TELEMETRY NURSES KNOWLEDGE OF ALARM FATIGUE AND INTERVENTIONS FOR CHANGE: AN EDUCATIONAL PROGRAM DEVELOPMENT

by

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Abstract

Alarm fatigue is known to be one of the top safety concerns in the healthcare setting. The Joint Commission recognized Alarm safety as one of the 2017 National Patient Safety Goals. Alarm fatigue occurs when a healthcare worker becomes overwhelmed and often desensitized to patient monitor alarms. It has been established that interventions including ECG daily electrode and battery changes, skin prep for electrode placement, and adjusting alarm parameters to fit patient needs can lead to a reduction in false or nuisance alarms. In order for these interventions to be carried out successfully, education of nurses regarding alarm fatigue and interventions for change needs to be completed. Education is one of the most important phases of creating change. The purpose of this program development project was to determine the effectiveness of an educational program on alarm fatigue awareness for telemetry unit nurses. A program development project was developed utilizing a pre-test, educational intervention, and a post-test design. Tests were used to evaluate the nurses' knowledge improvement related to the educational intervention. Sixteen out of a possible 60 telemetry nurses completed the pre-test portion of this quality improvement project. (N=16, 26.6%). Fourteen of a possible 60 nurses attended the educational session and completed the post-test portion of this quality improvement project. (N=14, 23%). For the purpose of presenting the first four questions, only those tests with matching pre-and-post responses were utilized, (N=14). The mean scores from pre-tests were 51.2% and mean post-test scores were 92% which revealed an increase by 40.8% after an educational intervention. The APRN can assist in establishing and implementing an educational program. This educational program can help to implement interventions and provide evidenced based research to support the prevention of alarm fatigue.

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TELEMETRY NURSES KNOWLEDGE OF ALARM FATIGUE AND INTERVENTIONS FOR CHANGE: AN EDUCATIONAL PROGRAM DEVELOPMENT

Background/Statement of the Problem

In an acute care hospital, between 350 and 700 alarms per patient can be heard in the course of a single day. Although the majority of alarms heard in the hospital are essential to quality patient care, they may not always be signaling a patient change. Approximately 15% of alarms heard require actual clinical intervention (Petersen & Costanzo, 2017). In fact, many of the alarms heard occur when a device becomes disconnected from the patient or if a device is not working properly. A monitoring alarm system cannot be 100% sensitive to a patient's change in condition without also leaving room for error in monitoring. Monitor alarms that do not require clinical intervention are seen as non-actionable, false, or nuisance alarms. Peterson and Costanzo (2017) stated in their study, that 80 to 99 % of the alarms heard do not actually signify change in patient condition and do not require intervention. Alarm fatigue occurs when a healthcare worker becomes overwhelmed and overly aware of the alarms around them leading to a desensitization of these alarms. These alarms include but are not limited to monitor alarms, bed alarms, patient call lights, and intravenous infusion pump alarms. When a person is no longer sensitive to the alarms it causes a delay or complete lack of response. Alarm fatigue has been shown to lead to poor patient outcomes and has even been associated with impaired patient safety (Funk, Clark, Bauld, Ott, & Coss, 2014). The purpose of monitor alarms is to allow clinicians and hospital employees to be aware of a change in patient condition or status.

A nurse may miss an important or crucial alarm due to their desensitization causing a lack of appropriate intervention, making alarm fatigue a major patient safety

concern. Patient safety is always a number one priority in the hospital setting. The Joint Commission (TJC) released a sentinel event alert in 2013 regarding patient safety and medical device alarm safety. According to the TJC sentinel event database, between January 2009-June 2012, there were 98 alarm-related events, 80 of them being patient deaths (The Joint Commission, 2013). The Joint Commission has recently released 2017 National Patient Safety Goals (NPSG) that specifically assess the reduction of harm associated with clinical alarms. Their focus on harm reduction is to ensure that clinical alarms are recognized and responded to in an adequate amount of time (The Joint Commission, 2016). TJC recognizes that a major hazard associated with multiple alarms is the escalation of noise in the clinical setting and ultimate desensitization by healthcare workers. Additionally, the Emergency Care Research Institute (ECRI) identifies alarm safety as a number one priority in its 2015 Top 10 Health Technology Hazards. The issue of alarm fatigue has become a large priority in regards to patient safety (Top 10 Health Technology Hazards, 2014). The focus of the ECRI is on educating nurses to assess appropriate alarm limits, adjusting default alarm settings, and enabling/disabling appropriate alarms. Educating nurses is a major priority to the success of combating alarm fatigue.

Recognizing ways to combat alarm fatigue and prevent further adverse patient outcomes has become of large importance especially in regards to patient safety and nurses' ability to care for patients. The purpose of this quality improvement project was to determine the effectiveness of an alarm fatigue awareness educational program for telemetry unit nurses. Education for telemetry nurses included information regarding alarm fatigue importance, ways to combat alarm fatigue, and interventions for prevention

of false, non-actionable alarms. The overall goal of the education was improved knowledge in telemetry nurses regarding prevention and interventions for combating alarm fatigue.

Next, a review of the literature will be discussed.

Literature Review

A thorough review of the literature was conducted using CINAHL, PubMed, and Ovid. Searches for literature included the keywords alarm fatigue, alarm fatigue education, clinical alarms, false alarms, and alarm prevention. Limits to the literature reviewed were only those published in English and included only literature from the last 10 years, 2007-2017.

Alarm Fatigue

Background. Clinical monitor alarms in the hospital setting allow clinicians to be aware of a change in patient condition. The nurse is notified of the patient's change when the monitor triggers an alarm. This change is noted as a deviation from what the monitor has been set to define as "normal". The alarm then helps to identify which patient has had the change, the type of change, and an appropriate response to that change (Korniewicz, Clark, & David, 2008). Monitor devices make measurements in an on-going basis for heart rate, respiratory rate, SpO2, systolic, and diastolic blood pressure. With the ongoing measurement of multiple values, there is a continuous chance for alarms to sound. The US Food and Drug Administration reported that 566 deaths were found to be caused by alarms on clinical monitors between the years of 2005 and 2008 (Weil, 2009). These deaths occurred due to the delayed or complete lack of response to alarms. Alarms were found to be silenced, inactive or ignored during a critical event. Deaths were said to have been preventable if alarms had been responded to appropriately during a cardiac event such as severe bradycardia, ventricular fibrillation, or ventricular tachycardia, known as lethal arrhythmias. Alarms are also often ignored due to nurse

alarm desensitization. Nurses who experience desensitization have had lack of immediate urgency and response which can impact patient care and safety (Weil, 2009).

