision if the ALERT nurses were internally triaging their own patients.

Implications for Nursing Research

Other research could explore nurses' awareness of when to call for assistance in order to stop patient deterioration. It would be interesting to study how nursing confidence, experience, training, and intuition relates to the development of this awareness.

Research Question 4: As more nurses were trained in the ALERT program, did the number of code blue calls decrease?

The number of code blue calls did not increase as more nurses were trained in the ALERT program. The code blue calls increased, although not significantly (IRR 1.02, CI [0.99, 1.05], $p = 0.244$). In this study, the emphasis on calling for assistance was memorable to ALERT participants, thus resulting in more code blue calls made in the post ALERT period. The nurses had greater confidence in requesting resources and did so more readily due to their training. Most of the research pertaining to confidence and the impact of education programs have measured overall confidence, not confidence in specifically activating a code blue team (Crowe, Ewart, & Derman, 2018; Herbers & Heaser, 2016). Overall, confidence often refers to a nurse's assessment skills and knowledge. In the recent literature focusing on barriers to activating an RRT, confidence is a common theme. Nurses have expressed concern with having to defend their decision to call a team (Braaten, 2015).

Another explanation for this finding is that there were merely more code blues in the institution during the study period compared to previous years. The volume of code blue calls could have overshadowed the impact of the education program. Unfortunately, data from past years were not available to make a comparison. Another explanation is that code blues were increasing due to the characteristics of the patients being admitted in the post ALERT period.

There could have been a higher volume of sicker patients, resulting in more code blue activations.

Speed of deterioration, presence of the signs and symptoms of deterioration assessed, and the setting where the deterioration took place, may also lend an explanation. Chan et al., (2016) found that three in five patients (60%) that experience cardiac arrest in the hospital do not express vital signs that would activate an RRT, within one hour of cardiac arrest. This finding suggests that if the nursing staff were looking at vital signs as indicators of deterioration, patient decline could have been missed. The likelihood of capturing this event is obviously increased if the patient is on continuous monitoring in a telemetry or PCU unit. In the absence of constant monitoring, vital signs are taken every four to eight hours, according to physician's orders. The practice at the study institution was conditional monitoring based on the patient's diagnosis and their medical assessment, rather than on surveillance monitoring of all patients. A recent study found that barriers to institution-wide surveillance monitoring include the need for staff to interpret the data collected in real-time and the financial considerations of implementing such a system (Vincent, et al., 2018). The presence of continuous cardiac monitoring was mixed within the medical-surgical units, as many of these units had the capability to monitor some, but not all, of their patients. While in the PCU areas, a majority of the patients had full vital sign monitoring, and the rest had continuous cardiac monitoring only. If the increase in code blue calls in the presence of more ALERT trained nurses were due to missed abnormal vital signs, it would be beneficial to return to the original dataset and compare call counts with a more detailed look at the level of monitoring.

When a nurse presses the code blue button above a patient's bed, it is for one of two reasons: either the patient does not have a pulse, or the nurse believes the patient will be pulseless very soon. The code blue record that was used in this analysis did not capture if the cardiac arrest itself was witnessed or unwitnessed. If this information were captured, it could have been helpful in analyzing the recognizable changes in the patient's condition identified by

nursing staff. The symptomatology could have been very subtle over a long period, or possibly, the patient had symptoms that were not emphasized in the ALERT course. The assessment skills learned in the program may not have assisted in detecting deterioration if it progressed in this manner.

Implications for Nursing Practice

In this study, the ALERT trained nurses may have anticipated the need for a code blue team when the symptoms of deterioration were either missed, too subtle, or too rapid to recognize. Both RRT and code blue calls increased, so more nurses were calling for assistance when needed. Although early recognition of deterioration is the preferred outcome and likely best for the patient, a delay in care could occur if no team was called at all. This finding supports the notion that clinicians, especially nurses, should be encouraged to call a code blue team to the bedside without concern or fear that it may be the wrong decision. It is vital to have a unit culture that encourages this practice, as well as unit and institutional leadership that are supportive. The decision to call should be seen as a learning opportunity rather than as a punitive experience if the patient turns out not to need the interventions offered by the team.

Implications for Nursing Research

A study that takes patient acuity and trends of code blue call rates into account should also be conducted. Using this information to describe the study institution where the ALERT program is implemented would provide more insight into its effectiveness.

The ALERT program uses a combination of physical assessment and vital signs to educate the participants on deterioration recognition. Research has shown that vital sign changes are helpful in less than half of deterioration cases (Chan, et al., 2016). With respect to this finding, it would be interesting to explore the role of nursing assessment, aside from vital signs, in exposing risk for cardiac arrest.

Lastly, outcomes for patients experiencing an in-hospital cardiac arrest include expiration, transfer to a higher level of care, and remaining at the current level of care.

