5-3-2017

Reducing Alarm Fatigue in the Intensive Care Unit: A Quality Improvement Research Study

Megan E. Speich
University of Connecticut, Megan.McNally@uconn.edu

Reducing Alarm Fatigue in the Intensive Care Unit: A Quality Improvement Research Study

Megan Elizabeth Speich, DNP

University of Connecticut (2017)

A phenomenon called alarm fatigue has been identified as an outcome of nearly 40 different alarms that sound at any given time in the Intensive Care Unit (ICU) (Borowski et al., 2011). Alarm fatigue can result in impaired recognition of worsening patient conditions and has been implicated in fatal patient events (Kowalczyk, 2010; Altimari, 2017).

A quality improvement research study (QIRS) was conducted, aimed at reducing total alarms including noncritical (clinically irrelevant) and false alarms that contribute to the incidence of alarm fatigue and the potential for unsafe conditions. The project included exploration of the critical care nurse's attitudes toward alarms, review of the existing evidence based practice policy on clinical alarm management and introduction of a new bedside alarm parameter verification called an "Alarm Check". Measurements included: alarm rates collected pre and postinitiation of the educational sessions, as well as administration of the Healthcare Technology Foundation's Alarm Survey.

There was a statistically significant decrease in alarm frequency rates after the intervention. Secondly there were statistically significant decrease in noncritical alarm frequencies, but not false alarm rates. There was, however a decrease in the number of false alarms suggesting a clinical significance. These evidence based interventions suggest simple yet

effective ways at reducing alarm frequencies and therefore the incidence of potential alarm fatigue.

Keywords: alarm fatigue, intensive care unit, evidence based practice, clinical alarms, Synergy

Reducing Alarm Fatigue in the Intensive Care Unit: A Quality Improvement Research Study

Megan Elizabeth Speich

B.S.N., University of Connecticut, (2007)

M.S., University of Connecticut, (2012)

A Dissertation Submitted in Partial Fulfillment

for the Degree of Doctor of Nursing Practice at the

University of Connecticut

2017

APPROVAL PAGE

Doctor of Nursing Practice Dissertation

Reducing Alarm Fatigue in the Intensive Care Unit: A Quality Improvement Research Study

Presented by

Megan E. Speich, BSN, MS

Major Advisor _____

Paula McCauley

Associate Advisor _____

Jaclyn Cox

Associate Advisor _____

Joy Elwell

University of Connecticut
[2017]

Acknowledgments

This Doctor of Nursing Practice degree would not have been possible without the encouragement, patience and love from my family who have supported me from the first day I decided to become a nurse. To my husband, Joey, who with unwavering love and understanding kept us all together, coached me to not give up each time I thought I was going to, picked me up when I fell down and pushed me forward when I felt I was going backward. Thank you for being exactly who you are. To my sweet boy, Andrew, thank you for always understanding when Mommy has to do her "homework". To my future baby boy, thank you for not arriving too soon! You have gone through the most difficult parts of this journey right with me. I hope you and your big brother see that hard work, determination and patience are all part of the recipe for success. To my Mom- thank you for all of the support and encouragement. Your unconditional love have shaped me into the person I am today. You are, after all, the reason I became a nurse in the first place. And to my Dad: my statistician, editor and cheerleader. Without your insight this entire project would not have been feasible. Thank you for always offering suggestions, support and grammatical advice, even late at night, all while never letting me lose sight on why I started this journey in the first place.

This entire project is dedicated to my sweet Grandfather, Albert Gualtieri, who died several months before graduation. My biggest supporter, you never let us forget how loved we are or how proud you were.

Table of Contents

CHAPTER 1 INTRODUCTION ……1

Introduction ……1

Background of the Problem ……1

Significance ……3

Theoretical Framework ……...5

Study Questions ……..8

Definitions of Key Terms ……...8

Summary ……9

CHAPTER 2: INTEGRATED REVIEW OF THE LITERATURE ……11

Introduction ……...11

Empiric Literature ……12

Theoretical Literature ……22

Summary ……...24

CHAPTER 3 METHODS ……25

Introduction ……...25

Context ……..25

Intervention ……...25

Alarm Rate Collection ……..26

Survey Administration ……..27

Policy Review and Parameter Check ……27

Measures ……...28

Analysis ……29

Ethical Considerations ……..29

CHAPTER 4 RESULTS ……...31

Introduction ……...31

Sample ……...31

Analysis of Research ……33

Summary ……...40

CHAPTER 5 DISCUSSION ……41

Introduction ……...41

Variables ……...41

Theoretical Framework ……44

Study Limitations ……..45

Impacts for the Future ……...46

Summary ……...52

REFERENCES ……53

APPENDICIES ……61

Appendix A: Full HTF Survey results……...61

Appendix B: HTF Survey……..66

Appendix C: Permissions……...72

Synergy Model Picture……..72

HTF Survey……73

Appendix D: IRB approvals……...76

UConn Health..……..76

University of Connecticut…….……78

Appendix E: IRB requested materials……79

Recruitment e-mail……79

Informed Consent……...80

Chapter 1: Introduction

Introduction

Care of patients across the healthcare spectrum is focused on improving quality and safety of practices. The best practices are gathered from evidence found in research studies, peer-reviewed standards, case reports and expert opinion (Sendelbach & Jepsen, 2013; Titler, 2008). Identifying what areas need improvement and what the solutions to the needs are has been a challenge inclusive of all healthcare disciplines, such as medicine and nursing. Organizations, such as the American Association of Critical Care Nurses (AACN), have taken on the task of identifying pertinent quality issues, safety concerns and other nursing related issues and identifying ways to improve. Nurse researchers have explored, evaluated and identified evidence to change the practice of alarm management in an effort to reduce alarm fatigue, a clinical issue with fatal consequences (Kowalczyk, 2010; Sendelback & Jepsen, 2013; Sendelbach, Wahl, Anthony and Shotts, 2015). This document discusses the issue of alarm fatigue, management of alarms using evidence based practices and examines the impact of a quality improvement project in an academic medical center's intensive care unit (ICU). The aim of this quality improvement project was to reduce the noncritical and false alarms that contribute to the incidence of alarm fatigue and the potential for unsafe conditions as well as improve nurses' attitudes toward alarms. These unsafe conditions can lead to poor patient outcomes including death.

Background

A 1999 report by the Institute of Medicine (IOM) *To Err is Human*, identified that preventable medical errors contribute between 44,000 and 99,000 deaths each year. A more recent report identified that medical errors have now been ranked as the third leading of death, only behind heart disease and cancer (Makary & Daniel, 2016). Consequences of medical errors

include not only the mortality, but also financial loss, emotional distress and suffering (Kohn, 2000). The IOM report identified strategies to combat this problem, including improving knowledge surrounding patient safety, encouraging and supporting reporting of errors, creating minimum standards of excellence in safety and fostering an organizational culture encouraging a climate of safety (Kohn, 2000).

The ICU, where care is delivered to the critically ill and injured, is not immune to the medical errors that the IOM report discussed. The rapidly evolving complex system of care in the intensive care unit predisposes this patient population to potential increase in error rate (Beckmann et al., 2003). The complexity of the patient includes not only their medical or surgical problems, but also the machines and other apparatus supporting the patient such as the monitors reporting vital signs and ventilators providing life support. All these devices have methods to alert ICU staff that there is an issue, called an alarm.

An alarm identifies a non-normal status that is monitored, such as blood pressure, respiratory rate, pulse oximetry readings, heart rate and heart rhythm. There is usually a visual or an auditory notification associated with the alarm (Lukasewicz & Mattox, 2015). The particular device has a threshold goal set, and when that threshold is crossed, either above or below the goal, an alarm is triggered (Drew et al., 2014). One example might be a pressure monitor, measuring the mean arterial blood pressure with a set parameter of 65-75mmHg. If the patient's mean arterial pressure falls to 63 mmHg, an alarm will sound.

In 1983 it was identified that there were six alarms that were found sounding in the ICU (Kerr & Hayes, 1983). 11 years later, in 1994, that number jumped to 33 (Croop, Woods, Raney & Bredle, 1994) and by 2011, nearly 40 different alarms sound at any given time in the ICU (Borowski et al., 2011). The challenge with the many different notifications is that distinguishing

the sounds can be difficult (Croop, Woods, Raney & Bredle, 1994). A phenomenon called alarm fatigue has been identified as an outcome of the large amount of alarms. Alarm fatigue is a slowed or non-existent reaction to an alarm secondary to an increased frequency and quantity of the alarms that saturates the sense of the responder (Solet & Barach, 2011). One of the first examples of alarm fatigue occurred in 1974 when a patient's hypothermia machine alarm (flashing light) was ignored resulting in iatrogenic burns. The etiology of the missed alarm was thought to be secondary to alarm fatigue (Sendelbach & Funk, 2013).

Significance

Alarm Related Statistics. Although alarms are necessary in the healthcare setting, approximately 85-99% of them need no intervention by licensed professionals after they are sounded (Association for the advancement of medical instrumentation [AAMI]: alarms pose challenges to healthcare facility, 2011). These types of alarms are considered non-critical or false alarms and do not require the provider to attend to the patient. The ECRI Institute (formerly the Emergency Care Research Institute) continually rated alarm issues as a top hazard and in 2015, it was ranked as the number one hazard, citing "inadequate alarm configuration policies and practices" as the major issue (ECRI, 2014).

A danger of alarm fatigue. Alarm fatigue has become a high profile issue in the United States most notably from a 2010 event that occurred at The Massachusetts General Hospital (MGH) in Boston, Massachusetts. The incident occurred when an 89 year old male who a bradycardic event that was not noticed and evolved into cardiac arrest. This man ended up dying. A review of the event identified that alarm fatigue was a contributing factor in the alarm not being recognized. This situation was considered a sentinel event (Kowalczyk, 2010).

A sentinel event is an adverse outcome or event that causes death, permanent harm or severe temporary harm (Sentinel Event Policy and Procedure, 2014). The Joint Commission, a regulatory agency, in response to these sentinel events created National Patient Safety Goals (NPSG). Alarm related issues was added to the 2002-2003 National Patient Safety Goal list (AACE Healthcare Technology Foundation, 2007). The Joint Commission identified that between 2009 and 2013 there were 98 alarm related events, 80 of them resulted in fatal outcomes and alarm fatigue was identified as the most common causative agent (The Joint Commission sentinel event alert, 2013). Alarm related issues continued to persist and are included in the 2016 goals, NPSFG 06.01.01, which states the goal as to "Make improvements to ensure that alarms on medical equipment are heard and responded to on time" (The Joint Commission, 2016).

Nursing staff are on the frontlines of patient care monitoring the physical exam changes, vital signs and responding to any alarms that may be triggered. The actual auditory experience of an alarm occurs very frequently during the nurses' day. Evidence indicates that the nurses may effectively block out selective alarms (Bitan, Meyer, Shinar and Zmora, 2004).

Nurses' attention to critical alarms is necessary to provide safe quality care by intervening in life threatening situations. Patients are admitted to monitored units because their illness or injury requires an increased level of acuity nursing care. Nursing staff, poised at the frontline of patient care and those most affected by alarm fatigue, have an opportunity to implement change and improve safety, particularly in the ICU setting (Sendelbach, 2012). The Doctor of Nursing Practice (DNP) prepared nurse has an even greater opportunity of responsibility to take this issue on by utilizing the essentials of the DNP nurse role, most specifically the "Organizational and Systems Leadership for Quality and Systems Thinking" (American Association of Colleges of Nursing [AACN], 2006, p. 10). The system of the

intensive care unit is inherently complex, and the DNP prepared critical care nurse is poised to navigate alarm related issues in a complex environment. By having the essential skills necessary to seek out and understand the evidence based practice changes, how to implement them and what challenges may result in the entire process, the DNP prepared nurse can "sustain changes at the organizational level" (AACN, 2006, p. 10).

Quality improvement research study. This paper explores the current state of the science regarding strategies in alarm management, specific methods for reducing noncritical and false alarms in an ICU and examines the effect of a quality improvement research study. The aim of this quality improvement project was to reduce the non-critical and false alarms that contribute to the incidence of alarm fatigue and the potential for unsafe conditions which can lead to poor patient outcomes including death. The project also explored nurse's attitudes toward alarms. The quality improvement research study included a review of the hospital policy on clinical alarms and implementation of a standard alarm parameter review check. The policy included the specific alarm management strategies that were created by hospital administrators using evidence based practice techniques in a bundled format. The literature has suggested that it is not one technique that reduces the incidence of alarm fatigue, but rather multiple actions necessary.

Theoretical Framework

The overall planning, implementation and change component of this quality improvement research study was formulated using the Plan-Do-Study-Act or PDSA cycle. A methodology for quality improvement, the PDSA cycle is an organized way of examining a problem and what evidence based change can be a solution, implementing the change, studying the reaction and altering necessary components to have a successful outcome. This quality improvement research study can be considered the first PDSA cycle (Melnyk & Fineout-Overholt, 2015).

The conceptual framework and methodology for this quality improvement research study was concordant with the American Association of Critical Care Nursing's (AACN's) Synergy Model for Patient Care. This model, created in the 1990's, is composed of eight patient characteristics and eight nursing competencies that when are congruent with one another create synergy, improving patient outcomes within the care environment (Hardin & Kaplow, 2005).

The eight patient characteristics are: "resiliency, vulnerability, stability, complexity, resource availability, participation in care, participation in decision making and predictability" (Kaplow & Reed, p. 19, 2008). These characteristics are graded on a level system from one to five, with one being at the lesser end of the characteristic and five being the greater (Kaplow & Reed, 2008). Although the model utilizes the word "patient", the construct includes the family as a member of the grouping, also subjected to the characteristics at times. The patient characteristics represent the complexity of the patient, not only the ability to improve health but also focusing on the concern for weakness that may further exacerbate decline from optimal health status.