False alarms clinical impact. Gross, Dahl, and Nielsen (2011), assert that the problem of alarm fatigue, and a large part of defining alarm fatigue, begins with the elevated amount of false positive and clinically non-actionable positive alarms. These authors explain that the number of false alarms is known to range from 72% to 99%. In an article by Cvach (2012), the author states that as many as 700 monitor alarms will occur per patient per day. With the extensive number of alarms heard throughout the day, the awareness of these alarms begins to diminish. This lack of awareness leads to an overall desensitization to alarms, which creates what is known as alarm fatigue. Cvach (2012) states that a major contributor to alarm fatigue is the increase in false alarms, or alarms which do not require intervention. False alarms have been found to lead to nurses turning down alarm volumes, silencing alarms, ignoring alarms, and adjusting limits outside appropriate parameters (Cvach, 2012). When alarms are silenced without confirmation of patient safety, there is room for adverse patient outcomes and poor safety. The vast amount of false alarms leads to a sense of distrust in the monitoring system (Sendelbach & Funk, 2013). A distrust is created when a large amount of non-actionable and false alarms occur and a scant amount of actual true alarms occur. In many situations, nurse are checking patients and silencing false alarms without true clinical intervention. False alarms are those alarms that are triggering an event that is not actually occurring. An example of a false alarm is when the monitor reads Ventricular Tachycardia (VT) but the patient is actually coughing causing artifact in the monitor without true VT (Lukasweicz & Mattox, 2015). Other types of false alarms are

nonactionable and nuisance alarms. Nonactionable or nuisance alarms occur when an alarm signals correctly but there is no required clinical intervention. These alarms are often caused by monitor parameters being too "tight". An example of this would be a patient whose heart rate is known to be 130bpm, but alarms are set to ring when the rate is greater than 120bpm. This creates true alarms, as the heart rate is above 120bpm, but requires no intervention and leads to nonactionable, nuisance alarms.

Clinical evidence of alarm fatigue. Nurses are one of the first of all healthcare workers to feel the impact of alarms throughout a hospital unit. Nurses are at the patients' bedside throughout their shift causing them to be exposed to most of the alarms which often become background noise. In a 2010 Boston Globe article by Kowalczyk, a highly-publicized death occurred at prominent medical center and was found to be caused by lack of nursing response to low heart rate alarms. During the investigation, nurses working that day were interviewed and most did not recall even hearing the alarms. Alarm fatigue was found to be a major contributor to that patient's death (Kowalczyk, 2010). Lukasweicz and Mattox (2015) found that nurses identify silencing central alarms without checking on patients as a way to reduce the stress of alarm fatigue. Nurses also modify parameters to unreasonable limits, such as heart rates above 200bpm or below 20bpm, as well as disable or suspend alarms permanently, which can result in missing a true event. Lukaweicz and Mattox (2015) also believe "alarms perceived as 10% reliable generate a 10% response rate and alarms perceived as 90% reliable generates a 90% response rate" (p.51). These literature findings highlight that an excess amount of non-actionable alarms leads to a poor perception of alarm reliability and often affects nursing response to alarms. The overwhelming alarm numbers leads to a sense of fatigue known

as alarm fatigue. Alarm fatigue has been said to lead to multiple adverse events, such as delayed action in response to a patient change in condition, patient injury, or even death. Alarm fatigue is defined by Lukasewicz and Mattox (2015) as "A situation wherein people become desensitized to the alarms in response to excessive exposure" (p.47). Nurses realize they are overwhelmed by the sheer number of alarms which creates alarm fatigue and often leads to alarm-related events. Alarm related events are often under-reported although they occur frequently and are often caused by alarm fatigue (Honan et al., 2015). Brantley et al. (2016) explains that many of the alarms heard throughout the hospital day are not related to an actual clinical problem with the patient, but are found to be related to patient movement, poor monitor contact with the skin, or small changes that exceed set limits.

Drew et al. (2016) studied alarm data to determine alarm frequency, accuracy, and alarm burden as well as recommendations for solutions to the problems of clinical alarm fatigue. The research team used a prospective data collection design to look at all clinical alarms in the hospital's 5 adult Intensive Care Units (ICUs), totaling 77-beds. All alarm data was collected for a 31-day period. A total of 48, 173 hours of monitoring resulted in 2,558,760 audible and inaudible, or advisory message, alarms. Results showed that there was a specific total of 381,560 audible alarms which translates into 187 audible alarms per bed per day. This study looked specifically at types of arrhythmia alarms and their rates of false alarm. False alarms were looked at as alarms that inaccurately signaled, an alarm without a true event. The alarms were broken down into asystole, ventricular fibrillation, ventricular tachycardia, pause, and bradycardia. These alarms totaled 12,671 of which 11,251 or 88.8% were false alarms (Drew et al., 2016). Overall, this study found

that there is an overwhelming amount of false, non-actionable alarms in the hospital setting.

Clinical Significance of Alarm Fatigue

National Healthcare Technology Foundation (HTF) Survey. In 2005 the Healthcare Technology Foundation (HTF) foundation put together a task force of 16 members who developed an online survey aimed at evaluating clinical alarms occurring in the acute care hospital setting (Korniewicz et al., 2008). This foundation works to achieve safe use of technology in the healthcare field. Their mission is to improve healthcare outcomes by ensuring the appropriate use and application of heath care technology (Healthcare Technology Foundation, n.d.). The survey asked the respondents about their level of agreement with 19 statements regarding alarms. It was released nationally in 2005/2006 and received 1327 responses. In 2011 from August to September, the same survey was released again with 4 additional questions and resulted in 4278 respondents (Korniewicz et al., 2008). The task force's survey consisted of 4 main sections. The first section consisted of demographic data, the second section consisted of general statements regarding clinical alarms which participants could respond to as strongly agree, agree, neutral, disagree, or strongly disagree. The third section consisted of 9 issues inhibiting clinical alarm management of which respondents were asked to rank from most to least important. The fourth and final section allowed for commentary on alarms and needs for improvement (Korniewicz et al., 2008). The 2011 survey used all of the initial questions and sections with the additions of 4 questions. The 4 additional questions inquired about adverse patient events, monitor watchers, which are technicians who have been hired to watch monitors for low battery and lead off alerts, alarm

improvement initiatives, and any new technology to improve alarm safety. These surveys and the results presented by the HTF were examined and presented by multiple researchers and are included later in this review.

Empirical evidence using HTF survey. The 2005/2006 survey results were utilized and discussed by researchers Korniewicz, Clark, and David in a 2008 study. As previously stated, the 2005/2006 HTF survey was completed by 1327 respondents of which 51% were registered nurses. Other respondents were respiratory therapists, clinical engineers, and clinical managers. Korniewicz et al. (2008) looked specifically at the results from the HTF 2005/2006 survey and analyzed the data. The researchers found that false alarms occurring frequently were identified as a problem by 81% of participants and 77% of participants agreed that nuisance alarms disrupt patient care. Seventy-eight percent of participants agreed or strongly agreed that excess alarms lead to reduced trust in alarms and lead to the disabling of devices. However, the study by Korniewicz et al. (2008), also revealed that 72% of respondents felt the alarms were adequate in alerting staff of patient change in condition. Their findings discussed that an excess amount of staff frustration is caused by the elevated amount of false and nuisance alarms (Korniewicz et al., 2008). The authors continue to explain that alarms are distracting and interfere with a nurses' ability to perform daily tasks. Korniewicz et al., 2008 further states that "alarms contribute to desensitization of nurses to the devices, such that alarms for 'real' events are less likely to catch the attention of staff." (p. 39). Data from the HTF 2005/2006 survey contributed to the researchers' overall findings.