Comparing patient disposition and the number of code blue calls with the implementation of a deterioration education program would help to determine the effectiveness of the education. Survival rates post-cardiac arrest at given time frames could also be analyzed to see if the program had affected patient mortality.

Research Question 5: Was there an increase in specific reasons for RRT and code blue calls that match the content covered in the simulated content of the ALERT course?

The analysis of question five found that there were significantly more RRT and code blue calls for the cardiac (IRR 1.08 [1.05,1.11], $p = 0.001$) and respiratory reasons (IRR 1.09 [1.06, 1.12], $p < 0.001$) in the post ALERT period. The simulation content in the ALERT course that related to the cardiac causes was Hypovolemia, GI bleed, and Acute Coronary Syndrome. The concepts in the Pneumonia and Sepsis, Pulmonary Embolism, and Reduced Level of Consciousness-Opiates scenarios related to the respiratory distress/failure reasons for calling emergency teams. This finding indicates the ALERT training was effective in increasing nurses' ability to identify deterioration for cardiac and respiratory reasons.

Implications for Nursing Practice

The ALERT program uses the ABCDE mnemonic for teaching deterioration assessment. Airway, breathing, and circulation represent the first three letters. Although participants of the program are to address each letter with every patient they assess, the order of the assessments may be related to their retention of the program content. If a patient is deteriorating due to an airway, breathing or circulation issue, swift assessment and intervention are necessary to prevent respiratory and or cardiovascular failure. This point is emphasized and repeated using multiple educational strategies during the program. As discussed in Chapter 2, some of the top reasons for cardiac arrest are due to alterations in patients' cardiovascular systems (Hillman, et al., 2002;

Kause, et al., 2004) and respiratory systems (Schein, et al., 1990). In the RRT literature, cardiac and respiratory precursors were also identified as frequent reasons for team activation (Herod, et al., 2014; White, et al., 2016). If a patient deteriorates for respiratory or cardiovascular reasons more frequently than due to abnormalities in other body systems, nurses should concentrate on focused assessments that prioritize body systems such as those included in the ALERT program.

Implications for Nursing Research

It would be helpful to examine which educational techniques used in the ALERT program resulted in the greatest retention of information. High fidelity simulation using mannequins is an expensive tool to provide education and, therefore, difficult to adopt in many settings (Bowling & Underwood, 2016; Pringle, et al., 2014). The ALERT program utilizes an informal version of a standardized patient or human role player in the simulated scenarios, rather than a high-fidelity simulation (Lewis, et al., 2017). This method does not require sophisticated equipment or specialized technicians; instead, it requires participants to mimic simple patient symptomatology. This technique has shown to be beneficial in nursing school education. Nursing students performed better using high fidelity mannequins but were more satisfied with the learning experience using standardized patients (Lucktar-Flude, et al., 2012). The use of standardized patients has also been used when teaching hygiene care skills to nursing students (Basak, et al., 2019). The participants had higher performance, self-confidence, and satisfaction scores with the standardized patient than with a low-fidelity mannequin. Participant satisfaction in the experience could have resulted in an emotional connection to the material. This connection could have a role in increasing retention of the content, so it may be applied in clinical practice in the future.

Evaluation of Theoretical Framework

Ida Jean Orlando's Nursing Process Theory was used to explain the nursing thought process as they are exposed to a deteriorating patient using the structure of the ALERT program. The last step of her theory is the resolution of the situation, and the last step of the ALERT assessment involves repeated assessment until the patient is stabilized and their needs are met (May, 2013). The ALERT program considers the cyclic nature of the nurse's assessment and interventions to resolve the factors putting the patient at risk. The resolution of the problem is contingent on the relationship between the nurse and the patient (Potter, 2015). When a patient is deteriorating, the interaction between the nurse and the patient can still be considered a relationship because connection and behavior are shared and observed. Especially if the patient is unable to speak, the bond relies heavily upon the patient's expression of deterioration and the nurse's assessment of those symptoms.

Rosenthal (1996) has discussed Orlando's theory with perioperative nursing to improve assessments and interventions within small time frames. There are similarities in the intentionality of the perioperative nurses' assessments with the assessment of a deteriorating patient, where time is also an important factor. Potter has described Orlando's theory as "straightforward in its presentation while being multifaceted in its applications" (2015, p. 305). Similarities of this statement to components of the ALERT program, the ABCDE assessment, and communication techniques can be drawn. The approach is rather uncomplicated yet can be applied to any clinical situation in which a patient's condition changes. The communication techniques have a more global application to any clinical case where information is exchanged.