The eight nursing competencies include "clinical judgement ,advocacy and moral agency, caring practices, collaboration, systems thinking, response to diversity, facilitation of learning and clinical inquiry" (Kaplow & Reed, 2008, p. 19). Again, as with the patient characteristics, these competencies have a rating system based on levels one through five. These eight competencies are necessary to meet the needs of the patient based on their levels of acuity. For example, a critically ill patient has more needs than most, therefore requiring a more competent nurse in order to meet the needs (Hardin & Kaplow, 2005). An important concept of the Synergy Model is that there a fluidity to both patient need (characteristic) and nurse competency. Competency of the nurse is not just solicited from a nurse to patient relationship. There are other

relationships, such as nurse to nurse and nurse to healthcare system that can be utilized also (Kaplow & Reed, 2008). Figure 1 shows the relationships between patient need, nurse competency and the healthcare system.

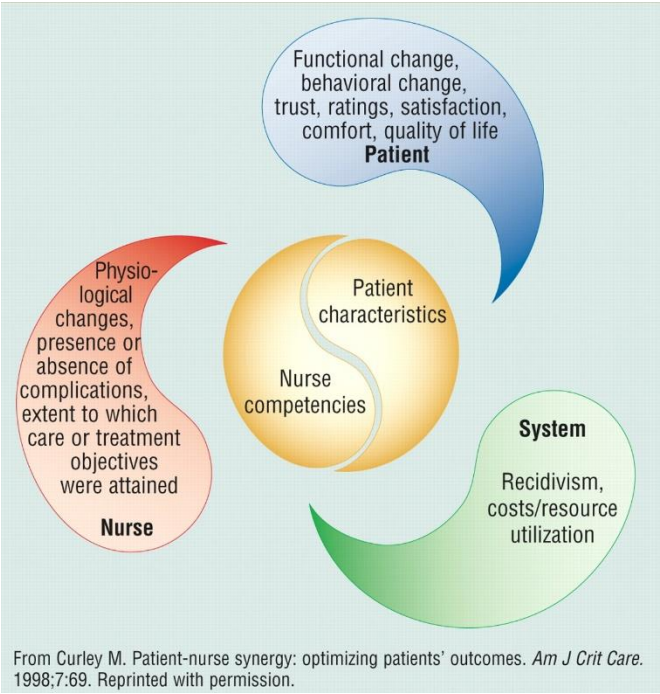


Figure 1. AACN's Synergy Model for Patient Care, used with permission (see Appendix C).

Alarm fatigue focuses on the nurses' inability to meet the needs physiologic, spiritual and emotional needs of the patient by not recognizing alarms, and putting the patient into an even more vulnerable state within the care environment. The nurse fails to meet patient needs secondary to a lack of competency in recognizing the alarming state, and is therefore not achieving synergy. This failure is a barrier to a successful relationship due to a lack of synergy. Additionally, nurse attitudes and perceptions towards alarms may create another barrier to the successful relationship. This quality improvement research study seeks to identify nurse's perceptions of alarms and to reduce alarm fatigue which should restore the synergistic relationship between patient need and nurse competency by minimizing added vulnerability of

the patient and improving the nurses' opportunity to soundly implement clinical judgment (Kaplow & Reed, 2008, p. 23; Walsh-Irwin & Jurgens, 2015).

Being a DNP prepared nurse driven quality improvement research study inherently subscribes to the characteristic and competency of clinical inquiry. The DNP prepared nurse is taking research proven methods and implementing them into actual practice, but doing so with an understanding of the dynamics of change and how to make it successful. The practice of using evidence based research ascertains the concept that the expertise level of advance practice nurse is that of expert as it relates to caring practices as well as systems thinking (Kaplow & Reed, 2008, p. 23; Walsh-Irwin & Jurgens, 2015).

Study Questions

1. What are the perceptions of the critical care nurse towards alarms and alarm policy in the ICU?
2. Does re-education of the critical care nurse regarding the hospital policy on clinical alarm management including instituting a formalized bedside nurse handoff alarm parameter check reduce the incidence of total alarms, including false and non-critical in the ICU?

Definitions of Key Terms

Conceptual. Alarm Management Strategies: Practice actions to reduce the incidence of false or non-critical alarms. These strategies include proper skin preparation, daily electrode changes, personalized alarm parameters, threshold settings, education regarding devices with alarms, inter-professional team establishment and only monitoring patients with clinical indicators (AACN, 2013).

Alarm Fatigue: a slowed or non-existent reaction to an alarm secondary to an increased frequency and quantity of the alarms that saturates the sense of the responder (Solet & Barach, 2012).

Non-Critical Alarms: An alarm that correctly signifies an alteration from expected value, but a value that is insignificant of intervention, for example patient's heart rate is always lower at 45 beats a minute, but the alarm is set for a threshold of 60 beats per minute. It signifies that the value is low, but normal and therefore non-critical for the patient (Lukasewicz & Mattox, 2015).

False Alarms: Most common reason for alarm. False alarms are alarms that sounds but not an actual true signifier of any kind of alteration. This can include technical alarms, such as interference between electronic products, a result of technical issue. (Korniewicz, Clark & David, 2008).

Operational. Alarm Rate: Frequency of alarm occurrence based on eight different alarm types. Measured by the rate of occurrence in a two hour period from 1730-1930 on five consecutive days. Measurement then separated into actual, false and non-critical alarms.

Summary

Alarm fatigue is a patient safety hazard in the hospital setting and intensive care units with potentially fatal consequences (Kowalczyk, 2010). This issue is recognized by many institutions and organizations, JCAHO and ECRI for example, as a top priority that requires investigation and resolution (AACE Healthcare Technology Foundation, 2007, ECRI, 2014). AACN has established a practice alert intended to bring attention to this issue and offers nursing practice considerations (AACN, 2013). Nurse researchers are realizing the critical issue that this

problem presents and have initiated care bundles in an effort to improve patient outcomes related to alarms (Sendelbach, Wahl, Anthony & Shotts, 2015).

Chapter 2: Review of the Literature

Introduction

The integrated review of literature was initially conducted using Scopus, a peer reviewed literature database and National Center for Biotechnology Information's PubMed database. Search phrases included: alarm management, false alarms, alarm management bundle and nurse attitudes toward alarms. The results yielded from those search terms were narrowed using subject classification limits of nursing, medicine, health professionals and social science. The search phrase "false alarms" initially yielded in excess of 21,000 results, which is what prompted the narrowing of subject matter. This reduced the yield to 1388 articles. The key phrase "alarm management" yielded 5999 articles, with subject area limit reducing yield to 1615. The key phrase "alarm management bundle" yielded 9 results, with only one that was applicable, however this was a key study related to the topic and useful. These articles were then evaluated for content and applicability. Searches also included key words focusing on the different parts of the alarm reduction bundle referenced by AACN, such as daily electrode changes, personalized alarms and skin preparation for electrocardiogram (ECG) lead placement.

The references listed within key articles that served as inspiration for this quality improvement research study were then evaluated. The AACN Practice Alert on Alarm Management listed references for their statements, which were also evaluated. All together there were 19 empiric studies that contributed to the integrative literature review. The literature was sourced from a variety of journals, the majority from nursing literature, critical care, anesthesia and pediatrics.

Lastly, the theoretical literature review was completed. Initially searched using the key phrase "Synergy Model", which yielded over 10600 citations. These were pared down by

isolating nursing literature, which limited it to 165 citations. These were reviewed and three useful articles were identified that contributed to the support of the Synergy Model as theoretical basis for this quality improvement research study.

Empiric Literature

False and clinically irrelevant alarms. Clinical alarms have been demonstrated throughout the literature to have a high rate of false positives and clinical irrelevancy. Determination of clinically relevancy is both contextual as well as patient specific. Observational research methods have explored why an alarm is triggered and what the response to the alarm is. Chambrin et al. (1999) observed the clinical alarms of 131 patients in five intensive care units at two university hospitals in France. The study explored the frequency of an alarm and resultant need for an intervention. The authors reported that only 25% of alarms required either a nurse or a physician's intervention, 58.2% of all alarms studied were triggered by a patient physiologic factor and 23.4% induced by staff members manipulating the patient and causing an alarm to sound, such as touching an electrode. Key connections were extrapolated from the data, suggesting that further investigation into reducing the staff member manipulation inducing alarms might be beneficial, especially focusing on the idea of alarm suspension during nursing care. A difficulty, however, with this observational study is that the alarms themselves were not identified based on specific concern but rather broad types of alarms, such as heart rate and respiratory rate threshold variance. Also, the context of this study is 17 years ago, when technologies and alarm amounts in intensive care unit are not what they are today (Croop, Woods, Raney and Bredle,1994; Borowski et al., 2011).

Further investigations continued to mount evidence about the existence of false alarms in patient care settings. Researchers have examined the frequency, types and trueness of

physiologic alarms. Aboukhalil, Nielsen, Saeed, Mark and Clifford (2008) identified again the incidence of false alarms. Their data was collected from a database of physiologic waveforms and other information called Multi-Parameter Intelligent Monitoring for Intensive Care II (MIMIC II) from a combination of ICUs in a single center. Of the 447 patient's alarms reviewed, observers concluded that 42.7% of the critical (life threatening) ECG alarms were false. An example is the asystole alarm, which represents cessation in the electrical conduction of the heart, which in this study had a false alarm rate of 90.7%. These author's introduced an algorithm intended to capture whether the alarm is true or not by reviewing additional sources of information, such as arterial blood pressure monitoring. If a patient is truly asystolic, there will be no muscle contraction and therefore no arterial blood pressure waveform. The results suggest that an algorithm such as that does improve the rate of false alarms, in this case by 59.7%.

Similarly, Drew et al. (2014), at the University of San Francisco, completed an observational study in five ICUs with total of 77 beds, specifically examining electrocardiogram related alarms. The authors explored connections between the variety of physiologic measurements that have the potential to alarm, the false alarm rates and proposed potential alterations in observational methods that might reduce the false alarm rates. They annotated both inaudible and audible alarms, identifying a total of 2,558,760. Of this number, 381,560 were audible alarms with 12,671 arrhythmia alarms. Of the audible arrhythmia alarms, 88.8% were falsely positive. Drew et al. suggests that their data provides a more likely sample of actual ICU patients as compared to the MIMICII because their sample includes more ambulatory patients as opposed to the MIMICII database which were sedentary patients.

Additional studies, such as Inokuchi et al. (2013) reviewed alarm relevancy. Their data concluded that 21.7% of alarms were technically false and 71% technically true. Of the total

number of alarms, both true and false, only 6.4% were relevant. This prospective observational study concludes similar findings, that combining physiologic data reduced clinically irrelevant alarms by 21.4%. This study, however included a comparatively small sample size, a noted limit to the study.

Nurses' perceptions of alarms. Multiple studies have utilized the tool created by Healthcare Technology Foundation (HTF), which was a survey initially completed in 2005-2006 and again in 2011. The instrument measures nurse's perceptions towards alarms (Funk, Clark, Bauld, Ott & Coss, 2014). This instrument will be utilized in this quality improvement project. Funk, Clark, Bauld, Ott and Coss, (2014) explored the survey's responses. The authors of the study are all associated with the HTF. The intent was to explore the different responses between the initial survey completed 2005-2006, and the subsequent follow up in 2011. The sample (n=1327) of the 2005-2006 HTF survey was higher in percentage of nursing respondents (sample was interdisciplinary), but overall lower number while the 2011 survey was a large sample size (n=4278) but smaller percentage of nurses. The majority of respondents identified that "nuisance alarms disrupt patient care" and that "nuisance alarms occur frequently". Funk, Clark, Bauld, Ott and Coss (2014) also identified that in the 2011 survey, significantly fewer respondents felt that nuisance alarms impacted patients care and occurred frequently. The authors thought this may be secondary to advances in both technology and response to alarms. They did not find overwhelming differences between the two studies, but did concur that clinical alarms are still a concerning issue (2014).

Honan et al. (2015), expanded upon the data analyzed by Funk et al. (2014) and examined the free text comments written by the respondents in the 2011 HTF survey. 410 nurse's, or 29% of total 2011 respondents, commentary was examined and themes were

extrapolated using qualitative analysis using Krippendorff's analytic technique. The six themes included: "dissonance and desensitization; pollution, panic and pathology; calling for accountability; calling for authority of nurses; clinical alarm management is crucial but not a panacea; and hope for the future" (Honan et al., 2015; p. 390-393). The overall commentary suggests concern that danger exists and identified particular areas of need including suggestions for improvement, such as a focus on accountability of all nurse providers in the patient care setting (Honan et al., 2015).

Cvach, Frank, Doyle and Stevens (2014) at The Johns Hopkins Hospital explored the utilization of alarm escalation algorithms and nurse carried pagers as a means to reduce alarm noise. A second aim of their study was to evaluate nurses' attitudes in regard to alarms and the use of these alarm notification devices. They used the same survey created by HTF as Funk, Clark, Bauld, Ott and Coss (2014) and Honan et al. (2015), however they utilized a Likert Scale to quantify results rather than allow for commentary as Honan et al. did (2015). In regard to the nurse attitudes, Cvach, Frank, Doyle and Stevens noted an improvement in nurse perception of sensitivity and response to alarms a result of using an alarm escalation system with pagers (2014).

An Australian study published in 2014 further expanded on the body of nurse attitudes towards clinical alarms. Christensen, Dodds, Sauer and Watts (2014), using a descriptive survey methodology, queried 48 critical care nurses from one intensive care unit using a ten question survey, with two multiple choice questions and eight open ended questions. The questions addressed alarm fatigue in addition to alarm practices in the sample ICU. The authors identified five categories from the responses, including: "defining a nuisance alarm, alarm setting practice, the practice of silencing other nurses alarms, the practice of altering another nurses alarm limits

and informing colleagues of alarm limit change" (Christensen, Dodds, Sauer & Watts, 2014; p. 207). Although the responses from this study focus more on the action of managing alarm limits, the findings concur that an overabundance of alarms can cause desensitized reaction, and slower response times or "silencing or disabling alarms inappropriately" (Christensen, Dodds, Sauer & Watts , 2014; p. 207). Two general perceptions were drawn out of the commentary: inappropriate alarm settings and delayed response times. The respondents identified feelings of concern that important alarms might be missed as well as anger and frustration when there was a delayed response to alarms by nursing staff.