Funk, Clark, Bauld, Ott, and Coss (2014) utilized the HTF's 2011 clinical survey results as well as the 2005-2006 survey results to review a comparison of attitudes and

practice changes throughout the years. Funk et al. (2014) completed their study by reviewing the HTF survey results and utilizing Microsoft Office Excel to determine differences in responses between the 2005 and 2011 survey results. Initially, Funk et al. (2014) reviewed demographic data results which revealed that the 2005-2006 survey had a higher number of nurses who responded, in comparison to other disciplines who responded. The data analysis revealed that 51.8% were registered nurses in the 2005-2006 survey results in contrast to 33.06% nurse respondents in the 2011 survey results. The second section of the HTF survey asked about respondent's level of agreement with statements regarding alarms. The majority of the survey statement findings revealed no change between the 2005-2006 years (Funk et al., 2014). Respondents either agreed or strongly agreed in 2005 and 2011 that alarms on the unit are adequate to alert staff of a potential change in patient condition. Respondents also agreed or strongly agreed in 2011 and 2005 that there are frequent instances when alarms are missed and not heard. However, review of the 2011 results did reveal that more respondents disagreed that nuisance alarms occur frequently and disrupt patient care in comparison to 2005 survey results. Respondents in 2011 disagreed that setting of alarm parameters was of high complexity and in 2005 respondents strongly agreed that setting of alarm parameters was of high complexity. The third section of the survey, which involved ranking 9 different alarm issues by order of importance, was reviewed. According to Funk et al. (2014) in both 2005 and 2011, respondents ranked frequent false alarms as an issue of most importance. The least important issues were similar in both survey results to be lack of training on alarm systems and difficult setting alarms properly. In the 2011 survey there were four additional alarm related questions which could not be compared to a previous

survey. Funk et al. (2014) reviewed these results as they specifically addressed alarm adverse events and initiatives for change. One in 5 respondents stated they had experienced an adverse patient event in the last 2 years. Clinical alarm improvement initiatives were started by 21% institutions and only 19% of respondents reported that their institution had implanted solutions to improve alarm safety. Half of the respondents did however state that their institution utilizes monitor watchers as way to prevent adverse patient outcomes. A monitor watcher is able to view all monitors on the unit and call with any low battery or lead off alerts. Funk et al. (2014) discussed that little progress has been made in the improvement of alarm safety and prevention of alarm fatigue through the comparison of the 2005 and 2011 HTF survey results. Nurses continue to feel the burden of alarm fatigue and continue to see clinical alarms as overwhelming and disruptive to patient care (Funk et al., 2014).

Honan et al. (2015) utilized responses from the 2011 HTF survey results and the findings reported were specific to the nurse comments from the parent survey. The nurse-specific comments had not been analyzed or reported in previous studies discussing HTF results. A total of 790 nurse comments were analyzed using the Krippendorff method of content analysis, which identified six themes related to nurses' experiences. The first theme revealed nurses face a sense of conflict and desensitization. Nurses are said to "disassociate, or discount" alarms which leads to a lack of trust in the alarm system. This lack of trust comes from the excess amounts of false and nuisance alarms (Honan et al., 2015). A second theme discovered, relates to "noise pollution," and the idea of patients and their families suffering from the overwhelming noise. Nurses state that visitors and patients complain about the constant noise and the fear of alarms. A third theme relates to

accountability across the organization. Nurses discussed the need for patient care to include team work and that each nurse should respond to any and all alarms. This theme also relates to the need for nurses to follow through with alarms, which means checking patients without simply silencing an alarm. The fourth theme found relates to nurses perspectives related to authority to change alarm settings. The hesitancy of changing alarms comes from the idea of missing an important event when standard parameters are not in place. Nurses are at the bedside each day and feel they should be able adjust alarm limits as long as it is documented (Honan et al, 2015). The fifth theme discussed the importance of having a monitor watcher as well as allowing nurses to work at full staff abilities. The final theme that emerged was a hope for future guidelines and technology to improve interventions for change. This includes alarm delays for transient change in numbers such as a low oxygen level with sleep apnea that quickly recovers and different alarm signals to identify what changes are occurring such as heart rate or blood pressure. The results of analyzing nurses' comments shows the need for nursing involvement in policy change and alarm management (Honan et al., 2015).

Peterson and Costanzo (2017) also utilized the 2011 HTF clinical alarm survey, which included 4 additional questions, to complete a quality improvement project on a critical care unit. Their goal was to understand nurses' insight into the problems of alarm fatigue. Utilizing the 2011 version of the HTF clinical alarm survey, the goal was to identify nursing alarm fatigue concerns and use them to guide interventions for change. A convenience sample of 31 nurses were asked to complete the HTF survey of clinical alarms and their perceptions of alarm fatigue. Twenty-six of the 31 nurses working in critical care completed the HTF's clinical alarm survey. The survey consisted of 36

questions including multiple choice, open-ended and close-ended questions as well as Likert scale data. The results showed that 96% of the nurses agreed or strongly agreed that nuisance alarms disrupt patient care, 88% agreed with questions regarding the increased occurrence of nuisance alarms, and 100% agreed that the nuisance alarms reduce trust in the system. The findings of this study demonstrate that nurses are highly aware of alarm fatigue and there is a lack of overall training in alarm management (Peterson & Costanzo, 2017).

The results of this study by Peterson and Costanzo (2017) led to many interventions for change including creation of an alarm management policy. Policy implementation helped to create interventions including allowing RNs to adjust alarm parameters and turn off certain alarm triggers, such as atrial fibrillation or tachycardia, when necessary. Nurses adjusted alarm parameters based on patient's baseline data and doctor awareness of a patient's known condition. Results from this study explained that additional training would help nurses to better understand monitors and how to change a monitor's alarm parameters. Staff was therefore educated through a hands-on practice training annually. Throughout the hands-on training, nurses were able to practice utilizing patient scenarios, which required nurses adjust parameters based on patient data and new policy alarm limits (Peterson & Costanzo, 2017).

Impacts of Over-monitoring on Alarm Fatigue

Background. With the excess amount of alarms heard daily, the issue of over-monitoring becomes prevalent. Telemetry monitors are being utilized on patients who have no true reason for cardiac monitoring. Over-monitoring is often thought of as benign to patient's safety, however this leads to an increase in opportunities for alarms to sound.

The increase number of alarms, true and nuisance, leads to alarm fatigue which effects patient's safety. Over-monitoring has therefor become a large part of the problems of alarm fatigue. The increased workload created by over monitoring of patients who do not meet clinical criteria leads to false alarms and nurse interruptions. The nurse is also unable to pay as close attention to the patients who require monitoring (Benjamin, Klugman, Luckmann, Fairchild, & Abookire, 2013). Excess monitoring has not been shown to contribute to early detection of arrhythmias, decreased long-term mortality, or change in level of care (Feder & Funk, 2016). Over-monitoring also increases cost of healthcare and increased unit noise, contributing to alarm fatigue.

Empirical evidence. A research study by Benjamin et al. (2013), looked at four Massachusetts teaching hospitals utilizing cardiac telemetry monitors in units outside of intensive care and stepdown. This study was completed by utilizing the American College of Cardiology and the American Heart Association guidelines for telemetry use. Benjamin et al. (2013), used the guidelines to determine how many days patients being monitored were indicated or non-indicated. Data was collected through chart reviews, which included start and stop dates of monitoring, indications for monitoring, number of days guideline criteria was met, number of non-indicated guideline days, and any occurrences of arrhythmias. Data was collected during a one-week period, January 1 2008 through January 7, 2008, at each of the participating 4 hospitals. A 95% confidence interval was obtained. Benjamin et al. (2013), found that 35% of clinical monitor days were not supported by the clinical monitoring guidelines. The researchers identified 2 types of situations where monitors were overused which were no indication for initiation of telemetry and continuing telemetry monitoring past the recommended stop time.

Benjamin et al. (2013), also estimated that with a 35% rate of non-indicated telemetry days there is an excess cost of $ 250,000 per year.

