2014

Alarm Fatigue: A Technology Hazard

Iracena Santos Lopes
Rhode Island College, isantos_2324@ric.edu

ALARM FATIGUE:
A TECHNOLOGY HAZARD

by

Iracena Santos Lopes

A Major Paper Submitted in Partial Fulfillment

of the Requirements for the Degree of

Master of Science in Nursing

in

The School of Nursing

Rhode Island College

2014

Abstract

This research project sought to investigate the impact of alarm fatigue on nurses in an inpatient adult acute care setting at an academic and magnet medical center in the Northeast. The project methodology included a 12-question survey containing 9- likert and 3 open ended questions, designed by the student researcher. The survey was administered to 48 registered nurses on two telemetry-monitoring units. The survey explored whether nurses are aware of alarm fatigue, and also how their daily workflow was impacted by alarm fatigue. Surveys were anonymous and confidential. Descriptive statistics were performed on the study variables, and responses from three open-ended questions analyzed. The questions did not lend themselves to determining themes. Several respondents did request further telemetry monitoring system review and education. The survey results established that nurses from both units were experiencing alarm fatigue as well as workflow disruption as a result of frequent nuisance alarms. Implications for nursing practice are complex and of great importance given the patient safety implication. Nurses must spearhead initiatives to tackle and mitigate alarm fatigue. Participation at a system level is necessary to review current practice standards and policies in order to drive changes necessary to improve the patient care environment. End users of monitoring systems are in a unique position to work with vendors in order to create monitoring devices with sophisticated capabilities for monitoring which decrease nuisance alarms.

Acknowledgements

Foremost, I would like to express my sincere gratitude to Dr. Cynthia Padula who stimulated me to think critically and formulate concepts at the beginning of this paper, Dr.

Carolyn Wood for the continuous support of my study and research, for her patience, motivation, enthusiasm, and immense knowledge. Her guidance helped me in all the time of research and writing of this paper. I could not have imagined having a better advisor and mentor for my study. I would also like to thank Professor Donna Huntley Newby for her contributions as my second reader and my third reader Dr. Nancy Stone to whom I owe a very important debt for her unwavering support and confidence in me. I would not have been able to make this major accomplishment without all of your contributions and support.

Finally, to my caring, loving, and supportive husband, Milton Lopes: my deepest gratitude. Your encouragement when the times got rough are much appreciated and duly noted. It was a great comfort and relief to know that you were willing to provide management of our household activities while I completed my work. My heartfelt thanks to you and all of my family.

Table of Contents

Alarm Fatigue

Background/ Statement of Purpose

Healthcare is continuously transforming in order to provide patients with innovative treatment options. At the same time, clinicians and organizations aim to provide the best care possible, which includes utilizing some of the most up to date technology, including medical devices with sophisticated settings and multiple alarms. As new technology is phased in and continues to evolve, the issue of alarm fatigue continues to grow and contribute to patient safety issues in acute care settings across the country.

Alarm fatigue is an emerging topic in healthcare, principally in acute care settings. There have been several definitions of alarm fatigue presented by many organizations, including The Joint Commission (TJC). According to TJC (2013), alarm fatigue is defined as "The constant beeping of alarms and an overabundance of information transmitted by medical devices such as ventilators, blood pressure monitors and ECG (electrocardiogram) machines. As a result, clinicians become desensitized or immune to the sounds, and are overwhelmed by information- in short, they suffer from 'alarm fatigue'(p. 1).

The Boston Globe published several articles in a series of investigative reports warning patients of the dangers of alarm fatigue. A 2011 Globe investigation identified at least 216 deaths nationwide from January 2005 to June 2010 linked to alarms on patient monitors including devices that track heart function, breathing and other vital signs (Kawalcyzk, 2013). As if these statistics are not alarming enough, findings of further investigation into many patient deaths indicated that healthcare providers failed to respond to life threatening alarms and changes in patient conditions, which resulted in many of these sentinel events (Kawalcyk). The challenge is further illustrated by the results of a study conducted at John Hopkins Hospital in Baltimore in a 15 bed intensive

care unit. Staff documented an overwhelming 942 alarms per day while working with 100 different alarm systems, which breaks down to about one critical alarm every 90 seconds (Kowalczyk, 2011).

The Emergency Care Research Institute (ECRI) is an independent nonprofit institute that has focused on clinical alarms and best practices in patient safety and quality. The ECRI annually releases a list of top 10 technology hazards in healthcare. In 2010 and 2011, alarm fatigue was second on the list of top 10 technology hazards (ECRI, 2010). However, in 2012, 2013, and 2014 alarm fatigue was identified as number one on the list of top technology hazards (ECRI, 2014). Although physiologic monitors and alarms are designed with the goal of improving patient monitoring and safety, the overwhelming number of alarms on any given inpatient unit may be doing the exact opposite: The result is that caregivers become overwhelmed with efforts to respond to multiple alarms. Caregivers also experience desensitization, resulting in missed alarms, and delayed response to critical alarms further placing patients at risk (ECRI).

As the issue of alarm fatigue continues to surface in news headlines and sentinel events, several organizations in the healthcare arena have also focused on alarm fatigue. The Food and Drug Administration (FDA), the TJC, the ECRI institute as well as the Association for the Advancement of Medical Instrumentation (AAMI) all collaborated in order to create a list of recommendations as part of TJC report aimed at healthcare organizations in order to reduce patient harm related to alarm fatigue. Healthcare organizations were encouraged to review alarm fatigue. The Joint Commission issued a sentinel event alert in April 2013 warning healthcare organizations of the dangers of medical device alarms and their contribution to alarm fatigue in clinicians. The severity of alarm fatigue is further emphasized by the findings of a four-year review (2005-2008) of the FDA medical device-reporting database. These reports are mandatory for device

manufacturers when adverse patient events associated with medical devices occur. There were greater than 560 alarm related patient deaths reported. However, this is likely an underestimate as some may not be reported if manufacturers are not notified of issues with a device (Weil, 2009). The FDA has since set into motion a number of initiatives in order to reduce alarm fatigue. They began by reviewing the process to certify medical devices and provided further education and training to reviewers regarding alarm standards and safety. The FDA also issued a guidance report to the medical device industry in order to notify them of future expectations for alarms on medical devices. Along with this guidance report, the FDA challenged the industry to combat alarm fatigue and work towards creating devices that use multiple physiologic functions at the same time in order to decrease nuisance alarms (FDA, 2012).

The continuous introduction of technology into acute care environments are challenging nurses to manage the unintended consequences of physiological monitors and medical equipment including increased alarms and maintaining competency with numerous pieces of equipment. These challenges are not only related to education and effective use of sophisticated devices but also include managing the many false and nuisance alarms created by many physiologic monitors.

There have been many studies conducted on alarm fatigue; however very little identified that specifically address the impact of alarm fatigue on nurses. It is critical to address this information gap since alarm fatigue clearly affects patient care outcomes. Therefore, the purpose of this research project is to investigate the impact of alarm fatigue on nurses in an inpatient adult acute care setting. The focus will be the degree to which nurses experience alarm fatigue and the impact on nursing workflow.

Literature Review

A literature review on the topic of alarm fatigue was performed utilizing the databases CINHAL, OVID, and Pub Med. The search was conducted on information from 1990 through 2014 and was completed utilizing key words alarm fatigue, monitor alarms, telemetry alarms, physiologic monitoring equipment, critical care monitoring and patient safety.

Introduction

Patient safety has become increasingly important in healthcare, driven by the Institute of Medicine (IOM) reports published in the last decade (IOM, 1999, 2011), and most recently the 2014 national patient safety goal introduced by The Joint Commission, focusing on clinical alarm management and safety, citing the need for improved safety in clinical settings. The American International Group (AIG) conducted a study to obtain a better understanding of what drives patient safety. This study also sought to identify

actionable items that can be executed in order to succeed with patient safety goals. The study used a computer assisted telephone survey, which was administered over a 15 minute time frame**.** Study participants answered questions measuring attitudes and behaviors related to patient safety and hospital risk. The study then further looked at the complexities of patient safety exploring internal and external challenges (AIG, 2013). The sample consisted of 126 hospital executives and 93 hospital risk managers from across the United States (US). The confidence level for this survey was 95% with a +/- 5% margin of sampling error. Results indicated that 96% of total respondents stated that their hospital had a culture of safety. Risk managers and patient safety executives struggled with patient safety and agreed that the situation was further complicated as new technology, regulation, metrics and patient education were introduced. Patient education aimed at helping patient safety is sometimes perceived as having the opposite effect. Only 33% of hospital executives and 37% of risk managers acknowledged that their hospitals needed to undergo major changes in order to maintain the culture of safety in the future. Barriers to patient safety that were identified included lack of teamwork, poor communication, and negative culture.

Inconsistencies regarding who nursing executive and risk managers perceived as being responsible for patient safety were also identified. Of the respondents, 98% of both executives and risk managers agreed that all staff members were responsible for patient safety. However, 52% of executives and 51% of risk managers believe that nurses are primarily responsible for patient safety (AIG, 2013). An additional finding was that 23% of executives and 24% of risk managers admitted that their hospitals are more concerned with publicly reported metrics rather than truly impacting patient safety (AIG, 2013). These findings highlight the difficulties of patient safety and perceptions of those at the helm of this challenge.