A quality improvement project completed at Boston Medical Center, published in 2014, aimed to reduce non critical alarms as they relate to default parameters set by the alarm system manufacturer. Also, the study explored nurse perceptions of noise level and their satisfaction (Whalen et al., 2014). In regard to satisfaction with the interventions set in place, which included, for example, a broadening the default range of normal values, the nurses had an improvement in their level of satisfaction in addition to a reported a 64% improvement in acceptable noise level from pre to postintervention.

AACN Practice Alert. Strategies in reducing alarms have been suggested within the AACN Practice Alert regarding alarm management. The intention of the practice alert is to reduce the non-critical and false alarms that contribute to the alarms sounding off in the ICU. The practice alert identifies seven practices and the evidentiary support. These practices include: Providing proper skin preparation for ECG electrodes, changing ECG electrodes daily, customizing alarm parameters and levels on ECG monitors, customizing delay threshold settings on oxygen saturations via pulse oximetry monitors, providing initial and ongoing education about devices with alarms, establishing inter-professional teams to address issues related to alarms and

monitoring only those patients with clinical indications for alarms (AACN, 2013). The AACN Practice Alert was formulated by the AACN Evidence Based Practice Resources Work Group and published in 2013. The practice alert recommendations are complete with evidence levels and referenced explanations that support the success of these practice changes (AACN, 2013). Evidence, as demonstrated in the AACN practice alert, is essential to successful change in nurse practice. It is what distinguishes between what is being done and what must be done, by providing undisputable proof of effectiveness.

Electrocardiography Interventions. Proper skin preparation for electrode placement was evaluated first back in 1989 by Medina, Clochesy and Omery and again in 1991 by Clochesy, Cifani and Howe. Both studies concluded that clean skin that was mildly roughed decreased artifact, known to contribute to falsity of alarms. In more recent literature, Walsh-Irwin and Jurgens (2015) completed a prospective descriptive study that examined if proper skin preparation and electrode placement had an effect on the frequency of ECG alarms. This study was completed on 15 patients admitted to the Veterans Affairs Medical Center. The alarm rates were monitored for 24 hours prior to intervention and 24 hours after intervention. The proper skin preparation included: clipping hair as needed, washing skin with soap and water, drying skin with washcloth, attaching electrodes to leads, and correct anatomical placement. The results of this intervention revealed a statistically significant decrease in alarms from 1341 to 992 in 24 hours, or a 44% reduction. A limit to this study was the small sample size, so bootstrapping was used to make the results more generalizable for a population. Also, the measurement was only for 24 hours.

Disposable ECG leads have been examined as a means to reduce false alarms. Knowing that poor ECG signal quality can contribute to the amount of false alarms, Albert, et al. (2015),

sought to examine if using disposable ECG lead wires alters the alarm rates differently than reusable wires. This study was a prospective, cluster randomized, controlled and blinded study measuring comparative effectiveness. It was conducted at the Cleveland Clinic in Ohio in four hospital units with telemetry. Two units were randomized to control (reusable wires) and two were randomized to the intervention (disposable wires) group, for months one and three, and then the groups were swapped for months two and four. The study was conducted over four months, and data was collected remotely by personnel who were blinded to the participants. The alarms were categorized based on five types, including true and false alarms. The authors identified that the aim of their study was not to measure false alarm rates, but rather to identify differences between the two groups. The results identified that in this particular study, there was a statistically significant difference in the "no telemetry, leads fail, leads off" alarm subtype for the superiority of the disposable wires, as compared to reusable wires, with a 29% risk reduction when comparing all cases studied. There was statistically significant non-inferiority (meaning not any worse than) of the disposable wires in both the "monitoring (artifact)" and "all false" alarm type. In regard to true crisis alarms and false alarms, there was no statistical significance between reusable and disposable leads (Albert et al., 2015). This evidence give some information that this technology can reduce certain alarm situations, however was not overwhelmingly compelling that the disposable leads can reduce unnecessary alarms in every situation.

A quality improvement project was initiated in 2011 that examined if changing the electrodes daily on a patient reduces the number of ECG technical alarms (Cvach, Biggs, Rothwell and Charles-Hudson, 2012). The study was completed at The Johns Hopkins Hospital in a 15 bed Medical Progressive Care Unit (MPCU) and 25 bed Cardiology Care Unit (CCU). The intervention was to change the electrodes on each patient in the group daily between 0800

and 1200. The intervention also included following The Johns Hopkins Hospital's skin preparation procedure. Both preintervention alarm rates were counted, in addition to the type of alarm (based on priority level) as well as post-intervention for 8 days in each group. The intervention group had a 32% decrease in technical alarms in the MPCU and 56% decrease in the CCU. This quality improvement study represents a very small body of research, but compelling results (Cvach, Biggs, Rothwell and Charles-Hudson, 2012), so much so that AACN utilized this study as part of the evidence towards daily electrode change.

Alternate methods of alarming. Cvach, Funk, Doyle and Stevens (2014) examined alternative methods to alerting staff of alarming conditions, such as a pager system for notification associated with an alarm escalation algorithm. Their research built upon previous inquiries in the use of a dedicated monitor watcher, studied by Funk, Parkosewich, Johnson and Stukshis (1997) and Zweig et al. (1998). Cvach, Funk, Doyle and Stevens (2014) examined if the alarm escalation algorithm that attempted to filter alarms in a systematic way to the nurse, via a paging system effectively communicated the necessary notifications and explored nurse attitudes towards alarms. Their results suggested that there was a significant decrease in alarms to 0.75 per bed/per day, specifically secondary to the use of the alarm escalation algorithm with paging system (Cvach, Funk, Doyle & Stevens, 2014).

Default alarm settings. Graham and Cvach (2010) utilized a "small tests of change" approach and examined implementing interventions related to alarm parameters and their effect on category and frequency of alarm. They developed an alarm management task force who worked together to devise the methodology and interventions. Their interventions included a three staged approach: first an educational session teaching nurses about alarm management best practices, second; altering the default alarm parameters including heart rate, oxygen saturation and

premature ventricular contraction (PVC) limit as well as eliminating duplicative alarms and third; a software update that allowed nurses to view alarm messages of one patient in any monitor location on the unit. There was also a focus on personalizing alarms based on the individual patient's need. A preintervention assessment of nurse's knowledge regarding alarm management was completed. Preintervention alarm amount was 16953 and postintervention was 9647, a reduction of 43%. Nurses also reported a perceived reduction in overall noise after the intervention occurred.

A recent study completed by critical care nurses at Emory University, published in July, 2016 by Brantley et al., examined the difference in pulse oximetry alarm rates before and after an educational session focusing on the personalizing of alarm parameters. They concluded a statistically significant reduction in pulse oximetry alarms at a 39% decrease. This study further suggests that personalization of alarm parameters can significantly reduce unnecessary alarms that contribute to alarm fatigue.

Bundle Approach. Multiple studies have examined the effectiveness of a bundle of approach in reducing noncritical and false alarms. Given the multiple factors that contribute to false and noncritical alarms, many studies in the literature take a bundle approach, grouping interventions together with the same aim. A quality improvement initiative conducted at the Cincinnati Children's Hospital Medical Center in the Bone Marrow Transplant Unit, aimed to formulate a task force to develop a "standardized process" (Dandoy et al., 2014, p. 1687) for ECG care with the goal of decreasing false and non-critical alarms, what the authors call "nuisance" alarms. The investigators initiated a team based approach, including physicians, nurse practitioners, nurses, nursing care assistants, clinical engineers and patient family representatives. This team used the Plan-Do-Study-Act (PDSA) method to implement this change, calling it a Cardiac Monitoring

Care Process (CMCP). Preintervention examination of alarm management processes were evaluated, postintervention alarm rates were measured per monitored day on all monitored patients. The interventions consisted of family engagement (by including them on an "interdisciplinary team"(p. 1688)), standard process to order age appropriate alarm parameters, daily lead change, daily assessment of monitoring parameters, role definition and responsibility allocation, standard process to discontinue monitor and personalized monitor delay and threshold settings. Initial compliance with the CMCP during the PDSA testing period (months one and two) was at median of 38%, however once the entire process was in place, compliance with interventions was median of 95%. The median false alarm rate went from 95% to 50%, with total alarm rate starting at a median of 180 to 40 alarms. Also, unique to this program the authors measured the number of minutes nurses spend addressing frequent alarms. Pre-intervention time spent was 20-25 minutes and post-intervention 10 minutes. The authors noted some difficulty measuring the family perception component of their study, thought to be secondary to the poor return rate of surveys by patient's families. They noted also that it was difficult during their analysis to identify which of the interventions was the most impactful (Dandoy et al., 2014).

Sendelbach, Wahl, Anthony and Shotts (2015) added to the limited body of literature focused on quality improvement initiatives aimed at reducing non-critical and false alarms. This particular study focused on reducing both ECG and pulse oximetry (SpO_2) alarms. Their intervention was a bundle approach which included: eliminating duplicate alarms, adjusting default alarms, personalizing alarms, daily ECG electrode change, standard skin preparation for ECG electrodes, disposable leads (this was initiated for two weeks, then discontinued secondary to poor results and cost analysis) and altering SpO_2 default settings/sensor placement. Initial alarm baseline data was collected weekly, Monday at 0700 to the following Monday at 0700. A

rapid process improvement workshop was initiated and the study was implemented between March 2013 and August 2013. Study results indicated an 88.5% reduction in ECG alarms. There was no difference in alarm rates of the SpO_2 alarm rates. The findings in this quality improvement project were sustained after study intervention, resulting in improved alarm rates from preintervention of 28.5 alarm signals per day per monitored bed to 3.29 in August 2013 to 3.05 in December 2013. Conclusions can be drawn that the impact of this bundle approach resulted in decrease in alarms, and therefore the potential for alarm fatigue (Sendelbach, Wahl, Anthony and Shotts, 2015). This study further contributes evidence that supports the methodology used in this quality improvement research study.

Theoretical Literature

Synergy model for patient care. Several studies have utilized the Synergy Model for Patient Care as theoretical framework for methodology building. Wysong and Driver (2009) completed a qualitative study examining patient's perceptions of the characteristics that make a nurse skilled or unskilled, the impact of technical skill on a patient's perception of nurse's skill, and perception of nurse's characteristics corresponding with the Synergy Model for Patient Care's framework. Their study was completed in a 12 bed progressive care unit at a hospital in Indiana, interviewing 32 patients. The results indicate that patients place a large emphasis on interpersonal skills as opposed to technical skills when identifying competency. Also, the respondents emphasized critical thinking skills (94%) as important, although they did not emphasize the importance of technical skill. The respondents identified seven of the eight domains suggested by the Synergy Model for Patient Care as skills competent nurses should have. This study validates the Synergy Model for Patient Care with real world patient's perceptions of nurses. The findings that Wysong and Driver (2009) identified confirm the

importance of the interpersonal and critical thinking skills as it relates to the patient's perception, but not the importance of technical skills. These findings help to support the needed skills as it relates to alarm management techniques further supporting the idea that it is not just interpersonal, critical thinking or technical skill alone that drives better outcomes, but all three type skills combined.

Kohr, Hickey and Curley (2012) studied nursing productivity using the Synergy Model for Patient Care as a theoretical framework. Completed at Boston Children's Hospital, the researchers first examined what factors are taken into consideration when the charge nurse makes nursing assignments, using the eight domains of Synergy as a guide. Secondly, using several survey techniques nurses were asked to connect levels of patient care difficulty with the factors created in the first stage of the study aimed at identifying "nursing productivity" (Kohr, Hickey and Curley, 2012, p. 422). Data was analyzed and results concluded that stability was the most significant dimension as it relates to patient and family care. The authors also concluded that the Synergy Model for Patient Care is an effective framework for determining and properly allocating nurse productivity. This study confirms the conceptual importance of the stability domain, and can be applied to alarm management, as alarms are a signifier of an alteration in stability.

There was only one singular study discovered during this integrative literature review that focused on alarm management techniques and utilized the Synergy Model for Patient Care. This study, already discussed within the Empiric Literature review, examined the effectiveness of proper skin preparation and ECG placement on ECG alarm frequency. Walsh-Irwin and Jurgens (2015) utilized the Synergy Model for Patient Care as a conceptual framework for the study because the focus on the model is "meeting patient needs to ensure positive outcomes" (p. 136).

The intention of the study was a quality improvement project, which in itself matches with the principals of Synergy, regardless of the aim of the study as the purpose of the project was improving practices in the spirit of clinical inquiry (Jurgens-Irwin and Walsh, 2015, p.136). The aim of the study is supported by the Synergy Model for Patient Care as it focuses on improving the competency of the nurse (skin preparation skills) with the intention of improving patient outcomes (reducing alarms to reduce alarm fatigue). The Synergy Model provides the theoretical framework for this quality improvement research study, as alarm fatigue presents a barrier to achieving the synergistic relationship.

Summary

There is much evidence on interventions to reduce false and non-critical alarms including ECG and SpO_2 alarms. False and non-critical alarms are an extensive global issue amongst monitored patients. The empiric evidence suggested that several different interventions have the potential for great reduction in alarms, all supporting the components of the policy utilized in this quality improvement initiative. There is also evidence in the literature to support the use of the Synergy Model of Patient Care for both theoretical methodology support and outcome management. Although the literature has identified how to achieve a reduction in alarm fatigue, it is essential to examine and provide rationale for why this is beneficial.

Chapter 3: Methods

Introduction

This quality improvement research study aimed to reduce the incidence of alarm fatigue by decreasing the number of false and noncritical alarms that contribute to the overall amount of alarms in an intensive care unit. The danger of alarm fatigue and its connection with poor patient outcomes suggested that this quality improvement research study had the potential to significantly reduce unsafe patient care conditions. This quality improvement research study also examined the perceptions of nurses towards alarms including noncritical (called nuisance alarms in the HTF survey) and alarm fatigue, using a validated survey, which has been used in national studies examining alarm management (AACE Healthcare Technology Foundation, 2007).