Perrin et al. (2017), completed a quality improvement project utilizing a nurse driven telemetry monitoring discontinuation protocol. The pre-post study was completed on a 15-bed medical care unit in a hospital. The purpose of this project was to implement a safe and successful method for discontinuing telemetry monitoring when it is no longer indicated. Six months of pre-intervention data was compared to six months of data during the interventional stage. A telemetry monitoring discontinuation protocol was put in place based on patient assessment and clinical judgement. Criteria for telemetry discontinuation was discussed at interdisciplinary rounds by the nurse caring for the patient based on lack of arrhythmia and maintenance of a normal heart rate in the past 24hrs. The physician had the ultimate final decision based on the presentation by nursing. Results revealed a 25hr reduction in average monitoring time compared with the pre-intervention group. Overall, results revealed that nurses and physicians can work together to decrease the number of patients maintained on telemetry monitoring without affecting patient safety. With a decreased number of patients being monitored there is a decrease in the number of false and nuisance alarms, which decreases the occurrence of alarm fatigue (Perrin et al., 2017).

Education for Nursing Intervention/Prevention

Multiple interventions for improvement of alarms have been tested in many studies. One of the suggested interventions include adjusting alarm parameters to better fit the patient. An example of this is adjusting heart rate alarms when a patient has a known bradycardia making the low limit 40bpm instead of 50bpm. Another intervention

for change includes changing of ECG electrodes daily with proper skin preparation. Better skin to electrode adherence minimizes artifact and drying of electrodes which reduces false alarms. Poor electrode conduction and dry electrodes leads to increase artifact which is associated with false alarms. Bundled interventions are also said to improve alarms and prevent nuisance alarms. Bundled interventions include a set of improvements that will prevent alarm burden. These include eliminating duplicate alarms, customizing alarm parameters, daily changes of electrodes, improved skin preparation for electrode placement, and staff education. Many of these interventions are discussed as being studied together rather than individually. The following studies discuss the interventions for change.

Adjusting alarm parameters. Implementing interventions to minimize clinical alarms and prevent false and non-actionable alarms is a large part of the management and prevention of alarm fatigue. Graham and Cvach (2010) looked at small changes to alarm limits as a goal to decreasing nuisance alarms. They recognized that non-actionable alarms lead to alarm fatigue which causes a delay in response time to all alarms. This quality improvement project occurred on a 15-bed unit with 30 registered nurses. Their study strictly evaluated the customization of alarm parameters as a way to minimize non-actionable alarms (Graham & Cvach, 2010). The proposed alarm changes included high heart rate alarms being changed from 120 to 150 and low heart rate alarms being changed from 60 to 50. Oxygen saturation alarms were changed from 90% to 88% and premature ventricular contractions were changed from 6 per minute to 10 per minute. These interventions were discussed at length during an education retraining program which included the importance of following the customization of alarm parameters. Alarms

went from 16953 to 9647 and revealed a 43% reduction in monitor alarms. Overall, these findings suggest that modifying alarm parameters leads to an improvement in clinical alarms, which in turn eliminates non-actionable alarms. The authors concluded that training and educating nurses on alarm limit changes is critical to making alarm limits individual to the patient (Graham & Cvach, 2010).

As Graham and Cvach (2010) studied changes to HR parameters, Whalen et al. (2014) also looked specifically at adjusting heart rate (HR) default limits for the improvement in clinical alarms and prevention of alarm fatigue. For this quality improvement project, HR low limits were changed to a low limit of 45bpm and a high limit of 130bpm. The HR adjustments were changed from a previous low limit of 50bpm and a high limit of 120bpm. It is important to note that this study was completed on a 24-bed telemetry unit where HRs are generally more controlled than in a critical care setting. After a 2-week period, he results showed a reduction of 87,823 alarms per week to 9,967 alarms per week. There was an 89% reduction in the number of audible alarms on the telemetry unit. More specifically, there was a 93% decrease in bradycardia, tachycardia and HR parameter alarms. This demonstrates that even small changes in alarm thresholds can reduce overall clinical alarms. Whalen et al. (2014), also point out that during the implementation of this project allowing for the changes to alarm limits, and the increased education, led to empowering of nurse to modify default alarm settings if an alarm did not indicate the need for clinical intervention (Whalen et al., 2014).

Daily electrode change. Interventions for alarm reduction may also include the evaluation of whether daily changing of electrodes lead to reduction of monitor alarms (Cvach, Biggs, Rothwell, & Charles-Hudson, 2013). Poor skin to electrode contact as

well as old dried out electrodes has led to interruptions in patient monitoring. Cvach et al. (2013) asked the question, "Does changing electrodes daily decrease the quantity of cardiac monitor technical alarms?" (p.266). The study was completed on two medical unit, a 15-bed medical progressive care unit (MPCU) and a 25-bed cardiology care unit (CCU). The intervention included daily changing of ECG electrodes, which was completed by technicians between 8am-12pm with morning care. Interventions for electrode change included clipping or shaving hair prior to application, rubbing area with gauze to remove dead skin cells, cleaning the skin with soap and water only, and drying skin prior to electrode change. Data was collected regarding clinical alarms over increments of 8 days for a total of 16 days. The first 8 days provided baseline data in each unit, pre-intervention, and the next 8 days provided data after intervention. Overall alarm reduction was shown to be 46% in the CCU and 47% alarm reduction in the MPCU. This study showed that changing electrodes daily is one of the ideal ways to decrease clinical alarms and help diminish alarm fatigue (Cvach et al., 2013).

Similar to Cvach et al. (2013), Walsh-Irwin and Jurgens (2015) studied electrodes and their impact on clinical alarms. The aim of this study was to review proper skin preparation and to evaluate if the placement of electrodes has an impact on alarm reduction. A prospective descriptive design was used to look at the proper skin preparation and ECG electrode placement. A sample size of 15 patients was utilized to observe alarms on a telemetry unit in a Veterans Medical Center. Alarms were observed for 24hrs after skin prep and proper placement showing a 44% decrease in alarms with a 95% confidence interval. Proper skin preparation and placement interventions included clipping hair, washing skin with soap and water, drying skin with washcloth, and

attaching electrodes in the correct anatomical place. They found that poor skin preparation and incorrect placement of electrodes leads to increased false alarms as well as increased risk of over diagnosing arrhythmias. They also found that proper skin preparation can improve electrode conduction and skin to electrode contact (Walsh-Irwin & Jurgens, 2015).

Bundled interventions. Sendelbach, Wahl, Anthony, Shotts (2015) conducted a quality improvement project aimed at bundled interventions for the reduction of nuisance alarms. This study took place in a 16-bed coronary care unit (CCU) at a Magnet hospital. The researchers started by gathering baseline data of alarms in the CCU and understanding the types of alarms observed. There was also an initial workshop for nurses to discuss important interventions for alarm improvement. These interventions included elimination of duplicate alarms, such as: tachycardia and high heart rate, customizing alarms to individual patient needs, daily changes of electrodes, improved skin preparation for electrode placement, and disposable ECG leads. This study looked at a bundled set of interventions for improvement of clinical alarms but initiated each intervention at separate periods of time. Disposable lead wires failed to show any change in alarm numbers during a 2-week trial, however all other interventions showed an 88.5% alarm reduction reducing numbers from 28.5 alarms per bed per day to 3.58 alarms per bed per day. Overall the project showed that a bundled set of interventions can decrease the number of nuisance alarms in a day (Sendelbach et al., 2015).