In 2003, TJC identified a patient safety goal to improve overall effectiveness of clinical alarms (Korniewicz, Clark, & Yadin, 2008). That goal remained on the list of patient safety goals in 2004. It was subsequently removed from the list of goals and became an accreditation requirement by The Joint Commission (Korniewicz et al., 2008). In 2014 TJC introduced a new patient safety goal addressing clinical alarm safety in hospitals (TJC, 2014). In 2010, the Emergency Care Research Institute (ECRI) listed alarm hazards as second on its top 10 list of technology hazards (ECRI, 2010). Alarm fatigue subsequently climbed to number one on the list in 2012-13 and 2014 (ECRI). This prompted a sentinel event alert issued by The Joint Commission warning hospitals of the dangers of alarm fatigue (TJC, 2013).

Alarm Fatigue: Definition and Scope of the Problem

Alarm fatigue is a clinical phenomenon experienced by many clinicians although they may not realize it, or may not have linked it to a definition. Alarm fatigue has been defined as "a type of human error that occurs when a practitioner is desensitized to alarms and alerts." (Hannibal, 2011, p. 1). The ECRI (2010) provides the following definition: "Alarm fatigue, in which staff becomes overwhelmed by the sheer number of alarms. This can result in alarm desensitization, which in turn can lead to missed alarms or delayed alarm response" (p. 359). According to TJC (2013), alarm fatigue is defined as "The constant beeping of alarms and an overabundance of information transmitted by medical devices such as ventilators, blood pressure monitors and ECG (electrocardiogram) machines. As a result, clinicians become desensitized or immune to the sounds, and are overwhelmed by information- in short, they suffer from 'alarm fatigue' (p.1). Welch (2011) defined alarm fatigue as "failure to recognize and respond

to true alarms that require bedside clinical intervention due to the high occurrence of alarms (p. 4)."

Alarm fatigue is a nationwide problem. The FDA Manufacturer and User Facility Device Experience database received 566 reports of patient deaths related to medical monitoring device alarms between 2005 and 2008. In 2010, during a four month period, a review of the database revealed 73 alarm related-deaths, of which 33 were directly correlated to physiologic monitors (Cvach, 2012). These deaths were a combination of several factors including failure to respond by staff as result of alarm fatigue, improper adjustments to parameters and directly turning off specific lethal arrhythmia alarms. These statistics can be attributed to a distressing number of nuisance alarms emitted from monitoring devices, especially physiologic monitors such as cardiac monitors, which utilize single parameter thresholds. The threshold limits are set either too high or too low and many times are not adjusted to specific patient trends which could minimize the number of nuisance alarms experienced by end users (Cvach).

Physiologic monitoring devices have very high sensitivities (97%) and low specificities (58%) which yield a negative predictive value of 99% (Chambrin et al. , 1999). Due to these characteristics, these monitors are a significant contributor to nuisance alarms. Nuisance alarms are characterized by high incidence of clinically non-actionable alarms, while false alarms are clinical alarms produced by artifact creating false data (Welch, 2011). The presence of false alarms with clinical insignificance ranges from 80%-99% (Cvach, 2012).

Alarm Fatigue: Clinical Significance

Alarm fatigue is a clinically significant problem in acute care settings. Ignoring fatal alarms can result in patient deaths and delayed response times (Kowalczyk, 2011). This issue was recently brought to light by a sentinel event that took place at Massachusetts General Hospital in January 2010. A patient on a medical surgical unit who was on a monitor died as result of a delayed response to several clinical alarms unaddressed over a 20 minute time period. Upon further investigation of the event, biomedical engineers discovered a lethal arrhythmia alarm setting was turned off at the central nurses' station. It was also found that there was error in the software when it was installed, and lethal arrhythmia alarms were left in a programing mode allowing users to turn off these alarms. In addition to alarms in the central monitoring systems being off, the bedside audible volume alarm had been turned off (Bryan, Hopkins, & Holden, 2012). This situation clearly depicts the consequences of alarm fatigue and the danger that it presents to patients.

This sentinel event triggered the hospital to review and standardize monitoring policies. Software and programming were reviewed for proper settings and default settings were also reviewed and changed to decrease nuisance alarms. Shortly after this event, a second patient died at UMass Memorial Medical Center, August 2010. A 60 year old man died in an intensive care unit after alarms signaling a fast heart rate and potential breathing problems went unanswered for nearly an hour (Kowalcyk, 2011). Further investigation by the institution including interviews of staff involved found that nurses were overwhelmed by cardiac monitor alarms and the number of patients who were being monitored, despite the fact that some patients had no medical indication for cardiac monitoring (Kowalcyk, 2011).

Although many systems implemented in the clinical setting have the goal of increasing monitoring and patient safety, Cvach et al., expressed it is unclear whether the hazards associated with alarm fatigue outweigh the initial goal of increased patient safety (2011). There are many medical devices in hospitals such as physiologic monitors (including cardiac monitors), ventilators, infusion pumps, and dialysis units that depend on alarms to help protect patients. However, the alarm systems on these devices can also be the basis for problems, and there clearly are times when alarms actually do add to the occurrence of adverse events (ECRI, 2010).

In 2008, a national online survey was conducted by Korniewicz, Clark, and David to evaluate the effectiveness of clinical alarms. The purpose was to survey healthcare workers in order to determine problems associated with alarm fatigue. The investigators consisted of a 16-member task force comprised of healthcare professionals, including nurses, clinical engineers, and technology professionals. The purpose was to evaluate reasons why healthcare workers did not respond to alarms. The task force members developed an online survey. Respondents (N= 1327) consisted of mostly healthcare providers 94% working in acute care hospitals. Nurses comprised 51% of respondents, of which 31% worked in critical care areas. More than 90% of respondents agreed with statements relating to the purpose of clinical alarms and the need to prioritize and easily differentiate audible and visual alarms. Many respondents also identified nuisance alarms as problematic. Respondents also agreed and strongly agreed (88%) that alarms occur frequently. Seventy-seven percent of respondents felt that clinical alarms disrupt patient care and 78% felt that nuisance alarms reduced trust resulting in caregivers disabling alarms. The authors concluded that monitoring equipment could improve effective clinical alarm management, and clinicians who take an active role in patient care could increase their learning about the full range of equipment capabilities. Hospitals that

recognize the complexities of clinical alarms are better able to create alarm management plans which are effective.

Limitations of this study included a convenience sample of healthcare professionals who were already educated regarding audible alarms and results were based solely on participants' opinions.

A research study developed by a team of biomedical engineers, nurses, physicians and biostatisticians was conducted (Talley et al., 2011) with the purpose of assessing conditions that generate cardiopulmonary monitoring alarms, including false positive alarms in critically ill children. The specific goals of this research included to compare cardiopulmonary monitoring alarms to clinically significant events (CSEs) in the pediatric intensive care unit in order to estimate sensitivity and specificity of alarms based on current practice of the unit. The second goal was to improve performance of cardiopulmonary monitor alarms. The study was conducted on a 24 bed pediatric intensive care unit (PICU) and included participants that were severely ill with potentially life threatening disease as well as post-operative patients with multi system diseases. Participants were excluded if they required less than 12 hours of monitoring or had a hospital length of stay that was less than 24 hours. The study procedure including notification to the biomedical engineering staff by the research nurse once patients were admitted and connected to monitors. The research nurse also notified nursing staff of study participants to facilitate nurses' report of clinically significant events if they were not observed during direct observation. Each patient in the study received an average of five hours of direct monitor observation over the course of three days. Biomedical engineering staff also extracted cardiopulmonary monitoring data. The study was conducted over a seven month period with 98 children monitored. Data analysis yielded

2,245 recorded alarms, 68 of which were CSEs which occurred over 45 observational days. Clinically significant events were defined prior to start of this study as a clinical event requiring intervention without which the patients' condition would deteriorate or worsen. The study confirmed that CSEs were common in critically ill children. Limitations to the study were related to study design. Researchers in the study were unaware that all alarms were not saved on the server and were unable to be extracted by biomedical engineering staff. This factor significantly lowered the number of clinical alarms that were recorded and reported despite the flaw, a noteworthy number of alarms (2,245) were documented.

Strategies for Intervention

Several of the research studies reviewed provided recommendations for tackling this challenge, including an environmental survey. The survey should include an evaluation of every piece of equipment in use within the clinical environment, including those with alarms (Phillips & Barnsteiner, 2005). This should be followed by activation of alarms. In this process, nurses activate alarms in order to ensure that alarms can be heard at the location in which the nurse is most likely to be. This assessment should also include consideration of possible pager or telephone alert systems if alarms are not audible to staff. In this step, cardiorespiratory monitors should also be trended for previous alarms in order to individualize physiologic parameters in order to decrease nuisance alarms. Review of policies addressing alarm response and acceptable time for response was also recommended. Hospital policies should address adjustment of patient

parameters and frequency of those adjustments Institutional polices should also address proper response times for specific alarms. A well thought out plan should also be in place to educate nurses to appropriately use monitors (Phillips & Barnsteiner, 2005). Bell (2010) made similar recommendations including that an assessment of the incidence of nuisance alarms should be the starting point for alarm fatigue mitigation. Bell also recommended that institutions should develop a policy for reviewing and adjusting default alarm settings and ensure nurses that have consistent training.