Context

The setting of this quality improvement research study was a 28 bed medical-surgical intensive care unit located at an academic medical center in New England. The patient population included medical, cardiac, surgical, neurologic, neurosurgical, cardiothoracic and, obstetrical critically ill adults. The current model for notification of an alteration in expected vital sign value (heart rate, rhythm, respiratory rate, pulse oximetry reading and blood pressure) are alarms sounded from the in room monitor. The alarms are then transmitted to two monitor stations located in the front main administrative station and scattered throughout the entire ICU in three separate areas as well as in each patient room.

Intervention

The quality improvement research study was a two armed preintervention process, followed by a postintervention reassessment First, preintervention data regarding the amount of

total alarms was collected including: heart rate, ECG (electrocardiogram) rhythm, blood pressure (both non-invasive and arterial pressure waveform), respiratory rate, pulse oximetry reading as well as “lead off” and “cannot analyze ECG”.

A preintervention survey was offered to all the registered nurses who work in the critical care unit, both regular staff and float pool. The survey is a shortened version of the 2011 Clinical Alarms Survey created by the Healthcare Technology Foundation (HTF) (see Appendix B for full survey utilized) and was used with their permission (see Appendix C). The survey asked several questions regarding the nurse’s feelings and perceptions towards alarms, alarm fatigue and alarm related policies, as well as demographic data.

After baseline data was collected, an educational session for all critical care RN’s was offered to reintroduce them to the clinical alarm policy and introduce the formal “Alarm Check” component to nursing report. The “Alarm Check” is an actionable method to implement one of the already existing policy components of modifying alarm parameters based on a patient’s individual clinical need on a regular basis. Postintervention data was collected similarly, with the exception of the survey component.

Alarm Rate Collection

The preintervention data collection was partially completed by using middleware software already available to the academic medical center, created by the manufacturer Connexall. Connexall services provide capture of alarm frequency data. For the purposes of this quality improvement research study the preintervention alarm data included the amount of alarms over a two hour period from 1730-1930 hours during five consecutive days. Because Connexall cannot distinguish between false and noncritical alarms, these data points will be

collected by the primary investigator during the same two hour/five day period using visual and auditory inspection and manual counting. The data was entered into MS Excel (Microsoft, Inc.). A specific form was developed for the primary investigator to capture the data in an organize fashion.

In the same fashion as the preintervention data, the postintervention data also was collected using both manual counting and evaluation of the Connexall data. The data was tabulated and stored in the same manner as pre-intervention data. Data was examined and frequency of alarm types compared between preintervention and postintervention, using a simple t-test for two samples assuming equal variances.

Survey Administration

The preintervention survey was administered to the approximately 30 critical care RN's working in ICU, including regular and critical care float pool staff. The survey was truncated and questions applicable to the nature of this quality improvement research study were maintained. Questions focused on nurse's feelings and attitudes towards alarms and alarm related policies. The survey was administered on paper, placed into each RN's mailbox. Anonymity was maintained, at the request of the IRB by asking the RN's to not write personal identifiable information. Completed surveys were placed into a secure box in the nurses' locker room. Nurses had two weeks prior to the intervention to complete the survey.

Policy Review and Parameter Check

The intervention component of the quality improvement research study consisted of a two-step process. The first was an education session consisting of an approximately 10 minute verbal lecture with slide show reviewing the hospital's clinical alarm policy. The specific items

discussed were: proper skin preparation before electrode placement, changing the electrodes every 24 hours, reaffirmation that the nurse is able to change to alarm parameters on the monitor without an order from a licensed independent provider (LIP), notification of the LIP for the order changed if the value falls outside of the expected value, and personalizing the alarms to meet the clinical needs of the patient. The educational session included the introduction of a formal name to an already existing component of the policy, called the "Alarm Check". The "Alarm Check's" occur when the two nurses who are involved in the handoff go directly to the bedside of the patient and verify that the clinical alarm parameters are in congruence with the patient's clinical status. The "Alarm Check" completion was verified initially with a check off card that is attached to the front of each bedside chart, using a dry erase marker also attached to the chart. The "Alarm Check" is a hypothesized method to ensure that alarm parameters are reviewed at each patient care handoff, and is not a validated tool but rather a conceptualized activity created by the primary investigator to successfully complete one of the policy components: personalizing the alarm parameters to meet the patient's clinical need. .

Measures

The Connexall data collection methods were identified as valid and reliable, per the company (R. Jennings, personal communication, June 1, 2016). There are no studies in the literature that prove validity and reliability. There are however examples in two studies that use the measures Connexall provides to capture alarm related data. Cvach, Biggs, Rothwell and Charles-Hudson (2013) utilized the same Connexall data collection, and generated reliable results. Additionally Ketko et al. (2015) preformed a similar improvement initiative to this proposed study in the neonatal environment and utilized Connexall data collection tools as a basis for their measurement of alarm frequencies. Alarm frequency validation was attempted

during the principal investigator's assessment of alarm types as part of this quality improvement research study, to identify if the Connexall alarm frequency totals were equal to the principal investigator's manual calculations.

Analysis

The pre-intervention and post-intervention alarm frequency data was statistically analyzed using two sample t-tests assuming equal variances, as the design is a pretest/posttest study comparing means. The survey data was also analyzed using descriptive statistics, including demographic data and survey response for mode.

Ethical Considerations

This study was intended to be an evidence based quality improvement initiative (EBQII). Given that the methodology is rooted in EBQII, it is inherently in itself an ethically minded activity, by bringing research based evidence into practice. The intervention arm of this study was not subjected to informed consent from the patients whose alarms will be measured, as measuring vital signs is a component of general clinical care. The survey component however of this EBQII study involved informed consent, obtained from the nursing staff who completed the study. Emphasis was placed on anonymity of responses and this was conveyed in the introduction to the survey (Melnyk & Fineoult-Overholt, 2011).

This quality improvement research study was reviewed for ethical standards by the academic medical center's IRB and the University of Connecticut IRB (See, Appendix D for IRB approvals; Appendix E for IRB requested materials). This quality improvement research study was deemed low risk to the patients as there was no change in policy, but rather a reeducation on the contents of the policy agreeing with the quality improvement methodology.

The alarm measurement data from this study were de-identified and stored as a data set/per analysis session by software purchased by the hospital and maintained on campus as well as the manual counting worksheets which were kept with the primary investigator in a secure location. The nurse's survey responses were anonymous and stored/maintained and available only to the research team.

Chapter 4: Results

Introduction

The aim of this research study was to explore nurse's perceptions towards alarms as well as to reduce alarm fatigue by implementing a structured quality improvement program that included a survey that explored nurse attitudes towards alarms in the ICU, an educational session with registered nurses reviewing the already existing evidence based clinical alarm policy, formalizing a component of that policy (beside shift change alarm parameter check) into an "Alarm Check" handoff. The educational sessions included a focus on a bundled approach with four steps: ensuring proper skin preparation prior to electrode placement, ensuring proper placement of electrodes, changing the electrodes every 24 hours and personalizing the alarm parameters to meet the clinic needs of the patients.

Rates of alarms were counted prior to and after the intervention. Nurse's perceptions were measured using the HTF's alarm survey, also before and after educational sessions. The post-intervention data was collected four weeks after intervention completion. For the purpose of this study the terminology of "nuisance alarms" as documented in the HTF survey is equivalent to a "non-critical" alarm accounted for during alarm frequency measure.

Sample

The sample for this research was to include approximately 30 critical care registered nurses working in the adult intensive care unit at an academic medical center in central Connecticut. The nurses were part of both regular staff and the critical care float pool. The survey component was offered to all nurses, however only 12 nurses responded (40%) to the preintervention survey. The educational session was delivered to all nurses working for two weeks, approximately 30, both day and night shift. At the start of the session participants were

informed that all information they were hearing was review of existing hospital policy and a standard of care. The survey component was also not mandatory and respondent were asked to not put their names on the form.

Of the preintervention surveys 11 were permanent ICU staff (91.7%) and one (8.3%) was a critical care float pool nurse. Three were men (25%) and nine were women (75%). There was equal distribution of age ranges amongst categories except no one was greater than 60 years of age and majority had three to eight years of experience. Demographic data is included in Table 1.

Table 1

Demographic Data of Sample

Characteristic	(N=12)	% of sample
Gender		
Male	3	25
Female	9	75
Age		
18-29	3	25
30-39	3	25
40-49	3	25
50-59	3	25
60+	0	0
Years RN Experience		
0-2	0	0
3-8	6	50
9-15	1	8.3
16-25	2	16.7
>26	3	25
Staff Category		
Permanent	11	91.7
Float pool	1	8.3

Note. Sample percentages are of the number who responded to survey.

Analysis of Research

Study Questions

Research question 1: *What are the perceptions of the critical care nurse towards alarms and alarm policy in the ICU?*

As shown in table 2, the majority of survey respondents (n=10, 83%) when asked if "nuisance alarms occur frequently" strongly agreed. When asked if those same nuisance alarms disrupt patient care, 91.7% commented that they strongly agreed. Likewise, the same amount of respondents either strongly agreed (n=8, 66.7%) or agreed (n=3, 25%) that "nuisance alarms reduce trust in alarms and cause care givers to inappropriately turn alarms off at times other than setup or procedural events". There was neutrality amongst the majority when asked if "there have been frequent instances where alarms could not be heard and were missed" (n=5, 42%).However, seven either disagreed or strongly disagreed that "clinical staff is sensitive to alarms and responds quickly" with one person not responding. 10 people either agreed or strongly agreed that "environmental background noise has interfered with alarm recognition" while two disagreed or strongly disagreed.

In regard to hospital policy the majority (66.7%), disagreed that "clinical policies and procedures regarding alarm management are effectively used in my facility, while two either agreed or strongly agreed and one was neutral. Similarly, the majority either disagreed or strongly disagreed that "there is a requirement in your institution to document that the alarms are set and are appropriate for each patient" (85.3%). The same percentage were unsure if the "…institution [has] developed clinical alarm improvement initiatives over the last two years", while seven identified that their institution has "experienced adverse patient events in the last

two years related to clinical alarm problems. No one answered “no” to that question, but five were not sure. Please refer to Appendix A for all survey question responses.

Table 2

Salient Pre-intervention Survey Responses

Questions	n (%)	Median Score[a]
Nuisance alarms occur frequently (n=12)		1
Strongly agree	10 (83.3)	
Agree	1 (8.3)	
Neutral	1 (8.3)	
Disagree	0	
Strongly Disagree	0	
Nuisance alarms disrupt patient care (n=12)		1
Strongly agree	11 (91.7)	
Agree	0	
Neutral	1 (8.3)	
Disagree	0	
Strongly Disagree	0	
Nuisance alarms reduce trust in alarms and cause care givers to inappropriately turn alarms off at times other than setup or procedural events (n=12)		1
Strongly agree	8 (66.7)	
Agree	3 (25)	
Neutral	1 (8.3)	
Disagree	0	
Strongly Disagree	0	
There have been frequent instances where alarms could not be heard and were missed (n=11)		3
Strongly agree	1 (9)	
Agree	3 (27.3)	
Neutral	4 (36.4)	
Disagree	3 (27.3)	
Strongly Disagree	0	
Clinical staff is sensitive to alarms and responds quickly (n=11)		2,3

Strongly agree	1 (9)	
Agree	4 (36.4)	
Neutral	4 (36.4)	
Disagree	0	
Strongly Disagree	2 (18.2)	
Environmental background noise has interfered with alarm recognition (n=12)		2
Strongly agree	2 (16.7)	
Agree	8(66.7)	
Neutral	0	
Disagree	1 (8.3)	
Strongly Disagree	1 (8.3)	
Clinical policies and procedures regarding alarm management are effectively used in my facility (n=12)		4
Strongly agree	1 (8.3)	
Agree	1 (8.3)	
Neutral	2 (16.7)	
Disagree	5 (41.7)	
Strongly Disagree	3 (25)	
There is a requirement in your institution to document that the alarms are set and are appropriate for each patient (n= 12)		4
Strongly agree	0	
Agree	3 (25)	
Neutral	2 (16.7	
Disagree	4 (33.3)	
Strongly Disagree	3 (25)	
Has your institution experienced adverse patient events in the last two years related to clinical alarm problems (n=12)		1
Yes	8 (66.7)	
No	0	
Unsure	4 (33.3)	
Has your institution developed clinical alarm improvement initiatives over the past two years (n=12)		2
Yes	1 (8.3)	
No	4 (33.3)	
Unsure	7 (58.3)	

Note. [a]Scoring system: strongly agree=1, agree;=2: neutral=3: disagree=4: strongly disagree=5. 1= yes; 2=no.

Research question 2: *Does re-education of the critical care nurse regarding the hospital policy on clinical alarm management including making a formalized bedside nurse handoff alarm parameter check reduce the incidence of total alarms, including false and non-critical in the ICU?*

Preintervention alarm rates were manually counted from 11/7/2016-11/11/11/2016 during the hours of 1730-1930. The type of alarm, whether it was true or false and then if indeed true whether it was critical or non-critical based on the clinical situation was recorded. The recording was done by one investigator for each night. The total amount of alarms counted for that time frame during the five days was 511 alarms. Taking into consideration the census, which was an average of 11 monitored beds per day for the pre-intervention week, the average daily alarm count per monitored bed was 9.16 alarms for that two hour period.

Eight subtypes of alarms were identified, including: arterial low or high, noninvasive blood pressure low or high, respiratory rate low or high, pulse oximetry saturation low, arrhythmia, heart rate low or high, noninvasive blood pressure measurement failure and probe off identification. During the preintervention manual collection, of the total 511 alarms 193 or 37.8% were secondary to an arterial blood pressure alarm (either high or low) followed by 121 or 23.7% secondary to a low or high heart rate alarm. Of the total alarms, 392 were true alarms, or 76.7% and119 or 23.3% were false alarms. Of the 392 alarms, 285 were considered to be non-critical, or 72.7% and 107 were critical or 27.3%.