Similar to this study, Turmell, Coke, Catinella, Hosford, Majeski (2017) evaluated a bundled set of interventions for reduction of clinical alarms in a 580-bed hospital over 2 years. The investigators utilized recommendations from evidenced-based

practice to support their bundled interventions. Recommendations from the American Association of Critical Care Nurses (AACN) were utilized and included daily electrode changes with proper skin preparation, removal of non-actionable and duplicate alarms as well as adjusting default limits, educating RNs on alarm customization, and decreasing telemetry over monitoring. Before each intervention was completed, education was provided to nurses on the techniques, goals, and importance of the change. The first intervention included changing daily electrodes at 10am, which showed a 33% reduction in clinical alarms over a 2- week period. The next intervention was eliminating non-actionable and duplicate alarms and adjusting default alarms which showed a 36% reduction of alarms on one unit and 84% reduction of alarms on another unit. Still another intervention involved customizing alarms, however this method did not result in improved alarm numbers. The authors suggest that this lack of change may be due to alarms not being adjusted fast enough given the patient's change from baseline. This intervention was stopped after just 48hrs given the lack of improvement and actual increase in alarm numbers. This project showed using an evidenced-based bundled approach to alarm management shows a reduction in overall clinical alarms (Turmell, Coke, Catinella, Hosford, & Majeski, 2017).

Allan, Doyle, Sapirstein, and Cvach (2017) also studied a set of bundled interventions for the reduction of clinical alarms. The aim of this study focused on five of the most frequent alarm areas including pulse oximetry and sensors, heart rate, blood pressure, and VT >2 alarms. This study took place in an 18-bed cardio-vascular intensive care unit which staffs 80 registered nurses and was split into multiple phases to allow for staff education at each phase. The nurses on this unit were educated on alarm limit

changes to promote reduction in clinical alarms. In the first phase, the pulse oximetry alarm settings were changed to reflect an alarm threshold for oxygen saturation change from 89% to 88% with a delay change from 5 seconds to 15 seconds. The VT>2 alarm which is defined by a 3 to 5 beat run of VT was changed from high alert to low alert alarm. The second part of phase one included the above changes as well as changing the high HR alarm from 120bpm to 130bpm, the systolic high limit was changed from 150mmHg to 170mmHg and the diastolic was changed from 40mmHg to 30mmHg. Phase two included auditing of nurse compliance in changing alarm parameters, as well as continuing staff education for change. The unit's average alarms per bed per day were reduced from 211 down to 83, which indicates a 61% decrease in overall alarms. This quality improvement project has limitations related to being unable to pinpoint which specific change had the biggest impact on alarm reduction. However, there was an obvious reduction in overall clinical alarms (Allan et al., 2017).

Next, the theoretical framework that guided this educational program will be discussed.

Theoretical Framework

The Logic Model through the W.K. Kellogg Foundation was utilized as the theoretical framework for development of this educational program. A program logic model guides the development of a program, describing how it will work, what resources and activities will be needed, and the overall outcome goals (W.K. Kellogg Foundation, 2004). The logic model assists in the planning, implementation, and evaluation of program development. This model is ultimately a blend of what resources you may need, how you intend to achieve your goal, and the outcomes you want to achieve. The key focus of this model is in the relationships between each phase and the elements that make up the program. One phase is directly related to the other and impacts how smoothly the program will run. Each phase helps to ensure systemized program planning, implementation, and outcomes.

Utilization of the logic model starts with the planning phase. This phase requires evaluation of what resources you have and any barriers to those resources, which could enable or limit the program itself. This phase is referred to as the "input" of the project (W.K. Kellogg Foundation, 2004). This project's resources included RN staff participants, the actual hospital environment and equipment, the amount of time needed for intervention, and the organization's assistance/approval for intervention. All resources were determined and obtained prior to the implementation of the project. The next step was also part of the planning but referred to taking the resources and creating the program activity. In this phase, one determined what the educational piece would be and how it would be evaluated. This step was the actual program development and included utilizing the tools and technology available to create a program for change. For this project, the activity was a 10-15-minute educational program for the telemetry nurse that

was evaluated through a pre-and post-test. Educational intervention and tests were piloted in a smaller group prior to implementation to ensure accuracy, which ensured that the overall program goals were achievable. These two phases combined created the planned work phase of this model. Utilizing these steps of the logic model helped to create organization for successful planning, similar to creating a blue-print. This led to program improvement and overall successful implementation for preferred outcomes.

The next phases of this framework were related to what the intended results and outcomes were. This consisted of three steps. The first step in this phase was related to actual "outputs", which means delivering the intended amount of information to create an outcome. For this project, the outputs were enabled by allowing enough time for telemetry RNs to complete the tests and receive the educational information. This meant completing the full educational program in the desired amount of time with the desired number of RNs. The actual delivery of the program is the intended output. The second step of this phase involved the actual outcomes achieved. In this project, the outcomes achieved were related to improved knowledge of alarm fatigue in telemetry RNs. This was examined at the individual level through the post intervention test. The final step of this phase was the impact of this individual program. This was related to the bigger picture and overall organizational goals. For this project, the hope was that by providing the education to telemetry staff RNs the result would be in an overall decrease in alarms and improvement in nursing alarm fatigue. This framework guides each program component from gaining resources to implementation of the program and finally the evaluation of overall knowledge change.

Next, the methodology for this educational program development will be presented.

Method

Purpose

The purpose of this program development project was to determine the effectiveness of an educational program on alarm fatigue awareness for telemetry unit nurses.

Design

The design of this quality improvement, program development project was a pre-test, educational intervention, and a post-test. Tests were used to evaluate the nurses' knowledge improvement related to the educational intervention.

Sample/Site

The study used a non-probability, convenience sampling plan, with the potential of including all staff nurses working on one 44-bed telemetry unit at a 328-bed community hospital in New England. Inclusion criteria included all registered nurses on the unit. Exclusion criteria included non-registered nurses. It was anticipated that approximately 60 staff nurses would meet inclusion criteria.

Measurement

The evaluation of alarm fatigue awareness and interventions for prevention of alarm fatigue was assessed using a researcher-developed test as there was no existing measure in place. The test is included in Appendix C of this paper. The test consisted of 10 multiple-choice questions related to the educational session. Questions numbered one through four were Likert-scale questions regarding opinions on alarm fatigue. The first four questions were used to determine if nurses' opinions on alarm fatigue would change after the educational session. Questions were measured using the responses agree, strongly, agree, neither agree nor disagree, disagree and strongly disagree. The next 6

questions were multiple choice questions addressing the interventions for prevention of alarm fatigue. These questions were all developed based on the information presented in the educational session. The 6 multiple choice questions were used to measure knowledge improvement after educational intervention. The test was taken by 4 nurses with telemetry monitoring experience prior to implementation to ensure adequate content.

Procedures

This project involved human subjects and was approved by the Rhode Island College (RIC) Investigational Review Board (IRB). This project was offered to all registered nurses to ensure equal access. There were no vulnerable populations studied and there were no identifying demographic factors on the tests delivered. Administrative approval was also obtained from the Chief Nursing Officer as well as the research coordinator, and the telemetry unit manager at Charlton Memorial Hospital (CMH). Enabling factors included approval from administration, including the chief nursing officer as well as the research coordinator and nursing education committee. The telemetry unit manager agreed to help in coordinating the appropriate time and space for the educational intervention. Barriers included ensuring participation by all staff RNs and the appropriate timing for the educational piece to be completed. The telemetry unit manager agreed to help ensure active participation and time for education.