A quality improvement project of alarm fatigue conducted by Grahm and Cvach (2010) was motivated by an excessive number of clinical alarms and fear of nurses experiencing desensitization. The method employed small tests of change to improve clinical alarm management followed by an assessment of monitor alarms. Nurses received education to individualize patient parameters and thus decrease nuisance alarms. After analyzing and collecting data related to alarm frequencies and ranges of default settings, monitor alarm parameter limits were adjusted. Finally, monitoring software was modified to promote audibility of critical alarms. As a result of these interventions, the pilot unit experienced a 46% decrease in false alarms. Recommendations also included review of current hospital policies in regards to physiological monitoring devices.

In an effort to decrease false alarms and overall volume of alarms that contribute to alarm fatigue, two studies yielded promising results. Grahm and Cvach (2010) implemented a comprehensive approach in a progressive medical care unit where alarms where analyzed and a policy review was then conducted. Nursing staff were educated in regard to setting parameters to patient specific conditions and needs while maintaining parameters within a safe range. Default parameters were also adjusted to fit the patient population on the unit. A comparison of alarms before and after the intervention showed a significant decrease in false alarm. The unit was found to have

experienced 16,953 alarms before as compared to 9,647 alarms after implementation of the initiative. The authors noted that proper training in order to mitigate and decrease nuisance alarms is an essential part of systems implementation and those devices monitoring physiologic systems are only as reliable as the clinicians who use them. Safety experts have voiced concern that hospitals are not improving management of alarm fatigue (McKinney, 2013). The author reported on recommendations issued by TJC to manage alarm fatigue which include individualizing alarms to patient conditions as well as regular inspection of equipment in use. A national patient safety goal was also implemented in 2014 by TJC. Nurses and bedside healthcare providers are primarily impacted by alarm fatigue and it is imperative that they be immersed in endeavors to create solutions that are successful in mitigating alarm fatigue (McKinney). The recently released 2014 national patient safety goals issued by TJC targeted hospitals and the safe use of alarms on medical equipment.

Impact on Nursing Workflow

Burgess, Herdman, Berg, Feaster, and Hebsur (2009) conducted a research study with the purpose of obtaining objective data to assist with setting alarm limits for early warning clinical systems. The methodology used in this study was to analyze continuous heart rate and respiratory data previous collected from 2003-2006. This data from a general ward population of adult patients with no severe adverse events was used to help guide alarm limit setting. The study included 317 patients with 780 days of total monitoring. Sample alarm settings that appeared to increase false positive alarm rates included: high heart rate of 130-135, low heart rate of 40-45; respiratory rate high of 30-35 and low of 7-8. These parameters were used to test default rates used for patient monitoring. The study also found that continuous monitoring systems deployed for early

warning of patient deterioration had an increased number of positive alarms which resulted in alarm fatigue as a result of these default parameters. This frequent false alarm resulted in workflow disruption for nurses, and also potentially leaves patients at risk for undetected deterioration of health condition. In conclusion, improperly set monitoring parameters will increase the number of false alarms emitted from monitoring systems contributing to alarm fatigue.

Nursing workflow is particularly affected by alerts emitted from remote patient monitoring devices (Vapio et al., 2012). Vapio et al. conducted a study to describe the frequency of alarms generated by patient monitoring devices and the responses of nurses caring for those patients. The second purpose of this study was to report nurses' explanations of impact of alarms on workflow and strategies of alarm response discuss strategies that were identified when you cite the findings of the study. The methodology of this qualitative analysis included data collection by a research assistant who observed nurses on a 31 bed medical ICU during the day shift. The study took place over five-months, and 49 hours of observation data was collected with detailed field notes of 46 nurses' response to alarms. Results included that during 49 hours of observations, 446 alarms were generated by monitors or one alarm every 6.59 minutes. Of these alarms 7.6% were life threatening priorities, 40% were serious, and 49% were advisory. Seventy percent of the alarms received no response from nursing, defined as not addressed within the hospitals designated 60-second response time. Participants in the study often chose not to allow alarms to interrupt their workflow and proceeded with the task at hand rather than stop to address clinical alarms. This study also confirmed the presence of alarm fatigue in this setting. The observer noted that of the 446 alarms experienced only 3.8% of alarms received a response in which the nurse physically went to the patients' room. Of note, 70% of the 446 alarms were advisory alarms and therefore did not result in

direct assessment of the patient by the nurses. The authors concluded that patient monitors are both a help and hindrance to patient care and concluded that clinical monitoring systems should be implemented with careful consideration of the workflow interruptions they may create.

Alarm fatigue is a consequence of technological innovations in the healthcare environment. Despite recent attention on this topic, there is a need to better understand the impact of alarm fatigue on nurses. The purpose of this research project is to explore impact of alarm fatigue on nurses in an inpatient adult acute care setting. The focus will be the degree to which nurses experience alarm fatigue and the impact on nursing workflow.

The Joint Commission issued a sentinel event alert in April 2013 warning healthcare organizations of the dangers of medical device alarms and their contribution to alarm fatigue in clinicians. The severity of alarm fatigue is further emphasized by the findings of a four-year review (2005-2008) of the FDA medical device-reporting database. These reports are mandatory for device manufacturers when adverse patient events associated with medical devices occur. There were greater than 560 alarm related patient deaths reported. However, this is likely an underestimate as some may not be reported if manufacturers are not notified of issues with a device (Weil, 2009). The FDA has since set into motion a number of initiatives in order to reduce alarm fatigue. They began by reviewing the process to certify medical devices and provided further education and training to reviewers regarding alarm standards and safety. The FDA also issued a guidance report to the medical device industry in order to notify them of future expectations for alarms on medical devices. Along with this guidance report, the FDA challenged the industry to combat alarm fatigue and work towards creating devices that

use multiple physiologic functions at the same time in order to decrease nuisance alarms (FDA, 2012).

The continuous introduction of technology into acute care environments are challenging nurses to manage the unintended consequences of physiological monitors and medical equipment including increased alarms and maintaining competency with numerous pieces of equipment. These challenges are not only related to education and effective use of sophisticated devices but also include managing the many false and nuisance alarms created by many physiologic monitors.

There have been many studies conducted on alarm fatigue; however very little identified that specifically address the impact of alarm fatigue on nurses. It is critical to address this information gap since alarm fatigue clearly affects patient care outcomes. Therefore, the purpose of this research project is to investigate the impact of alarm fatigue on nurses in an inpatient adult acute care setting. The focus will be the degree to which nurses experience alarm fatigue and the impact on nursing workflow.

Theoretical Framework

Edward Norton Lorenz was the original author of the Chaos theory in 1963. He was a meteorologist and mathematician whom later in 1969 created the term butterfly effect in referring to chaos theory. The Chaos theory (Lorenz, 1963) attempts to explain complex systems and also states that complex behaviors can be the result of simple actions, so a small change in any system can result in large concluding event (butterfly effect) (McEwen & Willis, 2007) The theory is based on the premise that despite the

appearance of overt chaos, there is a level of organization in the core layers of all complex systems. The chaos theory is further explained and broken down into four separate components: a dynamical system; identified system parameters; a specified equilibrium state; a specified state attractor (Haigh, 2001). A dynamic system is one in which change occurs with time; this system is dependent on the chaos within the system. Parameters are an essential piece of the chaos theory. Two starting points selected within any system regardless of proximity or distance may be plotted mathematically (Haigh, 2001). Equilibrium states are the opposite of what is assumed; in an equilibrium state, a complex system will settle in either a stable or unstable state, dependent on the chaos within the system. The end result is that the higher the degree of chaos within a system, the more fluctuation that will occur between stable and unstable states.

The theoretical framework of the chaos theory has been utilized by many to aid in the understanding of various complex topics. In healthcare the theory has been employed to clarify the complexities involved in self-care management of patients with chronic obstructive pulmonary disease (COPD) as well as the complex and variable trajectory in which these patients are prone to as a result of their disease. Cornforth (2013) employed the chaos theory to explain the disease process of COPD, stating that it is a complex chronic disease which is non-linear. The disease course is similar to the chaos theory in that small changes or exposures in the environment may trigger disease exacerbations with varying consequences. The pattern of the disease is similar to the butterfly effect in the theory, in which very small changes in a system may prompt disproportionate changes elsewhere. The chaos theory is used to further highlight the difficulties of managing patients with COPD in a multifaceted healthcare system. The primary care setting itself is a complex adaptive system with multiple influences and agents which

interact to create new patterns of behavior followed by a new system organization. (Cornforth, 2013).

The chaos theory similarly has been applied in clarifying the intricacies of behavioral change in the public health setting. Resnicow and Page (2008) described that behavioral change is often a quantum event rather than a linear event. This process resembled the theoretical framework of the chaos theory in that the change process was sensitive to initial conditions which were highly variable and difficult to predict. There is no predictability within the chaos theory which is parallel to unpredictability of healthcare. This unpredictability imparts itself to leadership in healthcare. Edwardson (2003) incorporated the chaos theory into healthcare stating that, just as the complexity and lack of order exists within the theory, there is very little order in healthcare systems. This challenges leaders not to be master planners but instead master adapters. Healthcare systems can be chaotic without an overt order yet there is always underlying order and direction to the disarray experienced within healthcare (Edwardson, 2003).