Postintervention alarm rates were counted on 12/26/2016 to 12/30/2016 from 1730 to 1930 hours. The same sub-type of alarms were measured as in the preintervention collection. In total 97 alarms were counted, but there were none falling into the “probe off” or “non-invasive blood pressure measurement failure”. Of the 97 alarms, 33 or 34% were secondary to pulse

oximetry saturation low or high followed by second most frequent type with 18, or 18.6%, the non-invasive blood pressure measurement alarm. Of the 97 alarms 44 were true alarms and 53 were false, or 45.4% and 54.6%, respectively. The 44 true alarms were comprised of 19 noncritical alarms, or 43.2% of total true alarms and 25 critical alarms or 56.8% of total true alarms. There was statistically significant decrease in all subtypes of alarms between pre and postintervention except for false alarms.

Table 3 displays the side by side comparison of pre and postintervention alarm rates based on veracity and variable measured.

Table 3

Alarm frequency manual measure per variable

	True (%)/OB	False (%)/OB	Non critical (%)/OB	Critical (%)/OB
Pre	392 (76.7)/35.3	119 (23.3)/10.6	285(72.7)/25.3	107(27.3)/12.3
Post	44(45.4)/6.4	53(54.6)/9.1	19(43.2)/3.42	25(56.8)/3.9
Difference	28.9(p= 0.002)	1.5 (p= 0.2)	22.1 (p= 0.01)	8.4(p= 0.04)

Note. OB: per occupied bed. Difference is per OB ; % of noncritical and critical per total true alarms

The preintervention and postintervention alarm rates per occupied hospital bed were compared using a standard t-test for two samples means. Utilizing the manually counted alarms between 11/7/2016-11/11/2016 (preintervention) and subsequent to the educational sessions the alarms counted between 12/26/2016-12/30/2016 there was a statistically significant decrease (n=29.6 or 64.6%) in the total number of alarms per occupied beds, with a p value of 0.008, which is less than accepted p value of 0.05.

Table 4 compares side by side the pre and postintervention alarm frequency data.

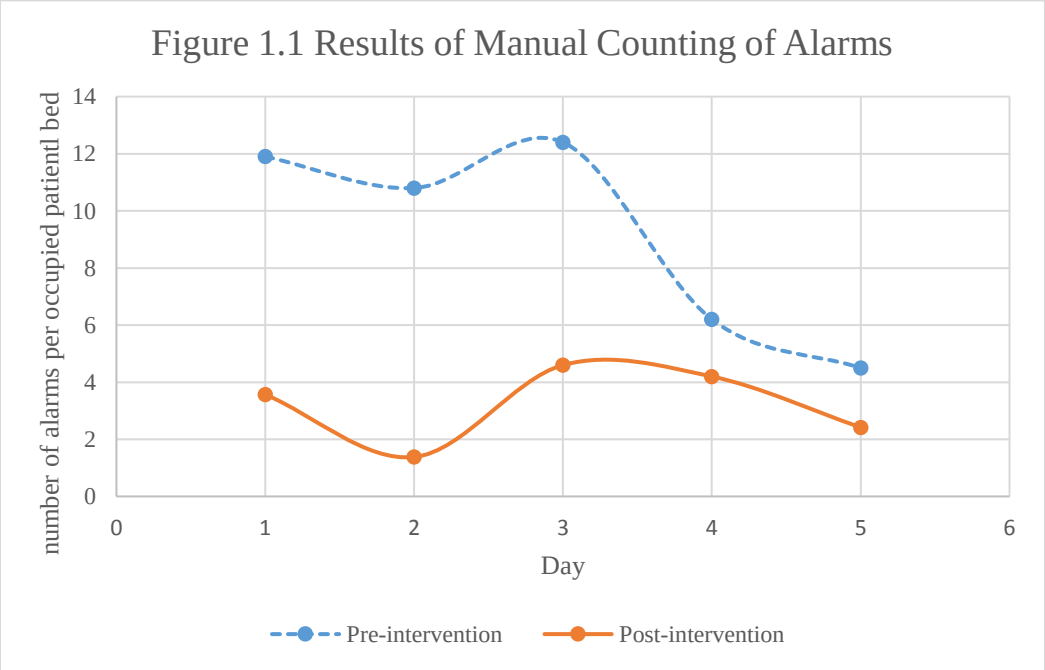
Table 4

Total alarm frequency manual measure per occupied bed 1730-1930 hours

	Day 1	Day 2	Day 3	Day 4	Day 5	Total	p value
Pre-intervention	11.9	10.8	12.4	6.2	4.5	45.8	
Post-intervention	3.6	1.4	4.6	4.2	2.4	16.2	
Difference						29.6	p= 0.008

Note. Occupied bed derived from actual census at time of measure

Figure 1.1 displays the manually counted alarms per occupied patient bed



The alarm rates were also counted using already existing middleware software owned by the academic medical center where this study took place. The software, Connexall, calculates alarm data generated by the eight subtypes mentioned above, in addition to another alarm type "respiratory rate impedance" which does not created an audible alarm but rather just visual. The

alarm data that the software compiles does not distinguish whether an alarm is true or false. Additionally, although not known at the time of data collection, the Connexall software's tally of alarm rates will include and exclude alarm signals based on how the alarm message is received. For example, if a nurse silences the alarm at the bedside this may not be counted, likewise if the alarm sounds and is not recognized after two minutes another "message" may be sent but is in fact the same original alarm. The same five day period for both preintervention and postintervention data was examined, and total alarm rates were divided by the number of occupied beds for that same two hour period (1730-1930). In total, there were 162 total preintervention and 78 postintervention alarms.

When the raw pre and postintervention alarm frequencies (not based on occupied bed) were compared using a t-test for two sample means there was a statistical significance difference found between the preintervention and postintervention time span, with a p value of 0.02 (accepted p value for statistical significance is <0.05). When the pre and postintervention data was then adjusted for occupied bed, there was no statistical significance found (p=0.73). Table 5 displays the side by side comparison for the pre and post-intervention frequencies for Connexall data per occupied bed.

Table 5

Total alarm frequency Connexall measure per occupied bed 1730-1930 hours.

	Day 1	Day 2	Day 3	Day 4	Day 5	Total	p value
Pre-intervention	2.7	2.2	3.6	1.8	4.6	14.9	
Post-intervention	2.7	2.9	4.6	1.6	1.8	13.6	
Difference						1.3	0.73

Note. Occupied bed derived from actual census at time of measure

When the manual alarm frequency data was compared to the Connexall generated data, there were multiple discrepancies found. Although both do find a decrease in total alarms, the Connexall data is not statistically significant. However, given the discrepancies this data was deemed unreliable.

Summary

This quality improvement research study's findings suggest that the methods employed in the educational sessions are effective in lowering the frequency of unnecessary alarms in the intensive care unit. Comparing pre and postintervention manually counted alarm rates, there was a statistically significant decrease in rates of alarms after the intervention. Nurse's identified nuisance alarms as a problem within the ICU and that they occur frequently and disrupt patient care. They identified a perception of ineffective clinical alarm policies and procedures regarding alarm management and that in their institution in the last two years, there has been an adverse patient event related to clinical alarm problems. After review of the manual and Connexall generated data and revelation of extreme discrepancies, with the exception of the third day's postintervention data, it was felt that the Connexall generated data was not reliable enough to utilize in making assumptions about the effectiveness of the educational sessions.

Chapter 5: Discussion

Introduction

One of the primary goals of care delivered in the ICU is that it is safe both in provision and maintenance, both in what is being done and the outcomes or effectiveness. Alarm fatigue produces a potentially dangerous environment that impairs the ability to provide safe care. This creates a lack of synergy between the patient and the nurse. The aim of this quality improvement research study was to improve the policy and process for monitoring alarms in an attempt to reduce the total number of alarms including the non-critical and false alarms that contribute to the incidence of alarm fatigue and the potential for unsafe conditions. By reviewing the already existing evidence based hospital policy on clinical alarms in the form of a face to face educational session as well as implementing a formal RN to RN bedside alarm parameter check there was a statistically significant decrease in total number of alarms per occupied patient bed including a statistically significant decrease in non-critical alarms and false alarms. This study also supports the idea that the DNP prepared nurse has the knowledge and skill set to successfully plan and implement an evidence based quality improvement initiative.

Variables

False alarms. In this quality improvement research study, the majority (76.7%) of alarms in the preintervention data were true alarms and therefore 23.3% false. This is similar to what Chambrin et al. (1999) found in their observation of 131 patients in five ICU's, in that they too found the majority of alarms (58.2%) to be triggered by patient physiologic factor. This also concurs with Abukhalil et al. (2008) and Inokuchi et al. (2013) who also identified that the majority of alarms are true. The postintervention data identified, however that the majority of

alarms were false alarms which concurs with Drew et al. (2014) in which 88.8% were false. This discrepancy within the literature is confirmed within this study, that one cannot say the majority of alarms are either usually true or usually false.

The possible explanation for the increase in postintervention false alarm rate (54.6%) may be (although decrease in total number and decrease in false alarms) is that the techniques the nurses implemented after the educational sessions while targeted at both false and non-critical alarms, had a bigger effect at true alarms including noncritical. This study was successful, in lowering the total number of false alarms however, and there was not statistical significance even when adjusted for number of occupied bed. Despite a lack of statistical significance, there can be assumed clinical significance. There is no identification of the threshold for alarm fatigue so one could argue that any reduction in false alarms is a potential reduction in the opportunity for alarm fatigue.

Non-critical alarms. This quality improvement research study found that nearly a quarter (preintervention: 21%; postintervention: 25.8%) of the total alarms were actual true critical issues that required attention As the literature has suggested, this study confirms the fact that true critical events are being obscured by alarms that indeed need no intervention by critical care personnel. Additionally, there was a statistically significant decrease in the number of non-critical alarms, reducing the percentages from 55.8% to 19.6% of total alarms.

Total alarm frequency using bundled approach. This quality improvement research study did find a statistically significant decrease in total alarms after the implementation of the educational session reviewing clinical alarm policy. Although it was not possible within the confines of this research study to identify what particular method of the four point bundle was the major causative agent in reducing alarms, the general statistically significant decrease in alarms is

reflective, too, of each individual study who identified that proper skin preparation prior to electrode placement resulted in a statistically significant decrease in the total number of alarms (Dandoy et al. 2004; Graham and Cvach, 2010; Cvach, Biggs, Rothwell and Charles-Hudson, 2012; Sendelbach, Wahl, Anthony and Shotts, 2015; Walsh-Irwin and Jurgens, 2015).

Nurses' perceptions of alarms. In general the responses of the nurses who completed the HTF survey in this quality improvement research study were similar to the responses of all participants captured by Funk, Clark, Bauld, Ott and Coss (2014). This study, found that the majority of respondents either strongly agreed or agreed that "nuisance alarms occur frequently". However, the majority in this study felt strongly that they occur frequently, suggesting perhaps a more dramatic negative perception of the nuisance, or non-critical, alarms. Similarly, the Funk, Clark, Bauld, Ott and Coss (2014) study like this quality improvement study either agreed or strongly agreed that the "nuisance alarms disrupt patient care" and that they "…reduce trust in alarms and cause caregivers to inappropriately turn alarms off at times other than setup or procedural events". The majority of participants felt strongly that the nuisance alarms disrupted care and reduce trust. This provides further confirmation that the nurse included in this quality improvement research study have perhaps a greater frustration with nuisance alarms.

In regard to general alarm issues, there were some dissimilarities between the Funk, Clark, Bauld, Ott and Coss (2014) study, in that this quality improvement research study found that the majority of respondents felt neutral that "there have been frequent instances where alarms could not be heard and were missed" and equal percentage felt that the either agreed or disagreed. In the Funk, Clark, Bauld, Ott and Coss (2014) study, the majority of respondents in both the 2005-2006 and 2011 study disagreed that these instances occurred. It can be reflected that this quality improvement research study's respondents despite strongly feeling that the

nuisance alarms are an issue, do not feel that they are missing actual alarms. Similarly, in this quality improvement research study there were more respondents who either had neutrality to or disagreed with the notion that "clinical staff is sensitive to alarms and responds quickly", suggesting further that they do not see this as a total barrier to alarm management, while alternatively in the Funk, Clark, Bauld, Ott and Coss (2014) study, the majority either agreed or strongly agreed that sensitivity is disrupted (in both the 2005-2006 and 2011 study).

The overall negative perceptions of the nurse's confirms the anticipated belief that they too feel that alarms are an issue within the care environment. By confirming this concept, it can be further generalized that the nurses may be more open to change in practice which may have contributed to the success of this quality improvement research study.

Theoretical Framework

This quality improvement research study successfully utilized the Synergy Model for Patient Care developed by AACN. This study did not measure specifically the reduction in alarm fatigue, but rather the driving component that creates it. It can be assumed that by reducing the number of causative alarms there is a theoretical decrease in the chance for alarm fatigue. These alarms exist in the environment in which the entire critical care team works and the ICU patient is being cared for in. By reducing the barrier within the environment that creates a disconnect between the patients need and the nurse's ability to meet that need, there is an improvement in the synergy within that relationship. The nurse and other care providers can now connect their abilities with the need for the patient.

For the purposes of this study, this theoretical framework worked well as the methodologic background as the intervention provided the opportunity to reduce the barrier

within the environment as well as improve the competency of the nurse both with knowledge (what methods can reduce the false and clinically irrelevant alarms) as well as empower them to intervene when necessary in an effort to reduce unnecessary alarms.

Study Limitations

Through the course of planning and actual intervention of this study the nursing leadership within the ICU where the study took place included three different nurse managers, which could have potentially created frustrations within the nursing staff who were requested to participate in this study. This could have confounded the nursing attitude's survey. Also, there was a decrease in the ICU nursing staff of approximately 13 people, or 43.3% of the 30 RN's asked to participate. This may account for the low survey response rate. This attrition was not predictable and likely would not be predictable in future studies therefore an unavoidable limitation. It is possible that increasing the number of study settings may have aided the response rate, for example extending this into other hospital ICU's or, staying within the same institution, but going to the intermediate care unit where the patients have similar monitoring devices.