The ABCDE approach to deterioration management has been recently applied in managing septic patients, trauma patients with spinal cord injuries, and postoperative patients (Vaughan & Parry, 2016; Kreinest, et al., 2016; Taherkhani, 2018). The purpose of this method is to assist healthcare providers in establishing the severity of a patient's illness and in prioritizing assessments and interventions (Thim, et al., 2010). The assessment tool is a standard component of the Advanced Trauma Life Support (ATLS) for physicians and the Trauma Nursing Core Course for nursing staff, both of which are taught on a global level (American College of Surgeons, 2019; Emergency Nurses Association, 2019).

Strengths and Limitations of the Study

One of this study's most significant strengths was the use of a large sample of patient care units that encompassed 660 licensed beds staffed by 1028 nurses. Also, two levels of care were involved in the sample. Another strength was the intervention. Each time the ALERT program was administered, it was done in the same way by the same group of 4-6 instructors. This decreased the variability in the way the program was taught, and the experience had by the participants.

One of the limitations of the study was the intermittent enrollment of participants in the post-ALERT period; this resulted in a challenging analysis of a secondary dataset. Nursing staff was exposed to the ALERT program approximately every month for almost one year, rather than training all of the nurses at once. As a result, outcomes were measured as the intervention was continuously administered. This was a limitation of using a retrospective dataset and not being able to control for the implementation of the intervention. Training all of the 1028 nurses in the medical-surgical and the PCUs would have allowed for the full effect of the ALERT program to

be measured. Administering the program according to the course guidelines for a group of that size would take considerable time and resources.

Another limitation is the lack of assessment of knowledge retention of the ALERT trained nurses throughout the post-ALERT period. The course manual states that the frequency of retraining staff is up to the institution providing the course (Smith, 2016b). At this institution, the course has not been repeated for previous participants, and no follow up of knowledge or skill retention has been done. It would have been beneficial to know if the nurses recalled the information as designated intervals from the initial training. Retention of the content presented in cardiac life support classes has been shown to decrease significantly 3-12 months after the training (Anderson, et al., 2019; Smith, et al., 2008). With this information, as it applied to the ALERT program, the frequency of retraining could also be recommended.

Conclusions

Educating nurses to recognize patient deterioration is valuable. This study examined the impact of an educational program designed to improve deterioration recognition as measured by RRT and code blue calls. RRT calls significantly increased as more nurses were trained in the ALERT program. These findings imply that trained nurses are identifying deterioration before cardiopulmonary arrest, and this has the potential to improve patient outcomes. There was an increasing trend for code blue calls in the intervention period. This finding may highlight the aspects of the ALERT training that focus on how and when to obtain resources. Cardiac and respiratory reasons for calling an RRT and code blue increased. Participants may have retained related content from the simulated environment in the program that led to this increase. More research is needed involving multifaceted educational programs involving simulation. Education

frequency and unit characteristics are important focus areas. Lastly, further scholarly inquiry is encouraged to explore the impact of proactive educational programs on outcomes. These outcomes would ideally include improvements in patient safety and reductions in morbidity and mortality.

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Appendix A. Deterioration Programs Evaluated by Participant Response

Author/Year	No. Participants	Method	Duration	Approach	Tool	Results
Bliss & Aiken, 2018	8 RN	Lecture High Fidelity Simulation	5 Days	ACBDE	Interviews	Increased knowledge Improved assessment skills Improved decision making
Gordan & Buckley, 2009	50 RNs	Lecture Skills Simulation	24 hours	n/a	Survey	Improvement in technical and non-technical skills
Buykx, et al., 2011	51, 4th year student nurses 35, under/post grad midwifery students 34 RNs	Reflective review Simulation	1 day	n/a	Modified MCQ (Smith & Poplett, 2002)	Increases in knowledge, confidence and competence scores
Duff, et al., 2018	60 RNs	E-learning Simulation	Not mentioned	ABDCE	Clinical Emergency Recognition and Response Survey (Buckley & Gordon, 2011)	Improvement in technical and non-technical skills used in deterioration recognition
Featherstone, et al., 2004	180 RNs, 113 MDs, 15 PTs*, 7 other	Lecture Case Study Video Simulation	1 day	ABCDE	Survey	Higher confidence in identifying increase patient acuity

Fuhrman, et al., 2009	220 RNs, MDs	Lecture Case Study Skills Simulation	1 day	ABCDE	Survey	Improvement in deterioration identification (85%) and teamwork (80%)
Harvey, Echols, Clark, Lee, 2014	39 RNs	Didactic then Simulation or Case Studies	3.5 hours	TeamSTEPPS	Early Identification and Protocol-Directed Rapid Treatment of Critical Illness Bedside RN Examination tool (Sebat et al., 2009)	Increased knowledge and skills in both groups, teamwork improved for sim group
Liaw, et al., 2011	15, 3rd Year BSN students	Simulation	6 hours	ABCDE	RAPIDS-Tool (Liaw, et al., 2011)	Improvement in assessing and managing deteriorating patients, more effective in reporting deterioration
Steen & Costello, 2008	184, 3rd year nursing students	Simulation Skills	Not mentioned	ABCDE	AIM-questionnaire	Enhanced clinical practice and awareness
Wehbe-Janek, et al., 2012	360 RNs	Simulation	9 hours	n/a	Surveys, Content analysis	Increase in awareness and preparedness, increase familiarity with equipment and roles