The Chaos theory can be applied to the concept of alarm fatigue. Alarm fatigue in clinical settings is an important consequence of technology and multiple monitoring systems usually developed by different companies. These different systems can cause a significant amount of chaos in clinical settings. In the clinical setting, in regard to alarm parameter settings, the more specific and individualized the parameters are, the fewer false alarms may be expected to occur, with a resulting decrease in alarm fatigue. However, if parameters are overly sensitive or non-specific to the patient, the opposite may occur, resulting in increased number of false alarms and increased alarm fatigue. A small change in the initial circumstances of a dynamic system can significantly affect the long term performance of that system (Haigh, 2001). As a result, nursing staff develop

'work arounds' and new strategies to cope with the overwhelming number of clinical alarms, thus creating organization amongst the chaos. Although it may appear to be a chaotic atmosphere to someone walking into the clinical setting, those who work within the setting have developed their own organizational style and specific strategies to deal with alarms. Although this may not be the most efficient way to address this complex issue, it results in an organization that nursing staff are able to create underneath the appearance of a chaotic environment. As clinicians become more knowledgeable about and experienced with equipment, they are often better able to distinguish true alarms from false alarms and either trouble shoot the equipment or respond as appropriate. Therefore, the chaos theory is an excellent model to incorporate into the complex issue of alarm fatigue. Complex systems whose behaviors' were once assumed random, actually demonstrated patters that repeated themselves through all levels of the system (Coppa, 1993).

Methodology

Purpose: The purpose of this study was to investigate the impact of alarm fatigue on nurses in an inpatient adult acute care setting. The focus being, the degree to which nurses experience alarm fatigue and the impact on nursing workflow.

Design: This research used a descriptive design. This design method was chosen in order to explore current clinical conditions in relation to alarm fatigue without implementation of independent variables.

Sample and site: The sample selected in this study utilized a non-probability convenience sample of nursing staff. Inclusion criteria include that all participants must be registered nurses employed on one of the two units, including floats and all shifts. There were no exclusion criteria. The sites included 4 East and 4 West, two medical surgical units at the Miriam Hospital, with a focus in cardiac and telemetry monitoring. These two in-patient units are very close in architectural design, having two private negative pressure rooms and 28 semi-private acute care beds each.

Procedures

The proposed study was submitted for approval to the Lifespan and Rhode Island College (RIC) Investigational Review Boards (IRB). RIC IRB approval was granted on

11/4/2013. Lifespan IRB approval was obtained on 11/15/13. After approval, the student researcher contacted unit managers and discuss the study details and distribution of study advertisement to staff. The unit managers were asked to announce the upcoming study at unit staff meetings as well as via email. A 15 question survey was developed by the researcher. Surveys were made available to nursing staff of both units and placed in a clearly labeled envelope in the break room of each study unit. Attached to the first page of each survey was an IRB approved informational letter describing the study purpose, procedures, and what is expected of participants. Contact information for the researcher, faculty member and principle investigator were also provided. Participants were assured that their participation was voluntary and responses were to be maintained anonymous and confidential. If they agree to participate, they were next asked to complete the attached survey and then drop it in a sealed box in the break room. Participants were advised to not include identifiers on the survey. Surveys were collected and stored in a locked filing cabinet accessible to the student researcher and primary investigator only.

Measurement

The impact of alarm fatigue on nurses was assessed using a researcher-developed measure as no existing measures were identified in the literature. The items on the measure (Appendix A) were constructed from the literature review and from clinical experience of the student researcher. The actual measure includes 12 items, of which 9 are Likert response items ranging from strongly agree to strongly disagree. Three open-ended questions followed by demographic questions for comparative purposes. All survey questions were preceded by one definition of alarm fatigue and a second of nuisance alarms. The measure was pilot tested on five nurses with clinical background in telemetry monitoring prior to use for content review by expert nurses. The proposed

sample size for this study will was a maximum of 100 registered nurses. The proposed survey was open to voluntary participants for a two week time period (12/8/13-12/22/13) after IRB approval.

Data Analysis

Data from nine multiple-choice questions were examined and graphed from a total of forty four completed surveys. The graphed data was subsequently utilized for comparison of responses between the two units surveyed. Responses were also graphed for ease of data dissemination. The three open-ended questions were analyzed based on responses.

Ethical considerations

Survey responses were maintained anonymous. Participant responses were returned to a securely closed box in each break room. The student researcher retrieved all surveys to ensure confidentiality of responses. Surveys were maintained in a locked file to which only the researcher and PI have access. No PHI was requested.

The Miriam Hospital is an academic and magnet facility which encourages research; therefore there were no anticipated barriers with regards to the institution.

Evaluation

Completed surveys were evaluated utilizing a quantitative approach on the first nine questions. Percentages were compiled and demonstrated in a bar graph format representing number of respondents for individual questions. Evaluation also included measurement of total response rate. Qualitative analysis was used for the three open-ended questions, which were reviewed by the student researcher as well as the principle investigator.

Dissemination

The study findings will be disseminated via poster and power point presentation. Staff from the two participating units will also be able to view results, which will be posted in both break rooms. Results should also be presented to appropriate hospital committees i.e. Nursing Informatics in order to interpret results and possibly formulate a plan in order to mitigate and improve alarm fatigue in clinical settings. The hospital taskforce currently working on mitigating alarm fatigue and improving education and awareness to staff at the study site will also receive study results. The research project was also submitted and accepted as a poster presentation to the New England Nursing Informatics Consortium annual conference.

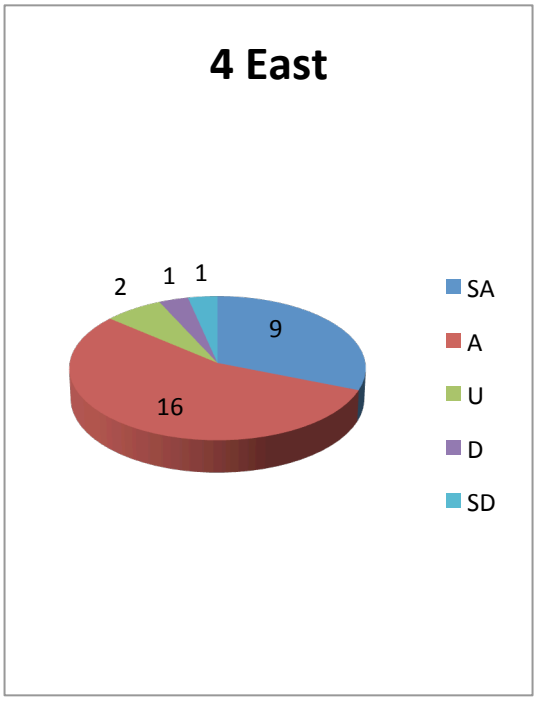
Results

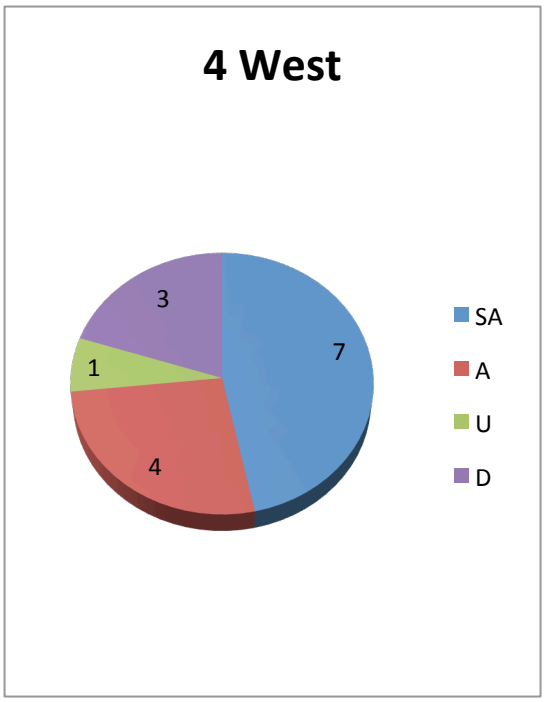
A twelve question survey was implemented on two inpatient medical surgical units with a focus in cardiac and telemetry monitoring. The survey consisted of nine likert questions, three open ended questions followed by three demographic questions. The first unit (4 East) had a response rate of 96.6% while the second unit (4 West) had a 45.5%

response rate. The first survey question sought to establish whether or not nurses on both units were experiencing alarm fatigue, based on a provided definition of alarm fatigue.

The following pie charts have the number of actual respondents imbedded within the graph. The percentages are broken down by slices within each pie chart, the vertical key to the right of each pie chart reflects respondents that strongly agree, agree, undecided, disagree and strongly disagree.

The first question yielded the following results.

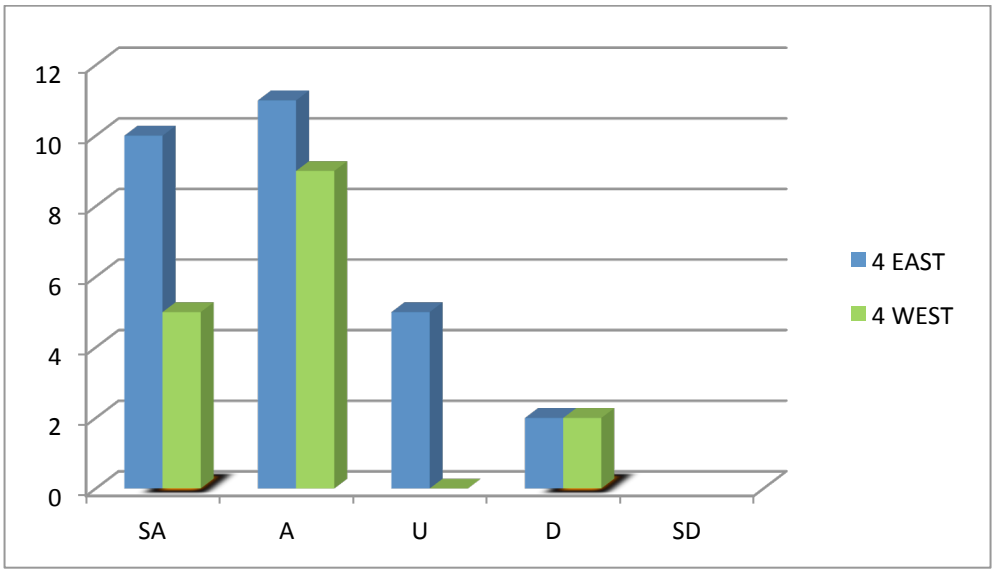




Of the respondents on 4 east 86.2% strongly agreed or agreed that they had experienced alarm fatigue. On 4 West 73.3% of respondents strongly agreed or agreed that they had experienced alarm fatigue.