Additionally, the two hour time frame of data collection was a limit to the study. An alternative situation may have been 24 hour data collection, however the size of the research team prevented a more expansive time frame for collection. A correction to this would be to enlist additional support personnel trained in assessing alarm frequencies and separating the 24 hour into shifts. If the Connexall data had been reliable, this would have been a possible method of assessing the alarm frequencies for 24 hour total. It still would not have identified the veracity of alarms, however, so manually counting would still be necessary.

Another limitation that possible may have contributed to the RN's responses to the survey as well as global participation in the educational session (participation was not measured) is that the ICU moved from an older building to a brand new adjacent facility approximately five months prior to study implementation. It is possible that the RNs were overwhelmed with learning new devices and monitors, including the cardiac monitor which was integral in the transmission of data as well as possibly not secure in using the equipment as it had only been in use for five months. A solution to this limitation may have been to delay study implementation to allow for more time for the RN's to become more comfortable in their surroundings. Alternatively, it is possible that rather than a limitation the study being implemented during a time of transition may have benefited the nurses, as they were becoming more familiar with the already existing policy.

Impacts for the Future

Impact of evaluation. The decrease in alarms, including the statistically significant reduction in clinically irrelevant alarms (non-critical), suggests that the reeducating the nurses to the existing clinical alarm policy and the bundle effect: proper skin preparation prior to electrode placement, proper placement of electrodes, changing the electrodes every 24 hours and personalizing clinical alarms based on clinical need of the patient, is essential for the theoretical reduction in alarm fatigue. Although future evaluation of alarm rates was not an intended measure within this study, by sharing the results there is the possibility for long lasting efforts amongst the RN's to continue to practice these evidence based techniques.

Interprofessional Collaboration. The registered nurse is not the sole provider of critical care services in the ICU. The ICU team includes physicians at all levels of training, therapists and non-licensed personnel. A concern brought up by RN colleagues during the course of the

educational sessions was that there was pushback from house staff (interns/residents) and advance practice registered nurses. The concern was that it was necessary to change the "notify provider" order in the computerized order entry so that the RN could feel comfortable in adjusting the clinical alarms based on the patient need. For example, if a patient had a resting heart rate of 45, but the notify MD order read "notify if HR <50 or >140" the RN did not want to adjust the heart rate low alarm parameter. Their fear was that they would miss if the heart rate dropped. In this example, however, the concept of the "patient's baseline" was being overlooked. Although the patient's heart rate is low, it is also their personal consistent baseline heart rate. Part of the solution elicited out of this study was for the RN to feel empowered to discuss the importance of personalizing alarms in an effort to reduce the possibility of alarm fatigue. The nurse must recognize the unique personalized patient situation and utilize their competencies in clinical alarms to suggest altering the notify MD order. This empowerment is reflective in the Synergy Model within the domain of collaboration (Kaplow and Reed, 2008). The nurses at the forefront of patient care should feel compelled to collaborate with the other professionals on the ICU team, mainly in this case, physician colleagues.

Although the targeted population for this study was the registered nurse, other team members can potentially benefit from the educational sessions. The health unit clerks who watch the ICU monitors are another point of collaboration in the effort to reduce alarm fatigue. Although they are unlicensed personal, they too have notification responsibilities and could be effected by alarm fatigue. It is a reasonable concept that they too should feel empowered to seek a licensed care giver (RN, APRN, MD) to consider changing alarm parameters to better meet the clinical need of the patient.

Impact on Information Technology. Alarm fatigue is a negative impact as a result of the interaction between technology and human beings. As innovators continue to identify new technology to reduce unnecessary alarms, for example two signal extraction algorithms (Borowski, Diebig, Wrede and Imhoff, 2011), it is clearly still necessary to attempt a human driven reduction plan as evident in this study. Additionally, this study represented the potential for technology related error, as in the miscalculation of alarm rates within the Connexall data. It is essential to have an understanding of how technology aspects all factions of alarms and alarm fatigue.

Implications for Future Studies. One potential future study that could assist in further reduction of alarms in an effort to reduce alarm fatigue is examining if there is a relationship between other demographic data and frequency of alarms. It can be postulated that perhaps more "seasoned" RN's with more years of experience, especially in the ICU, may potentially have more desensitization to alarms than a novice RN who has not been exposed to the cacophony for as long. Also, examining the relationship between care providers from a licensed independent provider is a possible future study, including does the patient whose primary care provider is an APRN have less alarms than one who is a physician. Additionally examining not just patient census, but also critical illness severity, for example correlating the APACHE II score and alarm frequency . It is possible that although there was a reduction in total alarms, by comparing the patient severity index is the decrease statistically significant. It can be assumed that the more monitoring a patient requires, the more severe their critical illness is. One could measure the number of alarming devices per patient as another means to address severity level.

Additionally, it may be beneficial to examine the perceptions of nurses towards the alarms by repeating the HTF survey in a timed follow up study. This is similar to Funk et al.

(2014) who re-issued the survey in 2011. Given that the initial findings were negative perceptions, there is the potential that this future study may find that with an improvement in unnecessary alarms and therefore reduction in alarm fatigue may improve nurse's perceptions.

Implications for Practice. Although this study focuses on the role of the RN in relation to reducing alarm fatigue, their role is not the only responsible party. As any member of the ICU team has the potential for alarm fatigue, reducing the amount of alarms is everyone's responsibility. The APRN must consider this issue as a daily part of their practice. For each patient encounter, it is not unreasonable to also expect them to be alert of alarms sounding and whether they are factual or clinically relevant. This small addition to daily practice routine can possibly further contribute to the reduction in alarms. It allows a gateway of discussion between all members of the ICU team promoting both patient safety and staff awareness. Additionally the evaluation of alarm parameters could be incorporated into the APRN handoff report.

Implications for Policy. From an institutional policy level this study supports the formal addition of a mandatory bedside alarm check, one that had previously been mentioned in the policy but with no accountability. By making it a peer to peer referenced activity at change of shift in addition to checking during daily rounds if the alarm check was completed, there is the opportunity for more personal and peer accountability. Just as a vital sign is recorded in the electronic health record (EHR), so too could the "Alarm Check" to verify that at every nurse to nurse patient handoff this is being completed. Rather than this being a means to identify those who are non-compliant with this activity it can serve as a reminder that if the "Alarm Check" has been forgotten about at shift change, then the recognizing RN finds a colleague to review the alarms with.

Additionally on institutional policy level, the findings from this study suggest that steps directly involving the actions of nurses have the power to reduce the fatal consequences of alarm fatigue. The policy at the academic medical center where this study took place does not require a licensed independent provider (LIP) order to adjust alarm parameters, however, the nurse must be able to notify the provider when a vital signs is outside an expected range. This presents the opportunity for initiation of a nurse driven protocol that assists in identifying proper alarm parameters and when to notify the LIP. This impact on policy can feasibly be constructed with the assistance of the DNP prepared APRN who can be the team leader of the policy change, both from a preparatory stage as well as implementation stage.

On a broader policy level, the argument can be made then that staffing plays a part in alarm fatigue. If a nurse has a large patient load they may not be able to attend to all the clinical alarm needs, which was a similar finding extrapolated from the Honan et al., (2015) study. This study looked at qualitative responses of nurses towards perceptions on clinical alarms and concluded that a lower nurse to patient ratio may better improve attentiveness to alarms and adherence to alarm related policy. This could potentially lead to mandatory staffing minimums per patient census.

Implications for Fiscal Responsibility. The tragic consequences of alarm fatigue demonstrated at Massachusetts General Hospital in 2011 are multifaceted, including actual and perceived safety risks, financial losses and most grave: the loss of human life. From a financial perspective while the value of human life is priceless, the legal system has imposed monetary settlements to compensate families for their loss. This tragic consequence of alarm fatigue is not exclusive to Massachusetts General. In January, 2017 a 5.8 million dollar settlement was reached between a patient's family and a hospital system, citing both the RN and the APRN in the civil penalty. The

jury found that the death of the patient was a result of missed bradycardia alarms and failure to connect a pacemaker. It can easily be argued that alarm fatigue may have been one of the potential reasons for the alarms being missed (Altimari, 2017). While no value nor compensation amount can truly be placed on human life, this settlement reflects an avoidable financial burden.

Implications for Education. Although this policy is part of initial nursing orientation, it is not revisited. Given the success in the alarm reduction as well, and the inability to postulate which of the four steps was the most effective at the reduction, and that it was due to the bundled effect, it is also fair to establish the "Alarm-Check" or RN to RN peer bedside alarm review should be an essential component to shift change bedside reporting and become a mandatory documented activity. Additionally it is a reasonable idea to include a review of the alarm policy on an annual basis for nursing and advance practice staff.

Role of the DNP prepared APRN. The backbone of this quality improvement based research study are based on skill sets that the DNP prepared APRN has expert knowledge of, including recognition of a clinical based problem, identifying the evidence based best practice, understanding the complexity of the system involved and recognizing both potential challenges and identifying ways to surmount them when implementing the evidence based change.

Although the actual intervention component of this project including the simplistic components of the educational sessions were not complicated to deliver, the environment in which this project took place is arguably the most complex in the entire healthcare setting. Implementing the methods in reducing alarm fatigue and sustaining the success of the interventions is appropriately best completed by the DNP prepared APRN who has understanding of both the complex RN bedside environment as well as the demands of the LIP role as well as an understanding of the larger system rather than focus just on the individual.

Additionally the DNP prepared APRN in this quality improvement project has the potential to assist in empowering the RN's to feel confident in their ability to collegially discuss this issue with the house staff physicians and fellow APRN colleagues. The DNP prepared APRN is qualified to take the findings from this study including the perceptions demonstrated by the RN's surveyed here and make institutional, local and national policy change that can impact patient safety, improve care delivery as well as promoting fiscal responsibility.

Summary

It is evident based upon the preintervention survey results that nurses perceived that noncritical alarms and alarms in general that can potentially impact patient safety. There is statistically significant evidence that the reeducation of an evidence based clinical alarm policy, including: proper skin preparation prior to electrode placement, proper placement of electrodes, changing the electrodes every 24 hours and personalizing clinical alarms based on clinical need of the patient as well as implementing the formal practice of bedside alarm personalization verification called an "Alarm Check" reduces the total number of alarms including noncritical or nuisance alarms. The implications of this are that if there is a reduced number of alarms then there theoretically is a reduction in alarm fatigue, reducing the opportunity for fatal sentinel events.

References

AACE Healthcare Technology Foundation. (2007**)** Impact of clinical alarms on patient safety: a report from the American College of Clinical Engineering Healthcare Technology Foundation. *Journal of Clinical Engingeering*.;32:22–33.

AACN. (2013). AACN practice alert alarm management. Retrieved 7 October, 2015 from http://www.aacn.org/wd/practice/docs/practicealerts/alarm-management-practice-alert.pdf

Aboukhalil, A., Nielsen, L., Saeed, M., Mark, R. G., & Clifford, G. D. (2008). Reducing false alarm rates for critical arrhythmias using the arterial blood pressure waveform. *Journal of Biomedical Informatics, 41*(3), 442-451. doi:10.1016/j.jbi.2008.03.003

Albert, N. M., Murray, T., Bena, J. F., Slifcak, E., Roach, J. D., Spence, J., & Burkle, A. (2015). Differences in alarm events between disposable and reusable electrocardiography lead wires. American Journal of Critical Care, 24(1), 67-74 8p. doi:10.4037/ajcc2015663

Altimari, D. (2017, January 25). Jury returns $5.8 million verdict against Hartford Hospital. *The Hartford Courant.* Retrieved from http://www.courant.com/news/connecticut/hc-hartford hospital-lawsuit-20170125-story.html.

American Association of the Colleges of Nursing. (2006). The Essentials of Doctoral Education for Advanced Nursing Practice. Retrieved from http://www.aacn.nche.edu/dnp/Essentials. pdf

About the joint commission. (n.d.). Retrieved October 7, 2015, from http://www.jointcommission.org/about_us/about_the_joint_commission_main.aspx

Association for the Advancement of Medical Instrumentation: Alarms pose challenges to healthcare facilities. (2011). *Biomedical Instrumentation & Technology,* 5-5.