An informational email (Appendix A) was sent to all telemetry nurses on the unit. The email included an informational letter (Appendix B) discussing the project and its purpose as well as a brief overview of the procedure and how test results would be used. This letter also explained that participation was voluntary and that there was no demographic data collected. Consent was implied when the nurse read the informational

letter, completed the anonymous tests, and attended the educational session. The project took place in early fall 2017. It began with a 10-question pre-test (Appendix C) developed by the researcher, which was completed on the day of an educational session. The test was piloted on 4 nurses with telemetry experience prior to intervention prior to the intervention to test reliability. The test assessed awareness of alarm fatigue as well as the appropriate interventions for prevention. The test was completed prior to the educational in-service and remained anonymous with no participant identifiers included. The tests were matched by having participants place their mother's date of birth at the top of each test in order to identify corresponding tests pre-and post-education. Completed tests were placed in a manila envelope, which were then placed in a locked box and the locked box was immediately secured in a locked box in the manager's office until data analysis began.

Educational Session

An educational program was developed and delivered to the telemetry nurses in cooperation with the professional nursing education department. Information regarding hospital policy and procedures was obtained from the professional nursing education department. Information on interventions for prevention of alarm fatigue was also obtained during the thorough literature review. The educational program was created using the information obtained and objectives were developed based on the test questions. The Logic Model through the W.K. Kellogg Foundation was utilized to create the educational program. A copy of the program outline and objectives can be found in Appendix D. The participants then received the same test they completed pre-intervention as a post-intervention test (Appendix C) to ensure satisfactory knowledge improvement.

The education was completed through a 10-15-minute in-service on the telemetry unit. This included a poster board presentation describing what alarm fatigue is, how it impacts nurses, and the appropriate interventions for prevention. The poster-board was taken down after each session prior to the post-test being distributed. Sufficient time was allowed for intervention with the help of the unit manager to assure adequate participation. There were three identical sessions offered at different times throughout the day to include all staff shifts and to ensure participation from as many nurses as possible. A handout (Appendix E) of simple tips was given to each telemetry nurse as a pocket-guide after completion of the post test. At the end of all the sessions, completed pre-and post-tests were compared through data analysis.

Data Analysis

Descriptive statistical analysis including mean was used to measure the effectiveness of the educational program development. Pre-test responses were compared and analyzed to post-education post-test responses utilizing percentiles and total scores. Data is presented in the results section.

Next, the results of this project will be discussed.

Results

Sixteen out of a possible 60 telemetry nurses completed the pre-test portion of this quality improvement project. (N=16, 26.6%). Fourteen of a possible 60 nurses attended the educational session and completed the post-test portion of this quality improvement project. (N=14, 23%). For the purpose of presenting the first four questions, only those tests with matching pre-and-post responses were utilized, (N=14). Questions number 1-4 were Likert-scale questions, which can be found in Appendix C. For the purpose of reporting data via excel, the Likert-scale was converted to numerical data. The numbers 1-5 were used to report data, 1-strongly agree, 2-agree, 3-neither agree nor disagree, 4-disagree, and 5-strongly disagree. The nurse's responses from pre-test and post-test are presented in Table 1.

Table 1:

Mean Response Scores Questions 1-4 (n=14)

	Mean Pre-Test Response	**Mean Post-Test Response**
Question 1	1.64	1.57
Question 2	1.86	1.71
Question 3	2.21	2.36
Question 4	2.07	1.86

In review of question one, a majority (13/14) nurses agreed or strongly agreed, in both pre-and post-tests, that in the past three months they have experienced alarm fatigue. In review of question two, again, the majority of nurses (13/14) nurses agreed or strongly agreed in both pre-and post-tests that false alarms not requiring clinical intervention

occur frequently throughout their day. In review of question three, the majority of nurses (10/14) in both pre-test and post-test agreed or strongly agreed that staff is sensitive to alarms and respond quickly. The final question, question four, had the most variation in responses. Pre-test responses for question four revealed 10 out of 14 nurses agreed or strongly agreed that they are likely to set alarm limits/parameters that meet their patients' needs. The remaining four nurses chose the neither agree nor disagree response to this question regarding changing alarm limits. Post-test responses for question four revealed 12 out of 14 nurses agreed or strongly agreed that they are likely to set alarm limits/parameters that meet their patient's needs while the remaining two nurses disagreed that they are likely to set alarm limits/parameters that meet their patient's needs.

Questions five through ten were all presented as multiple-choice items. The details of questions five through ten on the pre-tests and post-tests can be found in Appendix C. Each multiple-choice question had a correct response. These questions were scored based on the number of total correct responses for questions five through ten only. For the purpose of further score review, only those tests with matching pre-and-post responses were utilized. Ultimately, the scores were looked at for total improvement in responses. In review of matching pre and post-test scores, all showed an improvement. The mean scores from the matching pre-tests were 51.2% and matching mean post-test scores were 92% which revealed an increase by 40.8% after an educational intervention. All responses for pre-tests can be found in (Appendix F) and all responses for post-tests can be found in (Appendix G).

Table 2 reveals the percent of nurses from this project who answered each question with the appropriate response for both pre-test and post-test. Again, only those tests with matching pre-test and post-test scores were utilized.

Table 2:

Pre/Post Test Appropriate Response Score Comparison

Question	Pre-test (N=14)	Post-test (N=14)
5	78.6% (11/14) Answer A	100% (14/14) Answer A
6	42.9% (6/14) Answer A	100% (14/14) Answer A
7	50% (7/14) Answer C	92.9% (13/14) Answer C
8	0.07% (1/14) Answer B	71.4% (10/14) Answer B
9	64.3% (9/14) Answer A	100% (14/14) Answer A
10	71.4% (10/14) Answer C	85.7% (12/14) Answer C

Question number eight, which asks the participant to determine the high and low alarm limits for HR per hospital policy had the most improvement in responses. In pre-test responses, one out of fourteen nurses (0.07%) responded with the appropriate response. In post-test responses, ten out of fourteen nurses (71.4%) answered the appropriate response. This revealed an increase of 71.3%. Overall question number eight received the lowest percentage of appropriate responses (71.4%) in comparison to other multiple-choice post-test responses. Question number six, regarding how often electrodes should be changed, also showed increases in correct responses. In pre-test responses, seven out of fourteen nurses (42.9%) answered the appropriate response. In post-test responses, fourteen out of fourteen nurses (100%) answered the appropriate response.

This revealed an increase of 57.1%. Question seven, which asks about skin preparation prior to electrode placement revealed a 42.9% improvement in post-test scores. In pre-test responses, seven out of fourteen nurses (50%) answered the appropriate response. In post-test responses, 13 out of 14 nurses (92.9%) answered the appropriate response. All questions demonstrated increases in appropriate response answers.

Next, the summary and conclusions will be presented.

Summary and Conclusions

Education related to alarm fatigue has been identified as an area of need on many telemetry units nationwide. Alarm fatigue can often lead to poor staff intervention causing lack of response to a true patient condition change (Brantley et al., 2016). Alarm fatigue has a large impact on nurses and their daily workflow. Researchers have shown that there is improved nurse and patient satisfaction with education of nurses regarding alarm safety (Perrin et al., 2017). In providing clinical interventions for management of alarm fatigue, research shows a minimization of nuisance and false alarms (Sendelbach et al., 2015). Alarm fatigue is a growing problem in the hospital setting there has been improved alarm practice with education to nurses on alarm fatigue. In light of this relevant clinical need, a quality improvement project was developed by this investigator for the education of telemetry nurses related to alarm fatigue. This educational program was created with the help of the professional development team at a community hospital in New England and was evaluated using a pre/post-test model. The pre-tests were completed on the day of the intervention prior to the educational session. The educational session was completed in 10-15mins after which the nurses once again completed the same test. The pre-test answers were then compared to the post-test answers to assess for improved knowledge after the educational intervention.