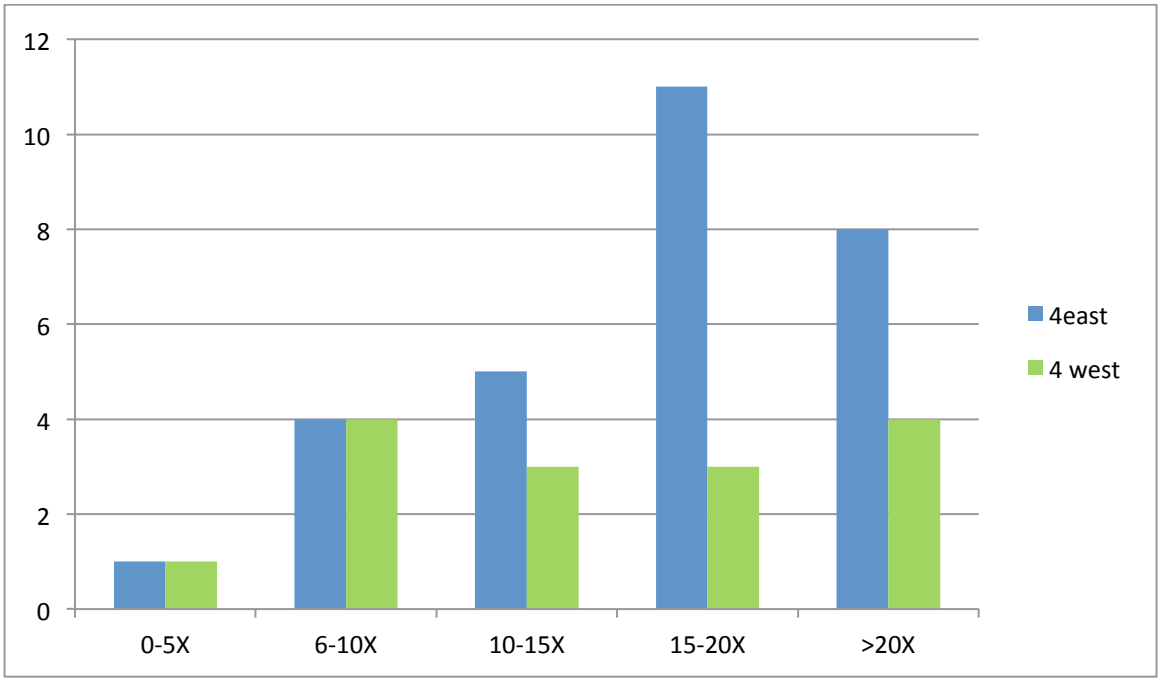
The following bar graphs horizontally depict the actual level of agreement and vertical numbers to the left of each graph represent actual numbers of respondents to each level.

The second question asked whether nuisance/ false alarms were a frequent occurrence in practice. On 4 east 93.1% of respondents strongly agreed or agreed that nuisance/ false alarms occurred frequently, on 4 west 93.3% of respondents strongly agreed or agreed. Question three asked whether nuisance/ false alarms disrupt patient care. Respondents on 4 East strongly agreed or agreed at a rate of 72.4%, on 4 West 93.3% of respondents strongly agreed or agreed as depicted in the chart below.

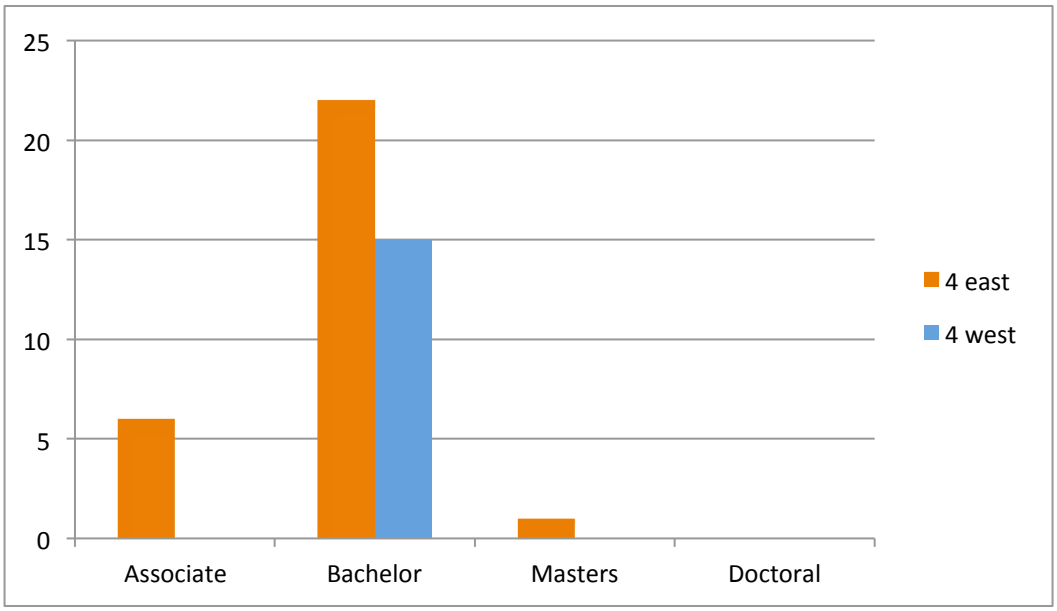


Question 4 asked participants whether nuisance/false alarms reduced their trust in alarms. On 4 East 75.8% of respondents strongly agreed or agreed. On 4 West 66.6% of respondents strongly agreed or agreed. When asked if nuisance/ false alarms contribute to lack of responses by many nurses 82.7% of respondents on 4 East either strongly agreed or agreed. On 4 West 86.6% of respondents strongly agreed or agreed. Respondents were also asked how confident they were in adjusting monitor alarm parameters in order to reduce nuisance/ false alarms. 80.2% of respondents on 4 East agreed or strongly agreed while 86.6% of respondents on 4 West strongly agreed or agreed. 61.9% of respondents on 4 East strongly agreed or agreed to feeling overwhelmed by the number of alarms on

the unit while 53.3% of respondents on 4 West strongly agreed or agreed. Respondents were also asked if clinical alarms were a significant contributor to their stress level. On 4 east 51.7% of respondents strongly agreed or agreed, on 4 west 46.6% of respondents strongly agreed or agreed. When asked how many times a shift they thought they were interrupted by a clinical alarm the following responses were reported below.

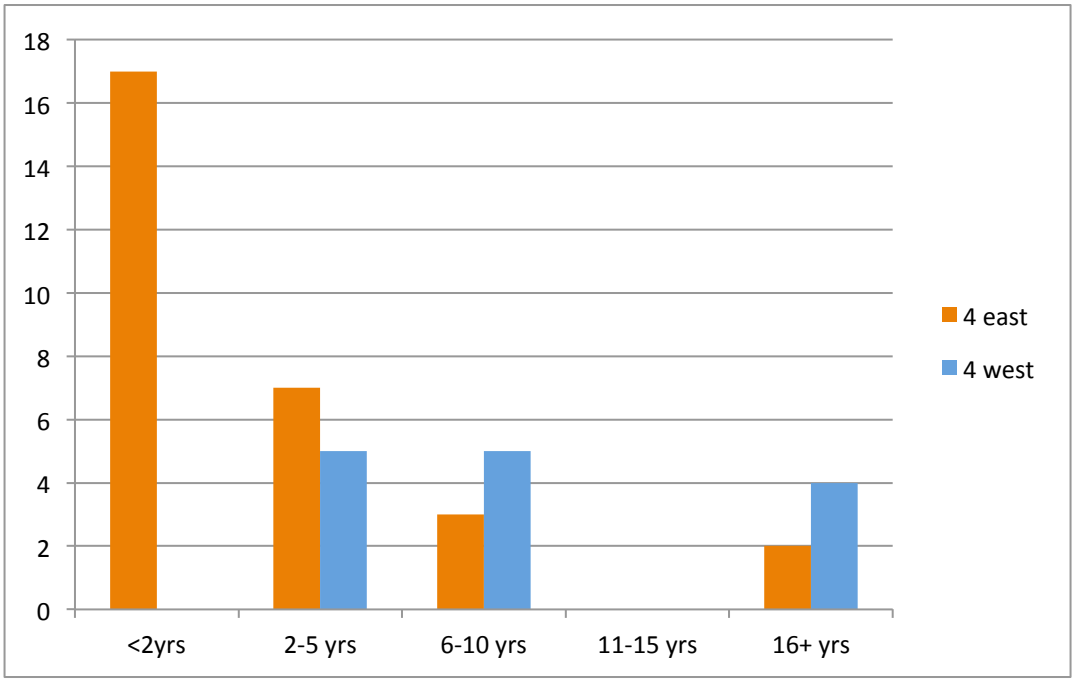


Survey respondents were asked three demographic questions including their highest level of education completed, with the following results.