Beckmann, U., Bohringer, C., Carless, R., Gillies, D. M., Runciman, W. B., Wu, A. W., & Pronovost, P. (2003). Evaluation of two methods for quality improvement in intensive care: Facilitated incident monitoring and retrospective medical chart review. *Critical Care Medicine, 31*(4), 1006-1011. doi:10.1097/01.CCM.0000060016.21525.3C

Bitan, Y., Meyer, J., Shinar, D., & Zmora, E. (2004). Nurses' reactions to alarms in a neonatal intensive care unit. *Cogn Technol Work, 6*(4), 239-246. Retrieved from www.scopus.com

Borowski, M., Görges, M., Fried, R., Such, O., Wrede, C., & Imhoff, M. (2011). Medical device alarms. *Biomedizinische Technik, 56*(2), 73-83. doi:10.1515/BMT.2011.005

Brantley, A., Collins-Brown, S., Kirkland, J., Knapp, M., Pressley, J., Higgins, M., & McMurtry, J. P. (2016). Clinical trial of an educational program to decrease monitor alarms in a medical intensive care unit. *AACN Advanced Critical Care, 27*(3), 283-289. doi:10.4037/aacnacc2016110

Chambrin, M. -., Calvelo-Aros, D., Jaborska, A., Chopin, C., Ravaux, P., & Boniface, B. (1999). Multicentric study at monitoring alarms in the adult intensive care unit (ICU): A descriptive analysis. *Intensive Care Medicine, 25*(12), 1360-1366. doi:10.1007/s001340051082

Christensen, M., Dodds, A., Sauer, J., & Watts, N. (2014). Alarm setting for the critically ill patient: A descriptive pilot survey of nurses' perceptions of current practice in an Australian

regional critical care unit. *Intensive and Critical Care Nursing, 30*(4), 204-210. doi:10.1016/j.iccn.2014.02.003

Clochesy, J. M., Cifani, L., & Howe, K. (1991). Electrode site preparation techniques: A follow-up study. Heart and Lung: Journal of Critical Care, 20(1), 27-30. Retrieved from www.scopus.com

Cropp, A. J., Woods, L. A., Raney, D., & Bredle, D. L. (1994). Name that tone: The proliferation of alarms in the intensive care unit. *Chest, 105*(4), 1217-1220. Retrieved from www.scopus.com

Cvach, M. M., Biggs, M., Rothwell, K. J., & Charles-Hudson, C. (2013). Daily electrode change and effect on cardiac monitor alarms: An evidence-based practice approach. *Journal of Nursing Care Quality, 28*(3), 265-271. doi:10.1097/NCQ.0b013e31827993bc

Cvach, M. M., Frank, R. J., Doyle, P., & Stevens, Z. K. (2014). Use of pagers with an alarm escalation system to reduce cardiac monitor alarm signals. *Journal of Nursing Care Quality, 29*(1), 9-18. doi:10.1097/NCQ.0b013e3182a61887

Dandoy, C. E., Davies, S. M., Flesch, L., Hayward, M., Koons, C., Coleman, K., . . . Weiss, B. (2014). A team-based approach to reducing cardiac. *Pediatrics, 134*(6), e1686-e1694. doi:10.1542/peds.2014-1162

Drew, B. J., Harris, P., Zègre-Hemsey, J. K., Mammone, T., Schindler, D., Salas-Boni, R., . . . Hu, X. (2014). Insights into the problem of alarm fatigue with physiologic monitor devices:

A comprehensive observational study of consecutive intensive care unit patients. *PLoS ONE, 9*(10) doi:10.1371/journal.pone.0110274

ECRI (2014) 2015's top 10 health technology hazards. Health Devices. Retrieved October 7, 2015 from https://www.ecri.org/Resources/Whitepapers_and_reports/Top_Ten_ Technology_Hazards_2015.pdf.

Facts about the national patient safety goals (2015, January 13) Retrieved October 7, 2015 from http://www.jointcommission.org/standards_information/npsgs.aspx.

Funk, M., Parkosewich, J. A., Johnson, C. R., & Stukshis, I. (1997). Effect of dedicated monitor watchers on patients' outcomes. *American Journal of Critical Care, 6*(4), 318-323. Retrieved from www.scopus.com

Funk, M., Clark, J. T., Bauld, T. C., Ott, J. C., & Coss, P. (2014). Attitudes and practices related to clinical alarms. *American Journal of Critical Care, 23*(3), e9-e18. doi:10.4037/ajcc2014315

Gazarian, P. K. (2014). Nurses' response to frequency and types of electrocardiography alarms in a non-critical care setting: A descriptive study. *International Journal of Nursing Studies, 51*(2), 190-197. doi:10.1016/j.ijnurstu.2013.05.014

Graham, K. C., & Cvach, M. (2010). Monitor alarm fatigue: Standardizing use of physiological monitors anddecreasing nuisance alarms. *American Journal of Critical Care, 19*(1), 28-34. doi:10.4037/ajcc2010651

Hardin, S.R., & Kaplow, R. (2005). Synergy for clinical excellence: The AACN Synergy Model for Patient Care. Sudbury MA: Jones and Bartlett Publishers.

Honan, L., Funk, M., Maynard, M., Fahs, D., Tobey Clark, J., & David, Y. (2015). Nurses' perspectives on clinical alarms. *American Journal of Critical Care, 24*(5), 387-395. doi:10.4037/ajcc2015552

Inokuchi, R., Sato, H., Nanjo, Y., Echigo, M., Tanaka, A., Ishii, T., . . . Yahagi, N. (2013). The proportion of clinically relevant alarms decreases as patient clinical severity decreases in intensive care units: A pilot study. *BMJ Open, 3*(9) doi:10.1136/bmjopen-2013-003354

Kaplow, R., & Reed, K. D. (2008). The AACN synergy model for patient care: A nursing model as a force of magnetism. *Nursing Economics, 26*(1), 17-25. Retrieved from www.scopus.com

Kerr, J. H., & Hayes, B. (1983). An "alarming" situation in the intensive therapy unit. *Intensive Care Medicine, 9*(3), 103-104. doi:10.1007/BF01772574

Kohr, L. M., Hickey, P. A., & Q. Curley, M. A. (2012). Building a nursing productivity measure based on the synergy model: first steps. American Journal of Critical Care, 21(6), 420-431 12p. doi:10.4037/ajcc2012859

Kohn, L. (2000). *To err is human building a safer health system*. Washington, D.C.: National Academy Press.

Korniewicz, D. M., Clark, T., & David, Y. (2008). A national online survey on the effectiveness of clinical alarms. *American Journal of Critical Care, 17*(1), 36-41. Retrieved from www.scopus.com

Kowalczyk, L. (2010) MGH death spurs review of patient monitors. Available: http://www.boston.com/news/health/articles/2010/02/21/mgh_death_spurs_review_of_patient_monitors/?pages=1 Accessed 15 September, 2015.

Lukasewicz, C. L., & Mattox, E. A. (2015). Understanding clinical alarm safety. *Critical Care Nurse, 35*(4), 45-57. doi:10.4037/ccn2015113

Makary, M. A., & Daniel, M. (2016). Medical error-the third leading cause of death in the US. *BMJ (Online), 353* doi:10.1136/bmj.i2139

Melnyk, B. M., & Fineout-Overholt, E. (2011). *Evidence-based practice in nursing & healthcare: A guide to best practice* (3rd ed.). Wolters Kluwer.

Medina, V., Clochesy, J. M., & Omery, A. (1989). Comparison of electrode site preparation techniques. Heart and Lung: Journal of Critical Care, 18(5), 456-460. Retrieved from www.scopus.com

Sendelbach, S. (2012). Alarm fatigue. *Nursing Clinics of North America*, *47*(3), 375-382. doi:10.1016/j.cnur.2012.05.009

Sendelbach, S., & Jepsen, S. (2015). Alarm management. Retrieved from www.scopus.com

Sendelbach S, Jepsen S. Alarm management. (2013) Retrieved October 25, 2015 from http://www.aacn.org/wd/practice/content/practicealerts/alarm-management-practice-alert.pcms?menu=practice.

Sendelbach, S., Wahl, S., Anthony, A., & Shotts, P. (2015). Stop the noise: A quality improvement project to decrease electrocardiographic nuisance alarms. *Critical Care Nurse, 35*(4), 15-22. doi:10.4037/ccn2015858

Sentinel Event. (2015). In *Comprehensive Accreditation Manual for Hospitals* (2nd ed.). http://www.jointcommission.org/assets/1/6/CAMH_24_SE_all_CURRENT.pdf

Sentinel Event Policy and Procedures. (2014, November 19). Retrieved October 7, 2015, from http://www.jointcommission.org/Sentinel_Event_Policy_and_Procedures/default.aspx

Siebig, S., Sieben, W., Kollmann, F., Imhof, M., Bruennler, T., Rockmann, F., . . . Wrede, C. E. (2009). Users' opinions on intensive care unit alarms - A survey of German intensive care units. *Anaesthesia and Intensive Care, 37*(1), 112-116. Retrieved from www.scopus.com

Solet, J. M., & Barach, P. R. (2012). Managing alarm fatigue in cardiac care. *Progress in Pediatric Cardiology, 33*(1), 85-90. doi:10.1016/j.ppedcard.2011.12.014

The Joint Commission sentinel event alert: Medical device alarm safety in hospitals. (2015). Retrieved from www.scopus.com

The Joint Commission (2016). *National Patient Safety Goals*. Retrieved February 15, 2016, from https://www.jointcommission.org/assets/1/6/2016_NPSG_HAP_ER.pdf

Titler, M. (2008). The evidence for evidence-based practice implementation. In *Patient safety and quality: An evidence-based handbook for nurses*. Rockville (MD): Agency for Healthcare Research and Quality.

Walsh-Irwin, C., & Jurgens, C. Y. (2015). Proper skin preparation and electrode placement decreases alarms on a telemetry unit. *Dimensions of Critical Care Nursing, 34*(3), 134-139. doi:10.1097/DCC.0000000000000108

Whalen, D. A., Covelle, P. M., Piepenbrink, J. C., Villanova, K. L., Cuneo, C. L., & Awtry, E. H. (2014). Novel approach to cardiac alarm management on telemetry units. *Journal of Cardiovascular Nursing, 29*(5), E13-E22. doi:10.1097/JCN.0000000000000114

Wysong, P. R., & Driver, E. (2009). Patients' perceptions of nurses' skill. *Critical Care Nurse, 29*(4), 24-37. doi:10.4037/ccn2009241

Zwieg, F. H., Karfonta, T. L., Jeske, L. J., Kollauf, C. R., White, S. K., Drazewski, R. E., & Leske, J. (1998). Arrhythmia detection and response in a monitoring technician and pocket paging system. *Progress in Cardiovascular Nursing, 13*(1), 16-"22, 33". Retrieved from www.scopus.com

Appendix A

Pre-intervention Survey Responses

Questions	n (%)	Median Score
Alarm sounds and/or visual displays should differentiate the priority of alarm (N=12)		1
Strongly agree	10 (83.3)	
Agree	2 (16.7)	
Neutral	0	
Disagree	0	
Strongly Disagree	0	
Alarm sounds and/or visual displays should be distinct based on the parameter (e.g. heart rate) or source (device type) (n=12)		1
Strongly agree	7 (58.3)	
Agree	4 (33.3)	
Neutral	1 (8.3)	
Disagree	0	
Strongly Disagree	0	
Nuisance alarms occur frequently (n=12)		1
Strongly agree	10 (83.3)	
Agree	1 (8.3)	
Neutral	1 (8.3)	
Disagree	0	
Strongly Disagree	0	
Nuisance alarms disrupt patient care (n=12)		1
Strongly agree	11 (91.7)	
Agree	0	
Neutral	1 (8.3)	
Disagree	0	
Strongly Disagree	0	
Nuisance alarms reduce trust in alarms and cause care givers to inappropriately turn alarms off at times other than setup or procedural events (n=12)		1
Strongly agree	8 (66.7)	
Agree	3 (25)	
Neutral	1 (8.3)	

Disagree	0	
Strongly Disagree	0	
Properly setting alarm parameters and alerts is overly complex in existing devices (n=12)		4
Strongly agree	2 (16.7)	
Agree	2 (16.7)	
Neutral	2 (16.7)	
Disagree	5 (41.7)	
Strongly Disagree	1 (8.3)	
Newer monitoring systems (e.g., less than three years old) have solved most of the previous problems we experienced with clinical alarms (n=12)		4
Strongly agree	0	
Agree	1 (8.3)	
Neutral	1 (8.3)	
Disagree	6 (50)	
Strongly Disagree	4 (33.3)	
The integration of clinical alarms into the Joint Commission patient safety measures, have reduced patient averse events (n=11)		3
Strongly agree	0	
Agree	2 (18.2)	
Neutral	6 (54.5)	
Disagree	0	
Strongly Disagree	3 (13.6)	
The alarms used on my floor/area of the hospital are adequate to alert staff of potential or actual changes in a patient's condition (n=11)		2
Strongly agree	0	
Agree	6 (54.5)	
Neutral	1 (9.1)	
Disagree	2 (18.2)	
Strongly Disagree	2 (18.2)	
There have been frequent instances where alarms could not be heard and were missed (n=11)		3
Strongly agree	1 (9)	
Agree	3 (27.3)	

Neutral	4 (36.4)	
Disagree	3 (27.3)	
Strongly Disagree	0	
Clinical staff is sensitive to alarms and responds quickly (n=11)		2,3
Strongly agree	1 (9)	
Agree	4 (36.4)	
Neutral	4 (36.4)	
Disagree	0	
Strongly Disagree	2 (18.2)	
The medical devices used on my unit/floor all have distinct outputs (i.e., sounds, repetition rates, visual displays, etc.) that allow users to identify the source of the alarm (n=12)		2
Strongly agree	0	
Agree	6 (50)	
Neutral	3 (33.3)	
Disagree	1 (8.3)	
Strongly Disagree	2 (16.7)	
When a number of devices are used with a patient, it can be confusing to determine which device is in an alarm condition (n=12)		2
Strongly agree	2 (16.7)	
Agree	5 (41.7)	
Neutral	3 (33.3)	
Disagree	1 (8.3)	
Strongly Disagree	1 (8.3)	
Environmental background noise has interfered with alarm recognition (n=12)		2
Strongly agree	2 (16.7)	
Agree	8(66.7)	
Neutral	0	
Disagree	1 (8.3)	
Strongly Disagree	1 (8.3)	
Central alarm management staff responsible for receiving alarm messages and alerting appropriate staff is helpful (n=12)		2
Strongly agree	2 (16.7)	
Agree	4 (33.3)	

Neutral	3 (25)	
Disagree	3 (25)	
Strongly Disagree	0	
Alarm integration and communication systems via pagers, cell phones, and other wireless devices are useful for improving alarms management and response (n=12)		2
Strongly agree	0	
Agree	4 (33.3)	
Neutral	3 (25)	
Disagree	3 (25)	
Strongly Disagree	2 (16.7)	
Clinical policies and procedures regarding alarm management are effectively used in my facility (n=12)		4
Strongly agree	1 (8.3)	
Agree	1 (8.3)	
Neutral	2 (16.7)	
Disagree	5 (41.7)	
Strongly Disagree	3 (25)	
There is a requirement in your institution to document that the alarms are set and are appropriate for each patient (n= 12)		4
Strongly agree	0	
Agree	3 (25)	
Neutral	2 (16.7	
Disagree	4 (33.3)	
Strongly Disagree	3 (25)	
Has your institution experienced adverse patient events in the last two years related to clinical alarm problems (n=12)		1
Yes	8 (66.7)	
No	0	
Unsure	4 (33.3)	
Has your institution developed clinical alarm improvement initiatives over the past two years (n=12)		2
Yes	1 (8.3)	

No	4 (33.3)	
Unsure	7 (58.3)	
Has your healthcare institution instituted new technological solutions to improve clinical alarm safety (n=12)		3
Yes	3 (25)	
No	3 (25)	
Unsure	6 (50)	

Appendix B

HTF HealthcareTechnology FOUNDATION

REDUCING ALARM FATIGUE IN THE ICU: A QUALITY IMPROVEMENT RESEARCH STUDY

1) In the right upper corner box, please write the first two letters of your favorite ice cream flavor followed by the first three letters of your street name for anonymous coding.
2) Do not write any identifying information on this survey.
3) When done, please place survey into the box labeled "ALARM SURVEYS".