A total of 16 nurses out of a possible 60 nurses completed the pre-test and a total of 14 nurses out of a possible 60 nurses completed the post-test after attending the educational session. The first four questions asked the nurses their opinions of alarm fatigue through Likert-scale responses. The goal of these questions was to reveal if nurse opinions changed after explanation of alarm fatigue and interventions for improvement. For the purpose of this project, only pre-tests with matching post-test answers were

utilized to compare responses. In review of question one, which asks if alarm fatigue has occurred in the last three months, responses were consistent in both pre and post-tests. One nurse changed their response from agree to strongly agree in the post test, with the majority of nurses (13 out of 14) choosing agree or strongly agree in both pre and post-tests. Likewise, Funk et. al (2014) found that a majority of nurses agree that alarm fatigue has occurred recently throughout their day. Question two inquired about false alarms not requiring intervention occurring frequently. Once again, the majority of nurses (13 out of 14) choose to agree or strongly agree that those false alarms occur regularly. Two nurses changed their responses from agree to strongly agree in the post-test responses. Honan et. al (2015) similarly observed that nurses felt false alarms occurred commonly and lead to lack of immediate response to high alarms.

The findings of question three, which discussed staff response to alarms, is refuted by Honan et al (2015) who discovered that nurses lack sensitivity and immediate response to monitor alarms. In this project's pre and posttest responses, the majority of nurses (13/14) chose to agree or strongly agree that staff is sensitive to clinical alarms and respond quickly to those alarms. There was some variation in responses to the post-test with two nurses changing their answers from agree to strongly agree and one nurse changing their response from disagree to strongly disagree. This question may have had different responses if the project had discussed more research results about staff responses to alarms and facts on decreased staff responsive after false alarms. The final question, question four, had the most variation in responses. Question four talked about the likeliness of the nurse to change alarm settings. In the pre-test answers for question four, only three nurses strongly agreed and seven nurses agreed they were likely to

change alarm settings. In the post-test answers for question four, six nurses strongly agreed and six nurses agreed they were likely to change alarm settings. This was a change indicating that with education on alarm limit settings, nurses may be more likely to set alarm limits to fit their patient's needs. However, two nurses disagreed in the post-test that they were likely to change alarm limits, so it may have been useful to demonstrate how alarm limits are changed on hospital monitors. Research from Honan et. al (2015) revealed that nurses wanted more authority through policy to support them altering alarm settings and setting different parameters. This research supports question four's results showing that after reviewing the hospital's alarm policy nurses were more willing to agree to changing alarms.

In review of questions 5-10, only those tests with matching pre-test and post-test scores were utilized. All pre-test scores improved after educational session. Pre-test mean scores had a mean score of 51.2%. After educational intervention, post-test scores had a mean score of 92%. All questions had improved responses from pre-test to post-test. Educational intervention proved effective in increasing knowledge of alarm fatigue and interventions for prevention of alarm fatigue. Research by Sendelbach et al., (2015) supported the use of an educational quality improvement project promoting interventions to minimize nuisance alarms and prevent alarm fatigue. Questions number 6 and 8 showed most improvement in responses. Question 6 had a 57.1% increase in correct responses and question 8 had a 71.3% increase in correct responses. These two questions were related to hospital policy that is currently in place and after review of this policy knowledge increased.

Limitations were evident in this project. Project participation by staff was very low with only 23.3%-26.6% of nurses participating. An informational email was provided to nurses one week in advance as well as manager and professional development encouragement. Low participation may have been to lack of nurses checking their email as well as lack of flyers being posted on the unit. Education was also provided during staff work times which makes it difficult for nurses to take the time to participate. Korniewicz et al., (2008) implemented an online survey for 5 months which allowed for more participation and ease of participation. Turmell et. al (2017), used the hospital intranet as well as flyers and manager input to assist with gathering participants for their study. Some participants who completed the pre-test were unable to stay for the educational session and complete the post-test due to patient needs. Future studies should allow for uninterrupted time for project completion. Research from Turmell et. al (2017), also made implementation of interventions a requirement to the unit which allowed for more active participation.

Overall, this educational project showed success for nurses who participated. Improved knowledge of alarm fatigue and interventions for prevention of alarm fatigue was evident.

Next, recommendations and implications for advanced practice nurses will be presented.

Recommendations and Implications for Advanced Nursing Practice

The Advance Practice Registered Nurse (APRN) has many opportunities to identify gaps in nursing education, as well as improvement of nursing practice. APRNs are leaders in demonstrating best practice using evidenced based nursing in the daily care of their patients and education of staff for nursing interventions. Educational interventions have been identified as one of the most important ways to effectively improve nursing practice and help provide a process for change. Alarm fatigue has been shown to have large knowledge gaps in daily nursing practice. The literature supports this, making it evident that alarm fatigue is not only a nursing concern, but a major patient safety issue, which educational interventions may help to prevent.

Education

The APRN can assist in establishing and implementing an educational program. This educational program can help to implement interventions and provide evidenced based research to support the prevention of alarm fatigue. The APRN can utilize research to support a bundled set of interventions for prevention of nuisance alarms and improvement of patient alarm safety. Brantley et.al (2016) revealed that with an educational intervention dedicated to the customization of alarm parameters showed a reduction in the number of nuisance and false alarms. APRN's are key to helping provide support for changes to nursing practice. The APRN can educate staff on the use of interventions and importance of setting monitor parameters to prevent alarm fatigue. It is important that APRN educates nursing on what alarm fatigue is and why prevention is key. Brantley et. al (2016) discussed that reducing bedside clinical alarms and minimizing noise helps to promote sleep, safety, and patient satisfaction.

This project helped to identify that there is a gap in nursing knowledge regarding alarm fatigue. Education for practice should include changing of monitor electrodes with proper skin preparation, changing of monitor batteries, and alarm parameters that fit patient needs. Sendelbach et. al (2015) discussed a quality improvement project that utilized bundled interventions to reduce nuisance alarms including eliminating duplicate alarms, adjusting default alarms and customizing those alarms, and daily ECG electrode changes with skin prep. APRNs can use the researched interventions to provide education as to why these interventions have worked in the past and demonstrate proper practice. The APRN can assist nurses in appropriate alarm settings and demonstrate how these settings should be adjusted safely in conjunction with hospital policy. Alarm parameters need to fit patient needs and must be patient specific. Turmell et. al (2017) revealed that customizing alarms to fit the individual is the best method to decrease false and nuisance alarms. EKG leads and batteries also must be changed regularly per policy to prevent nuisance alarms and false alarms. Walsh-Irwin & Jurgens (2015) discovered that proper skin preparation and changing electrodes daily led to a reduction in the number of alarms on a telemetry unit. Future research should be done on further interventions for prevention and the best approach to these interventions.

Clinical Practice

Recommendations for practice include having a bundled set of interventions for prevention of alarm fatigue and providing appropriate education to nurses to fulfil these interventions according to policy. Turmell et. al (2017) found that an educational program promoting a bundled set of interventions led to an 80% to 90% reduction in alarms. Tip sheets should be available to nursing to encourage staff to follow appropriate

policy and list interventions for prevention. Education has been found to be the most important change factor for alarm fatigue prevention. The APRN should work alongside staff nurses regularly to reinforce the significance of utilizing bundled sets of interventions. APRNs offer a unique set of skills to support and model best practice by not only assisting staff nurses to perform interventions but allowing them to understand why these interventions are important. Graham & Cvach (2010) revealed that staff need complete support and buy-in to achieve success in alarm management interventions. Education on how to fulfil these interventions needs to be completed regularly to ensure understanding and follow through of change.