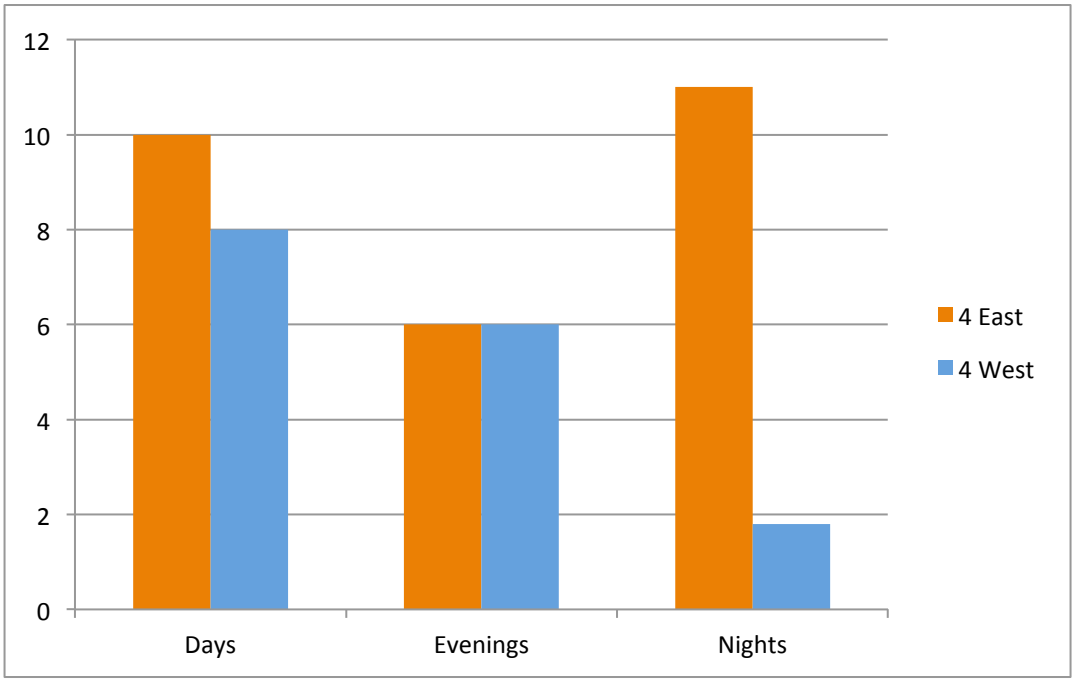
There is a greater number of baccalaureate prepared nurses on both 4 East and 4 West.

Number of years practicing



The above graph depicts a pronounced number of nurses who have been practicing less than two years; more than half of respondents fell into this category. 4 West has a more diverse number of practice years amongst the respondents.

Shift worked



In summary nurses on both medical surgical units with a focus in cardiac monitoring and telemetry are experiencing alarm fatigue and a disruption in the nursing workflow as a direct result.

Three open ended questions were also evaluated without common themes. Respondents from both units identified receiving similar training. All respondents reported receiving a three day telemetry course including rhythm review, along with training by preceptors. In addition professional development identified by nurses on both units included monitor education provided by the representative of the manufacturer. When asked whether or not they felt they had received adequate education the majority of respondents on both units responded yes. Respondents were also asked what they would recommend for education if they felt they had not received adequate training. Those respondents who felt they had not received adequate preparation requested annual

telemetry review, "more in depth training" and in-services from manufacturer representative.

Open Ended Questions	4 East	4 West
Question 10: strategies to deal with false/nuisance alarms	• Adjust alarm settings • Change multi lead analysis • Check lead placement • Change lead placement • Change leads • Re- learn leads • Adjust parameters • Uncheck irregular HR alarm • Turn volume off on bedside monitor.	• Adjust alarm settings • Change multi lead analysis • Check lead placement • Change lead placement • Change leads • Re- learn leads • Adjust parameters • Uncheck irregular HR alarm
Question 11: What training did you receive on the system and its functionality	• 3 day telemetry course • In-service from manufacturer rep • Training with preceptor on orientation	• 3 day telemetry course • In-service from manufacturer rep • Training with preceptor on orientation

Question 12: Do you feel this training was adequate?	14/10 responded yes	8/5 responded yes

If no what would you recommend	More in depth training" "in-service by the company" "regular review of the system" "annual telemetry review"	"More in depth training" "in-service by the company" "regular review of the system" "annual telemetry review"

Survey participants were also asked to identify strategies they used to deal with nuisance/ false alarms. Respondents from both inpatient units listed the following, re-learning the monitor, changing alarm parameters, lead changes, battery changes, change multi lead to single lead analysis.

Summary and Conclusions

Alarm fatigue is an emerging topic in healthcare, principally in acute care settings. There have been several definitions of alarm fatigue presented by many organizations, including The Joint Commission (TJC). According to TJC (2013), alarm fatigue is defined as "The constant beeping of alarms and an overabundance of information

transmitted by medical devices such as ventilators, blood pressure monitors and ECG (electrocardiogram) machines. As a result, clinicians become desensitized or immune to the sounds, and are overwhelmed by information in short, they suffer from 'alarm fatigue'(p. 1). Therefore a survey was designed and implemented to discover whether in fact nurses at on two units at the Miriam hospital were experiencing alarm fatigue and whether it impacted their daily workflow.

The project methodology included IRB review and approval through Rhode Island College as well as The Miriam Hospital. A literature review on the topic of alarm fatigue was performed utilizing the databases CINHAL, OVID, and Pub Med. The search was conducted on information from 1990 through 2014 and was completed utilizing key words alarm fatigue, monitor alarms, telemetry alarms, physiologic monitoring equipment, and patient safety In reviewing the literature, there were no surveys available that exclusively targeted the discipline of nursing. Therefore a 12-question survey containing 9- likert and 3 open ended questions was designed by the researcher. It was administered to 44 registered nurses on two telemetry-monitoring units. The survey was created based on common themes found in the literature.

The survey was available to respondents for a two week time period. The survey explored whether nurses are experiencing alarm fatigue, and also how their daily workflow was impacted by alarm fatigue. Surveys were anonymous and confidential. Unit A employs 30 staff RN's and unit B employs 33 staff RN's. On unit A there was a 96.6% response rate. On unit B there was a 45% response rate. Survey responses from unit A demonstrated that 86.2% of respondents either strongly agreed or agreed (SA, or A) to having suffered alarm fatigue in the 6 months preceding the survey. 72.4% of respondents strongly agreed or agreed that false alarms disrupted patient care. 82.7% of respondents reported being interrupted more than 10 times per shift by nuisance/false

alarms, which was defined on the survey administered. Two definitions of alarm fatigue were also provided. Of unit B respondents 73.3% of respondents strongly agreed or agreed to having suffered alarm fatigue. 93.3% of unit B respondents strongly agreed or agreed that false/nuisance alarms disrupted patient care. 66.6% of respondents reported they were interrupted more than 10 times per shift by nuisance/ false alarms. A majority of respondents reported being interrupted greater than 10 times per shift and upwards of 15-20 times in a single shift. Interestingly enough despite the high number of interruptions there was a relatively lower percentage of staff nurses who reported alarm fatigue being an increased contributor to their stress level. The percentages were not as high as expected in comparison to the percentages who reported suffering alarm fatigue. On 4 east 51.7% of respondents strongly agreed or agreed, on 4 west 46.6% of respondents strongly agreed or agreed that alarm fatigue contributed to their stress level.

Three open ended questions were also evaluated without common themes. Respondents from both units identified receiving similar education. All respondents reported receiving a three day telemetry course including rhythm review, along with training by preceptors. In addition, education identified by nurses on both units included in-servicing provided by the representative of the monitor manufacturer. When asked whether or not they felt they had received adequate training the majority of respondents on both units responded yes.

Respondents were also asked what they would recommend for education if they felt they had not received adequate training. Those respondents who felt they had not received adequate training requested annual telemetry review, “more in depth training” and in-services from manufacturer representative. Survey participants were also asked to identify strategies they used to deal with nuisance/ false alarms. Respondents from both

inpatient units listed the following, re-learning the monitor, changing alarm parameters, lead changes, battery changes, change multi lead to single lead analysis.

There were several limitations in this study. The first limitation being that lack of available surveys targeting nurses specifically on the topic of alarm fatigue and its impact on nursing workflow, therefore the student researcher administered a self-created survey. This survey has not been tested for reliability and validity, although it underwent peer review by other healthcare providers experienced with cardiac and telemetry monitoring. Responses to open ended questions were also a limiting factor in that there were no common themes generated from open ended questions. Additional limitations of the open ended questions included user interpretation and incomplete responses. The study was also limited in that the survey data is representative of a two week time period. The study would also have been improved by a larger sample, mixed units, and different settings.

In conclusion the research survey had a higher than expected response rate. The survey findings also indicated that staff nurses on both units surveyed were clearly experiencing alarm fatigue as well as disruptions in work flow as a direct result of alarm fatigue. In completing this survey, alarm fatigue is a topic of high priority with great clinical significance.