Staff Type:

- Permanent ICU Staff
- Critical Care Float Pool

1. Alarm sounds and/or visual displays should differentiate the priority of alarm:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

2. Alarm sounds and/or visual displays should be distinct based on the parameter (e.g. heart rate) or source (device type):

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

3. Nuisance alarms occur frequently:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly
- disagree

4. Nuisance alarms disrupt patient care:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

5. Nuisance alarms reduce trust in alarms and cause care givers to inappropriately turn alarms off at times other than setup or procedural events:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

6. Properly setting alarm parameters and alerts is overly complex in existing devices:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

7. Newer monitoring systems (e.g., less than three years old) have solved most of the previous problems we experienced with clinical alarms:

- Strongly agree

- Agree
- Neutral
- Disagree
- Strongly disagree

8. The integration of clinical alarms into the Joint Commission patient safety measures, have reduced patient adverse events:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

9. The alarms used on my floor/area of the hospital are adequate to alert staff of potential or actual changes in a patient's condition:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

10. There have been frequent instances where alarms could not be heard and were missed:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

11. Clinical staff is sensitive to alarms and responds quickly:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

12. The medical devices used on my unit/floor all have distinct outputs (i.e., sounds, repetition rates, visual displays, etc.) that allow users to identify the source of the alarm:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

13. When a number of devices are used with a patient, it can be confusing to determine which device is in an alarm condition:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

14. Environmental background noise has interfered with alarm recognition:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

15. Central alarm management staff responsible for receiving alarm messages and alerting appropriate staff is helpful:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

.

16. Alarm integration and communication systems via pagers, cell phones, and other wireless devices are useful for improving alarms management and response:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

17. Clinical policies and procedures regarding alarm management are effectively used in my facility:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

18. There is a requirement in your institution to document that the alarms are set and are appropriate for each patient:

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

19. Has your institution experienced adverse patient events in the last two years related to clinical alarm problems?

- Yes
- No
- Not sure

20. Has your institution developed clinical alarm improvement initiatives over the past two years?

- Yes
- No
- Not sure

21. Has your healthcare institution instituted new technological solutions to improve clinical alarm safety?

- Yes
- No
- Not sure

Demographic Data:

Age

- 18-29
- 30-39
- 40-49
- 50-59
- >60

Years of Experience as an RN:

- 0-2
- 3-8
- 9-15
- 16-25
- >25

Gender

- Male
- Female

Appendix C

AMERICAN ASSOCIATION of CRITICAL-CARE NURSES

March 10, 2017

Megan Speich

Avon, CT 06001

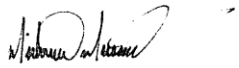
Dear Ms. Speich:

Thank you for your reuse permission request. We hereby grant permission for your reuse of the AACN copyrighted content indicated below, free of charge, subject to the following conditions:

1. Suitable acknowledgment to the original source must be made as follows: Curley AC. Patient-nurse synergy: optimizing patients' outcomes. *Am J Crit Care.* 1998;7(1):69. Reprinted with permission by: Alspach G. Extending the Synergy Model to preceptorship. *Crit Care Nurse.* 2006;26(2):10. ©1998,2006 by the American Association of Critical-Care Nurses. All rights reserved. Reprinted with permission from AACN.
2. Content will be reproduced in full one time only in an unpublished clinical practice dissertation written by the requester.
3. For different use cases, such as future publication, please reapply.

Thank you for your interest in the American Association of Critical-Care Nurses.

Sincerely,



Michael Muscat
Publishing Manager

Accepted:

SIGNATURE TITLE DATE

UCONN

Megan Speich <megan.mcnally@uconn.edu>

HTF Clinical Alarm Survey

Megan Speich <megan.mcnally@uconn.edu> Wed, Jan 13, 2016 at 10:03 PM
To: Marjorie.Funk@yale.edu

Dear Dr. Funk,

My name is Megan Speich, and I am a student in the DNP Program at UConn as well as a critical care nurse practitioner at the UConn Health Center in Farmington. I am writing you to ask permission to utilize and modify the HTF clinical alarm survey that you described in your 2014 AJCC article: Attitudes and practices related to clinical alarms.

My purpose of using this tool is for my Clinical Practice Dissertation which is a quality improvement project looking to identify if a clinical alarm management bundle reduces the amount of non-critical and false alarms in an intensive care unit as well as examining nurses attitudes towards alarms.

My modification to the survey would be to eliminate some questions that are not applicable to my unit's situation.

Your research has been an integral component to my dissertation, and I think that there is a real possibility that this quality improvement project might create major positive change in my ICU.

With appreciation,
Megan Speich

UConn School of Nursing
Doctor of Nursing Practice Student
--
UConn Health
Critical Care Nurse Practitioner
Adult Intensive Care Unit
C-860 543 1686

UCONN

Megan Speich <megan.mcnally@uconn.edu>

HTF Clinical Alarm Survey

Funk, Marjorie <marjorie.funk@yale.edu> Wed, Jan 13, 2016 at 10:26 PM
To: Megan Speich <megan.mcnally@uconn.edu>
Cc: "Ott, Jennifer C" <Jennifer.Ott2@mercy.net>

Hi Megan –

Thanks for your interest in our survey! We would be happy to have you use questions from our survey. I have copied Jennifer Ott, Secretary of the Healthcare Technology Foundation, who can provide the official release document. Once you sign and return that to her, she will send you the survey as a Word document.

I'm just curious . . . what is in the bundle that you are testing?

All the best with your project! I'll be interested to hear about your results.

Marge

Marjorie Funk, PhD, RN, FAHA, FAAN

Helen Porter Jayne and Martha Prosser Jayne Professor of Nursing

Yale School of Nursing

Yale University West Campus

P.O. Box 27399

West Haven, CT 06516-7399

Telephone: 203-737-2346

Fax: 203-737-4480

E-mail: marjorie.funk@yale.edu

Shipping Address: 400 West Campus Drive, Orange, CT 06477

From: Megan Speich [mailto:megan.mcnally@uconn.edu]
Sent: Wednesday, January 13, 2016 10:04 PM
To: Funk, Marjorie <marjorie.funk@yale.edu>
Subject: HTF Clinical Alarm Survey

Appendix D

UCONN HEALTH

Institutional Review Board
Human Subjects Protection Program

Full AAHRPP Accreditation

To: Paula McCauley, DNP, Principal Investigator

From: IRB Office

Date: October 27, 2016

Re: **Final Approval of Exempt Research**
IRB Number: 17-053S-2 ***IRB Panel:*** Panel 2
Project Title: Reducing alarm fatigue: a quality improvement initiative.
Submission Reference#: 008697
Sponsor / Funding Agency: Principal Investigator
Approved Key Study Personnel: *Jaclyn Cox, DO*

****

Please submit a study closure notice to the IRB upon completion of this project.

****

The study referenced above has received final approval from the IRB. The study was approved on 10/27/2016. The study was determined to qualify for exempt status as follows:

Category 2: Educational tests un-linkable to individuals and no risks from disclosure.
Please note that this study is subject to review by the Research Compliance Monitor.

It is the responsibility of the PI to ensure that all investigators and staff associated with this study fo low the approved protocol and use the approved forms in order to maintain compliance with the exemptior that has been granted.

If any changes to the design of the study or data collection instruments are contemplated, the PI should submit a request for modification to the IRB to ensure that the change will not impact the exempt status of the study.

If the IRB imposed a requirement of consent, the IRB stamped and dated informed consent form mu st be used when obtaining consent. If signatures are required, the consent form must be signed and dated by both the participant and the individual obtaining consent.

If applicable, PI's are also responsible for ensuring that IRB approval has been obtained and maintained at any collaborating sites involved in the research.

As a reminder, if you are going to recruit subjects through any type of advertising (fliers, newspaper ads, radio ads, web advertising, Billboards, etc.), all materials must be reviewed and approved by the Health Marketing and Multimedia Services Department. You may contact that Department by calling 860-679-4864.

c: Relying IRB

263 Farmington Avenue
Farmington CT 06030-1511
Telephone: 860-679-3054 Fax: 860-679-1005

UCONN

To: Patricia Gneiting
Coordinator Panel 3
Human Subjects Protection Office
University of Connecticut Health Center
Munson Building, 2nd Floor
263 Farmington Avenue
Farmington, CT 06030-3926

From: Douglas Bradway, M.A., CIP
Office of Research Compliance

Date: November 4, 2016

Re: Acceptance of IRB Review – Designation as IRB of Record

Protocol Title: Reducing alarm fatigue: a quality improvement initiative
UCHC IRB Number: 17-053S-2
UCHC Principal Investigator: Paula McCauley, DNP
Storrs Principal Investigator: Megan Speich
Storrs Student Investigator: Paula McCauley, DNP
Storrs Protocol Number: UCHC17-053S-2
Storrs Proposal Number: N/A

On November 4, 2016, the Institutional Review Board of the University of Connecticut (UConn) accepted the review conducted by your institution for the study noted above. The Storrs IRB will accept the UCHC IRB review of the study noted above. Per the cooperative agreement in place, the IRB of the University of Connecticut Health Center will serve as the IRB of record for this study, and, therefore, be responsible for all continuing review and review of amendments. Additionally, the UConn IRB is to be informed of all instances of non-compliance or unanticipated problems, related to this study, should they occur.

Please forward copies of IRB approval letters and study related activities to the UConn's Office of Research Compliance Services.

cc: Megan Speich
Paula McCauley

Office of the Vice President for Research
Research Compliance Services
438 WHITNEY ROAD EXTENSION UNIT 1246
STORRS, CT 06269-1246
PHONE 860 486 8802
FAX 860 486 1044
compliance.uconn.edu

Appendix E

Dear Colleagues,

As part of my clinical practice dissertation, I will be conducting a quality study aimed at reducing alarm fatigue within the Intensive Care Unit.

I am asking if you would be willing to participate in this study by taking two short surveys (5 minutes each) before and after a brief (10 minute) educational session which will be offered in the mornings before and after shift change for one week starting on 11/14/16 in the ICU by the central nursing station (University Tower, first floor S).

The survey will be looking at your attitudes and feelings towards alarms and alarm related policy.

The study will consist of a brief review of the already existing cardiac (vital sign) alarm policy and introduction of a name for the bedside nurse to nurse verification of clinical alarm limits (this is a step you should already be doing), which will be called the “A-Check”.

Starting 11/7/16 I will be on the unit to answer any questions and to deliver the surveys, which will be placed in everyone’s mail box.

If you are willing to participate, please return the surveys completed which will imply consent to participate in this study.

With much appreciation,

Megan Speich, APRN

INFORMED CONSENT-PRETEST
REDUCING ALARM FATIGUE IN THE ICU: A QUALITY IMPROVEMENT RESEARCH STUDY

Dear Participant,

You are being invited to participate in an anonymous research study sponsored by the UConn School of Nursing because you have been identified as one of approximately 30 UConn Health nurses working in critical care. This study is being completed by Megan Speich, APRN, UConn School of Nursing Doctor of Nursing Practice student as part of her clinical practice dissertation project. It is being done under the direction of Paula McCauley, DNP and primary investigator.

This study is aimed at reducing alarm fatigue as well as researching nurse's attitudes and feelings towards alarms and alarm related policies in the intensive care unit (ICU). This study will include a survey to be completed now and again after an educational session reviewing UConn Health's cardiac alarm policy. The survey should take no more than 5 minutes to complete.

The educational sessions will consist of a ten minute session reviewing UConn Health's current cardiac alarm policy. These sessions will occur during your shift, just before the end (night shift at 0650-0700) or the beginning (day shift: 0735-0745) of your shift. They will be offered for one week starting on 11/XX/2016. Secondly, alarm frequency rates will be calculated prior to and after the educational intervention.

The educational session will include discussion of the implementation of an "A-Check" which is the new name being given to a component already included in the existing policy aimed at reviewing patient's personal alarms. The "A-Check" is an actionable event where both nurses involved in patient handoff shift report will go to the patient's bedside and review that the clinical alarms are in fact appropriate for meeting the clinical needs of the patient. After the "A-Check" is completed, both RN's will initial a card placed on the front of the patient's bedside chart.

There should be no additional risks associated with completion of this study and in total of the 8 week duration of this study only 20 minutes of your time will be necessary. The intervention is already an existing policy at UConn Health. The benefit you may experience from this research is a reduction in the chance of alarm fatigue as well as improvement in nursing attitudes towards alarms and alarm related policy.

All survey responses will be kept anonymous, however confidentiality cannot be guaranteed as there are demographic questions that could potentially suggest specific respondents.

You will be asked on the first page of the survey to code your individual survey with the first two letters of your favorite ice cream flavor and first three letters of your street name.

Participants will not be specifically identified in any presentations or publications

Participation is voluntary and refusal to participate will involve no penalty or loss of benefit to which you were otherwise entitled. It is acceptable to listen to the educational session but not participate in the study so as to not divulge participation or not.

If you choose to participate you can withdraw or stop at any time. You may skip any question that makes you feel uncomfortable.

Once you complete this survey please place it in the box labeled "ALARM SURVEYS". Please return the survey by XX/XX/16 .

Please contact Megan Speich, MS APRN with any questions at megan.mcnally@uconn.edu or primary investigator Paula McCauley at 860 486 6004/paula.mccauley@uconn.edu .

Completion and return of these surveys implies consent.