Note. PT*- Physiotherapists

Appendix B. Code Blue and RRT Calls for Each Unit Averaged across Month for pre and post ALERT Periods

Unit	Code Blue		RRT		Trained Nurses	Total Nurses	Total Beds
	Pre-ALERT	Post-ALERT	Pre-ALERT	Post-ALERT	Post-ALERT		
A1							
Numbers (SD)	1.00 (0.82)	0.60 (0.84)	4.29 (2.87)	5.00 (2.45)	0.00	43	23
Percentages	0.18	0.10	0.82	0.90	0.00		
A2							
Numbers (SD)	1.29 (1.80)	0.80 (1.03)	9.29 (3.15)	6.70 (4.57)	1.9 (1.45)	69	24
Percentages	0.11	0.13	0.89	0.87	0.03		
A3							
Numbers (SD)	0.71 (0.76)	0.11 (0.33)	8.29 (1.70)	8.22 (3.07)	2.33 (1.58)	60	31
Percentages	0.07	0.01	0.93	0.99	0.04		
A4							
Numbers (SD)	0.86 (0.90)	0.40 (0.52)	5.86 (2.91)	6.30 (4.14)	1.00 (0.00)	65	32
Percentages	0.13	0.07	0.87	0.93	0.02		
A5							
Numbers (SD)	1.57 (0.98)	1.60 (1.51)	14.14 (4.41)	12.40 (4.95)	3.30 (1.06)	104	64
Percentages	0.10	0.11	0.90	0.89	0.03		
A6							
Numbers (SD)	0.86 (1.07)	0.60 (0.84)	4.57 (1.81)	6.60 (3.78)	6.50 (3.69)	110	64
Percentages	0.13	0.06	0.87	0.94	0.06		
A7							

Numbers (SD)	0.43 (0.53)	0.50 (0.85)	6.29 (4.11)	6.00 (4.40)	4.50 (2.64)	94	61
Percentages	0.10	0.07	0.90	0.93	0.05		
A8							
Numbers (SD)	0.17 (0.41)	0.20 (0.42)	4.33 (1.37)	3.50 (3.34)	4.70 (4.00)	43	24
Percentages	0.04	0.08	0.96	0.92	0.11		
A9							
Numbers (SD)	0.29 (0.49)	0.30 (0.67)	3.00 (2.08)	2.30 (1.64)	0.0 (0.00)	40	24
Percentages	0.05	0.08	0.95	0.92	0.00		
A10							
Numbers (SD)	0.29 (0.76)	0.25 (0.46)	2.57 (1.27)	2.75 (2.12)	0.0 (0.00)	40	24
Percentages	0.05	0.09	0.95	0.91	0.00		
A11							
Numbers (SD)	0.67 (0.82)	0.50 (1.07)	1.67 (1.75)	2.75 (1.58)	1.00 (0.00)	41	24
Percentages	0.36	0.08	0.64	0.92	0.02		
B1							
Numbers (SD)	0.86 (1.07)	0.90 (1.11)	8.86 (3.36)	9.10 (7.76)	6.10 (3.38)	57	30
Percentages	0.08	0.11	0.92	0.89	0.11		
B2							
Numbers (SD)	1.14 (1.07)	1.9 (1.73)	11.71 (3.25)	12.60 (5.34)	10.1 (5.34)	62	32
Percentages	0.09	0.13	0.91	0.87	0.16		
B3							
Numbers (SD)	1.29 (1.11)	1.30 (2.11)	13.00 (3.92)	13.70 (9.60)	6.50 (2.64)	62	32
Prop	0.10	0.07	0.90	0.93	0.10		
B4							
Numbers (SD)	1.14 (0.69)	2.40 (2.17)	7.71 (3.90)	8.3 (3.27)	14.40 (9.12)	128	62

Percentages	0.14	0.18	0.86	0.82	0.11		
B5							
Numbers (SD)	4.57 (2.51)	4.00 (4.19)	14.43 (4.83)	25.10 (8.31)	25.20 (12.37)	113	54
Percentages	0.23	0.12	0.77	0.88	0.22		
Total							
Numbers (SD)	1.08 (1.43)	1.05 (1.81)	7.79 (5.12)	8.37 (6.51)	5.62	1131	605
Percentages	0.12	0.10	0.88	0.90	0.07		

Note. (SD) = standard deviation.

Appendix C. Table of Contents: Figures and Tables

Figures

Tables