Implications for Advanced Practice

There are multiple implications for advanced practice in the context of alarm fatigue. The 2014 National Patient Safety Goal issued by The Joint Commission clearly depicts the requirement for actions to reduce alarm fatigue and improve clinical environments with the end result of improved patient safety. Alarm fatigue is the consequence of technological advances which warrants a targeted approach by all healthcare intuitions. This is a complex challenge which warrants the dedicated attention of an interdisciplinary team, allowing advanced practitioners a unique opportunity to formulate and lead teams to target alarm fatigue.

Implications for nursing practice in general related to alarm fatigue include opportunities for review of monitoring policies specifically related to telemetry monitoring. These policies should begin by addressing appropriate use of telemetry monitoring and provider education which would clearly outline appropriate indications and uses for telemetry monitoring. Reduction in number of patients being monitored can result in decreased number of alarms; this is of great clinical importance in cases where patients do not meet set criteria for monitoring. Organizational policies should also address clinical alarms and appropriate response times to specific alarms, particularly when different alarm levels are utilized in an escalation format i.e.: warning alarms to lethal alarms. A comprehensive monitoring policy also incorporates individualization of patient monitoring parameters and designates how often parameters should be reviewed/ changed and by whom. Actions to improve monitoring and decrease nuisance alarms

including proper skin preparation for lead placement, daily lead changes and battery changes with specified times for actions to be performed. The above actions have been found to improve monitoring and decrease artifact alarms. These actionable items have led to decreased number of nuisance/ artifact alarms and the latest in evidence based practice findings related to alarm fatigue. Cvach & Funk (2012), mentioned several of the above clinical interventions to assist institutions in decreasing alarm fatigue in a publication through the national patient safety foundation learning series including daily lead changes, battery changes, and individualization of patient monitoring parameters as well as changes in default parameters which lead to increased nuisance alarms as thresholds are set outside of typical physiologic parameters. These policy changes along with active auditing to ensure policy adherence are beginning steps to tackling alarm fatigue in acute care settings.

Advanced practice nurses (APN) and clinicians have a unique opportunity to spearhead these initiatives and provide necessary leadership in partnership with institutional leaders to enhance patient safety. APNs are in a unique position to not only provide leadership and mentor staff through change but also collaborate with other disciplines in order to ensure success and long term viability of change and forward progression in order to meet patient safety goals and improve patient outcomes.

Staff education, particularly end user education and training to specific monitoring systems are instrumental in achieving successful implementation of policy changes. End users must possess knowledge of technological systems used for monitoring in order to successfully incorporate key policy changes into practice i.e. individualization of patient parameters to enhance monitoring and decrease number of false/ nuisance alarms. APNs can be instrumental in the education of staff, having a background in nursing and understanding of the complexities of patient management in

acute care environments from a nursing perspective. Initial staff education on monitoring systems is crucial however ongoing education and staff training are equally imperative. Quality checks in relation to monitoring systems by biomedical personal are equally important in decreasing alarm fatigue in conjunction with auditing to ensure policies are adhered to. This quality check should also include the review of clinical alarms and decisions regarding nuisance alarms which are not actionable i.e. irregular rhythm alarms which plague clinical staff. The alarm frequently warns staff that patients are in an irregular rhythm (atrial fibrillation), however the alarm is not actionable and staffs are aware of the rhythm. These types of alarms should be scrutinized in relation to clinical benefit and removed when contributing to alarm fatigue and provide no benefit to patient monitoring or clinicians. The review of unnecessary alarms, default monitoring settings, over monitoring/ monitoring without appropriate clinical indication and review of standard monitoring practices are all integral sections that must be evaluated in order to mitigate alarm fatigue and improve clinical practice environments and most importantly, patient safety.

Implications for advanced practice nurses include the need for continuing educations particularly in the realm of healthcare informatics and present monitoring technologies as well as innovations in patient monitoring systems. This skill set is imperative in order to be an active participant and leader in the evolution of nursing practice as a result of innovation and implementation of technology in clinical environments. APNs possess a unique level of expertise and must maintain current not only on clinical practice but also on nuances in technology in order to lead and mentor staff in the transitioning health care environment in a truly effective and collaborative manner.

The role of the APN also provides great opportunity to be active participants in promoting patient safety. Active participation in environmental and safety initiatives in

order to increase the culture of safety is required. This will contribute to accurate and efficient patient monitoring. The 2014 National Patient Safety goal issued by The Joint Commission required that all organizations begin to examine and target the issue of alarm fatigue, beginning with the formulation of a committee in order to investigate and target alarm fatigue within organizations. This is an ideal opportunity for an Advanced Practice Nurse to be an active participant in the establishment of a committee with an objective of increasing patient safety through evaluation of current monitoring practices and implementation of interventions to mitigate alarm fatigue while promoting improved and effective use of patient monitoring devices. In completing the evaluation of results of the survey administered it is clear that nurses on both inpatient units are experiencing alarm fatigue.

Implementing strategies to tackle alarm fatigue is crucial to patient safety particularly in areas where nurses are experiencing the effects of alarm fatigue. Research has demonstrated that this has the potential to lead to delayed response to lethal arrhythmias as a result of staff desensitization caused by alarm fatigue. This is a major patient safety concern that must be targeted in order to avoid injury and poor outcomes to patients. In the two inpatient groups surveyed, each group identified an astounding number of interruptions to their workflow each shift. Although the two groups identified they were frequently interrupted, neither group acknowledged feeling increased stress related to the number of interruptions. This is of great concern as the two groups may have adjusted to the interruptions and do not feel increased stress related to the number of times they are interrupted. This could potentially be due to desensitization amongst respondents which has the potential to lead to missed alarms and delayed response to lethal arrhythmia alarms. It is imperative that nursing target alarm fatigue as a major safety issue.

Alarm fatigue has several consequences for patients related to the effects of noise on the environment. This has significant implications for health as noise from frequent alarms impinge on patient rest and sleep leading to decreased comfort and increased stress in patients attempting to rest and heal. Alarm noise is upsetting to patients and families since they are unsure of what the alarm is indicating and fear that the patient is experiencing a threatening event. This presents an opportunity for advanced practice nurses to spearhead initiative to decrease and address noise in order to proactively participate in clinical prevention of stress and decreased rest time and healing in an already compromised population.

Advanced practice nurses must become active participants in system initiatives in order to mitigate alarm fatigue. There is also great opportunity for end users and manufacturers of monitoring devices to collaborate and work towards a solution which would ultimately decrease alarm fatigue and benefit patient care and safety. Strategies identified in open ended questions to decrease alarm fatigue included daily lead and battery changes, proper lead placement and skin prep, removal of nuisance alarms that do not have clinical benefit i.e.: irregular HR alarms and reviewing of institutional alarm policies with specifics to response times for alms and individualization of parameters**.** These are all feasible and identical recommendations found in the literature, most of which have been implemented at The Miriam Hospital including removal of irregular HR alarm. An alarm fatigue committee was also formulated to in order to further target the issue and in response to the sentinel event alert issued by To Joint Commission.

Acknowledgement of alarm fatigue begins the journey of improved patient safety and outcomes. However interventions and education aimed at alleviating alarm fatigue must be tailored to skill and knowledge level of the staff being targeted in order to be successful. Interventions must also be in line with the goals and vision of the institution

in order to have a lasting impression. These beginning impressions become the foundation and ground work to build on as strategies are implemented to minimize the hazards of alarm fatigue. These strategies should include an interdisciplinary approach involving clinicians from all areas of practice. This interdisciplinary approach allows all disciplines the opportunity to dissect the issue at hand and brainstorm solutions that are practical and viable.

Alarm fatigue is an area for continued research by Advanced Practice Nurses with rigorous study designs aimed at decreasing alarm fatigue and improving working environment and patient safety. Opportunities for future research include comparative effectiveness trials, interdisciplinary research with collaboration between end users (nurses), engineers and industry leaders of monitoring devices. There is an abundance of items in which could generate research in regards to alarm fatigue. A particular area warranting further research which could result in substantial data is whether or not nuisance/ false alarms are decreased when physiological monitoring parameters are adjusted to more accurately reflect the population being monitored within safe ranges. This type of data could be utilized to drive change within organizations and could also be utilized as a model for similar institutions struggling to moderate similar challenges. The APN has a major role in identifying and implementing research initiatives related to alarm fatigue.

References

American International Group (2013). *Patient safety: Hospital risk*. Retrieved from http://www.aig.com/Chartis/internet/US/en/Patient%20Safety%20Hospital%20Risk%20White%20Paper_tcm3171-482027.pdf

Bell, L. (2010, January). Monitor alarm fatigue. *American Journal of Critical Care*. *19*(1), 38. doi:10.44037/ajcc2010641

Bryan, R. J., Hopkins, C. C., & Holden, L. (2012, March). Massachusetts general hospital case study: physiological alarm monitoring. *First do No Harm*. 1-4.

Burgess, L. P., Herdman, T. H., Berg, B. W., Feaster, W. W., & Hebsur, S. (2009). Alarm limit settings for early warning systems to identify at risk patients. *Journal of Advance Nursing*. *65*(9), 1844-1852. doi:10.1111/j.1365-2648.2009.05048.x

Chambrin, M., Ravaux, P., Calvelo-Aros, D., Jaborska, A., Chopin, C., & Boniface, B. (1999). Multicentric study of monitoring alarms in the adult intensive care unit: A descriptive analysis. *Intensive Care Medicine*, *25*, 1360-66.

Coppa, D. F. (1993). Chaos theory suggests a new paradigm for nursing science. *Journal of Advanced Nursing*, *18*, 985-991.

Cornforth, A. (2013). COPD self-management supportive care: Chaos and complexity theory. *British Journal of Nursing*, *22*(19), 1101-04.

Cvach, M., Dang, D., Foster, J., & Irechukwu, J. (2009). Clinical alarms and impact on patient safety. *Initiatives In Safe Patient Care*, 1-8.

Cvach, M. (2012). Monitor alarm fatigue. An integrative review. *Biomedical Instrumentation & Technology*, 268-276.

Cvach, M., & Funk, M. (2012, June 25). *Monitor alarm fatigue: Lessons learned*. Retrieved from http://www.npsf.org/wp-content/uploads/2012/06/PLS_12-6_CV_MF_Alarm_Fatigue.pdf

Edwardson, S. R. (2003). Chaos: A leader friend or foe. *Policy, Politics, & Nursing Practice*, *4*(4), 253-254.

FDA ramps up device reviews to crack down on 'alarm fatigue' - The Advisory Board Daily Briefing. (2012, March 27). Retrieved from http://www.advisory.com/Daily-Briefing/2012/03/27/alarm-fatigue

Graham, K. C., & Cvach, M. (2010). Monitor alarm fatigue: standardizing use of physiological monitors and decreasing nuisance alarms. *American Journal of Critical Care*. *19*(1), 28-30. doi:10.4403/ajcc2010651

Haigh, C. (2002). Using chaos theory: The implications for nursing. *Journal of Advanced Nursing*, *37*(5), 462-469.

Hanibal, G. B. (2011). Monitor alarms and alarm fatigue. *American Association of Critical Care Nurses*, *22*(4), 418-420.

Institute of medicine (1999, November). *To Err is Human: Building A Safer Health System - Institute of Medicine*. Retrieved from http://iom.edu/Reports/1999/To-Err-is-Human-Building-A-Safer-Health-System.aspx

Institute of Medicine (2011, November 8). *Health IT and Patient Safety: Building Safer Systems for Better Care*. Retrieved from http://books.nap.edu/openbook.php?record_id=13269

Lorenz, E. N. (1963). Deterministic nonperiodic flow. *Journal of The Atmospheric Sciences*, *20*, 130-141.

Korniewicz, D. M., Clark, T., & David, Y. (2008, January). A national online survey of effectiveness of clinical alarms. *American Journal of Critical Care*. *17*(1), 36-41. Retrieved from http://www.ajcconline.org

Kowalczyk, L. (2011, February 13). Patient alarms often unheard, unheeded. *The Boston Globe* [Boston], pp. 1-6.

Kowalczyk, L. (2011, December 29). State reports details 11 patient deaths linked to alarm fatigue in massachusetts. *Boston Globe* [Boston].

Kowalczyk, L. (2013, April 8). Hospitals warned of alarm fatigue. *The Boston Globe* [Boston].

McEwen, M., & Willis, E. M. (2012). Theories from the sociologic sciences. In *Theoretical basis for nursing*. (3rd ed.). (pp. 267-268). Philadelphia, PA, USA: Lippincott, Williams & Wilkins.

Phillips, J., & Barnsteiner, J. H. (2005). Clinical alarms improving efficacy and effectiveness. *Critical Care Nursing Quarerly*, *28*(4), 317-323.

Resnicow, K., & Page, S. (2008). Embracing chaos and complexity: A quantum change for public health. *American Journal of Public Health*, *98*(8), 1382-1389

Sentinel Event Alert Issue 50: Medical device alarm safety in hospitals | Joint Commission. (2013). Retrieved from http://www.jointcommission.org/sea_issue_50

Survey finds healthcare risk managers and executives struggle with patient safety. (2013). *Healthcare Risk Management*, *35*(6), 68-69.

Talley, L. B., Hooper, J., Jacobs, B., Guzzetta, C., McCarter, R., Sill, A., Cain, S., & Wilson, S. (2011). Cardiopulmonary monitors and clinically significant events in critically ill children. *Horizons*, 38-45.

The Joint Commission (2014). *Hospital: 2014 National Patient Safety Goals | Joint Commission*. Retrieved from http://www.jointcommission.org/hap_2014_npsgs/

Top 10 technology hazards for 2010. (2009, November). *Emerency Care Reasearch Institute*. Retrieved from http://www.ecri.org

Top 10 technology hazards for 2011. (2010, November). *Emerency Care Reasearch Institute*. Retrieved from http://www.ecri.org

Top 10 technology hazards for 2012. (2011, November). *Emerency Care Reasearch Institute*. Retrieved from http://www.ecri.org

Top 10 technology hazards for 2013. (2012, November). *Emerency Care Reasearch Institute*. Retrieved from http://www.ecri.org

Top 10 technology hazards for 2014. (2013, November). *Emerency Care Reasearch Institute*. Retrieved from http://www.ecri.org

Varpio, L., Kuziemsky, C., Macdonald, C., & King, W. J. (2012). The helpful or hindering effects of in-hospital patient alarms on nurses. *Computers, Informatics, Nursing*, *30*(4), 210-217. doi:10.1097/NCN.0b013e31823eb581

Weil, K. M. (2009). Alarming monitor problems. *Nursing 2009*, 58.

Welch, J. (2011). *An evidence based approach to reduce nuisance alarms and alarm fatigue*. Retrieved from http://www.aami.org/htsi/alarms/pdfs/Alarms%20Horizons_Secure_Watermarked.pdf

Alarm Fatigue: A Technology Hazard

Appendix A

ALARM FATIGUE SURVEY

The purpose of this study is to investigate the impact of alarm fatigue on nurses in an inpatient adult acute care setting. The focus will be the degree to which nurses experience alarm fatigue and the impact on nursing workflow.

Definitions: Alarm fatigue- When staff become overwhelmed by the sheer number of alarms. This can result in alarm desensitization, which in turn can lead to missed alarms or delayed alarm response (ECRI, 2010).

Nuisance alarms- are the high incidence of clinically non-actionable alarms (Welch, 2011).

False alarms- are clinical alarms produced by artifact creating false data (Welch, 2011).

Please select one response for all questions considering the above definitions.

1) Based on the above definition, have you experienced alarm fatigue in the past 6 months?

Strongly Agree Agree Undecided Disagree Strongly Disagree

2) Nuisance/ false alarms occur frequently in my practice.

Strongly Agree Agree Undecided Disagree Strongly Disagree

3) Nuisance/ false alarms disrupt my patient care.

Strongly Agree Agree Undecided Disagree Strongly Disagree

4) Nuisance/ false alarms reduce my trust in alarms.

Strongly Agree Agree Undecided Disagree Strongly Disagree

5) Nuisance/ false alarms contribute to lack of response by many nurses.

Strongly Agree Agree Undecided Disagree Strongly Disagree

6) I feel confident in adjust monitor alarm parameters in order to reduce nuisance/ false alarms.

Strongly Agree Agree Undecided Disagree Strongly Disagree

7) I feel overwhelmed by the number of alarms on the unit.

Strongly Agree Agree Undecided Disagree Strongly Disagree

Top 10 technology hazards for 2010. (2009, November). *Emergency Care Research Institute*. Retrieved from http://www.ecri.org
Welch, J. (2011). *An evidence based approach to reduce nuisance alarms and alarm fatigue*. Retrieved from http://www.aami.org/htsi/alarms/pdfs/Alarms%20Horizons_Secure_Watermarked.pdf

ALARM FATIGUE SURVEY

8) Clinical alarms are a significant contributor to my stress level.

Strongly Agree Agree Undecided Disagree Strongly Disagree

9) How many times in a shift, on average do you think you are interrupted by a clinical alarm?

0-5 6-10 10-15 15-20 greater than 20

10) What strategies do you utilize to deal with nuisance/false alarms?

_____
_____
_____
_____

11) What training did you receive on the telemetry monitoring system and its functionality?

_____
_____
_____
_____

12) Do you feel this training was adequate? If no, what type of training would you recommend?

_____
_____
_____
_____

What is the highest degree or level of school you have completed? (*please circle one*)

Associates Degree Bachelor's Degree Master's Degree Doctoral Degree

Top 10 technology hazards for 2010. (2009, November). *Emergency Care Research Institute*. Retrieved from http://www.ecri.org
Welch, J. (2011). *An evidence based approach to reduce nuisance alarms and alarm fatigue*. Retrieved from http://www.aami.org/htsi/alarms/pdfs/Alarms%20Horizons_Secure_Watermarked.pdf

ALARM FATIGUE SURVEY

Which best describes your total years spent as a practicing Registered Nurse?

- Less than two years
- 2-5 years
- 6-10 years
- 11-15 years
- 16- or greater

Which shift do you work? *(please circle one)*

Days Evenings Nights Other _____

Which hours best describes your shift worked? (*please circle one)*

8hours 12 hours combination of 8hours/ 12 hours Other _____

Top 10 technology hazards for 2010. (2009, November). *Emergency Care Research Institute*. Retrieved from http://www.ecri.org
Welch, J. (2011). *An evidence based approach to reduce nuisance alarms and alarm fatigue*. Retrieved from http://www.aami.org/htsi/alarms/pdfs/Alarms%20Horizons_Secure_Watermarked.pdf