Research

This study has revealed that future research should be conducted on most important interventions and how they impact alarm fatigue. It may be beneficial to trial each intervention and collect data as to the improvement of unit alarms pre and post intervention. This study clearly showed that education needs to be completed before any intervention can take place. In the future each intervention should be rolled out on telemetry units following policy and procedures in evidenced based practice. The overall goal of future research should be to ensure patient safety and improve nursing practice.

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Appendix A

Hello Telemetry Atwood 2 Nurses,

My name is Samantha Cruz, I am Rhode Island College Nurse Practitioner student. I am in a master's level program and I will be completing a quality improvement project on your floor. Attached to this email is an informational letter about the program. This letter will be available in the breakroom as well as in the manager's office. Time will be provided for completion of the program in early November. Participation in this program is voluntary.

If you have any questions or concerns regarding the program please feel free to contact me at my provided email.

Thank you,

Samantha Cruz

CCU RN Charlton Memorial Hospital

RIC NP Student

Cruzsm@southcoast.org

Appendix B

Informational Letter

Rhode Island College

Dear Fellow Nurses,

For those of you who do not know me, my name is Samantha Cruz and I am an RN in the CCU. I am also currently an Acute Care Nurse Practitioner Student at Rhode Island College. Each student in this master's program is required to complete a masters level project regarding a topic they have chosen. I have chosen to look at Alarm Fatigue in the Telemetry Nurse. In order to complete this quality improvement project, I am asking nursing staff on Atwood 2 Telemetry to participate.

This quality improvement project will focus on ways to prevent alarm fatigue and interventions to improve alarm monitoring. There will be a 10-15minute in service, which will take place on the unit during the beginning of November. This in-service will include an educational overview of alarm fatigue and interventions for alarm improvement. There will be an anonymous test that will be provided to all participants during this in-service which will be completed before and after the in-service. It will take approximately 5 minutes to complete the pre-test, followed by the 10-15minute in service, and then 5 minutes to complete the post test. This will take no more than 25mins of your time.

Participation will be completely voluntary and anonymous. The findings of this project will be presented in a poster at the Rhode Island College School of Nursing Colloquium in May 2018. The results will also be available to all telemetry staff on Atwood 2 via a poster on the unit.

If you have any questions feel free to email me at Cruzsm@southcoast.org. Thank you in advance for your time and participation.

Samantha Cruz, BSN, RN

Rhode Island College ACNP Student

Appendix C

The purpose of this program development project is to determine the effectiveness of an educational program on alarm fatigue awareness for telemetry unit nurses.

Alarm Fatigue Survey

Mother's DOB __/__/____

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1. **In the past 3 months, I have experienced Alarm Fatigue.**
   - ○ Strongly Agree
   - ○ Agree
   - ○ Neither Agree nor Disagree
   - ○ Disagree
   - ○ Strongly Disagree

2. **False Alarms not requiring clinical intervention occur frequently throughout my day.**
   - ○ Strongly Agree
   - ○ Agree
   - ○ Neither Agree nor Disagree
   - ○ Disagree
   - ○ Strongly Disagree

3. **Staff is sensitive to clinical alarms and responds quickly.**
   - ○ Strongly Agree
   - ○ Agree
   - ○ Neither Agree nor Disagree
   - ○ Disagree
   - ○ Strongly Disagree

4. **I am very likely to set alarm parameters and/or limits that fit my patient's needs.**
   - ○ Strongly Agree

- ○ Agree
- ○ Neither Agree nor Disagree
- ○ Disagree
- ○ Strongly Disagree

5. During blood draws by phlebotomy I should,

A. Place IV pumps on hold until phlebotomy notifies me they are finished
B. Stop all IV pumps
C. Do nothing, phlebotomy will take care of IV pumps
D. Assign a nursing assistant to pause IV pumps

6. How often should patient electrodes be changed?

A. Every 24hrs
B. Every 48hrs
C. Every 72hrs
D. Only when soiled or no longer sticking

7. Preparation of skin for electrode changes should be done with,

A. Shaving of excess hair followed by alcohol prep
B. Soap and water only
C. Shaving of excess hair followed by soap and water
D. There is no prep necessary

8. What are the High and Low alarm limits according to Southcoast's Alarm Policy?

A. High: 20BPM above baseline or <150BPM, Low: 10BPM below baseline or >45BPM
B. High: 20BPM above baseline or <200BPM, Low: 10BPM below baseline or >35BPM
C. High: 10BPM above baseline or <150BPM, Low: 20BPM below baseline or >45BPM
D. High: 10BPM above baseline or <200BPM, Low: 20BPM below baseline or >35BPM

9. How often should batteries be changed on telemetry monitors?

A. Every 24hrs
B. Every 48hrs
C. Every 72hrs

D. Only when a battery reads low (as needed)

10. Alarms can be silenced by:

A. CNAs and Nurses after assessing the patient

B. CNAs, Nurses, and HUCs

C. Only Nurses after assessing the patient

D. Any person who hears the alarm and assesses the patient

Appendix D

Alarm Fatigue Education: "The #1 technology hazard in healthcare"

Content Outline:

Please complete the alarm fatigue test labeled pre-test in front of you. Place your mother's DOB at the test in order to compare your answers before and after education. You will have 5mins to complete the test.

What is alarm fatigue?

- **Alarm fatigue occurs when a healthcare worker becomes overwhelmed and overly aware of the alarms around them leading to a desensitization of these alarms.**
- **These alarms include but are not limited to monitor alarms, bed alarms, patient call lights, and intravenous pump alarms.**
- **A nurse may miss an important or crucial alarm due to their desensitization causing a lack of appropriate intervention, making alarm fatigue a major patient safety concern.**

Learning Objectives:

- **Identify the proper ways to change electrodes**
- **Identify when batteries should be changed**
- **Describe alarm parameter settings according to SouthCoast Policy**
- **Describe when alarms should be silenced**

Why is alarm fatigue important?

- **The Joint Commission released 2017 National Patient Safety goals:**
  - **These goals include alarm safety for reduction of harm associated with alarms.**
  - **Improvements must be made to ensure that monitor alarms are heard and responded to on time.**
  - **Education should be provided to staff about the purpose of alarms and their responsibilities related to alarms.**
- **The US Federal Drug Administration reported 566 alarm-related deaths between January 2005 and June 2010**
- **Reduction of overall noise can produce a safer and more productive work environment.**

Educational: Nursing Actions for Alarm Management

- Changing electrodes should be done daily. Evidence suggests changing EKG electrodes daily decreases the number of false alarms.
    - Changing of electrodes includes proper skin preparation:
        - shaving hair, cleaning and prepping skin with soap and water only (alcohol can be drying to electrodes), and ensuring proper lead placement.
- Change batteries every day during the start of the 7pm-7am shift
- Pause Monitors:
    - Place appropriate IV pumps on hold to allow for phlebotomy to draw blood from an infusing arm. Be sure phlebotomy notifies the RN when finished to ensure the patient's medications are restarted.
    - RNs to answer all pump alarms using a team effort
- Set monitor alarms that fit your patient: Know your alarm parameters including high and low limits, give this information in report.
    - According to Southcoast health policy, the RN shall adjust heart rate alarm limits/parameters to meet patient's needs with the following guidelines or physician recommendation
        - High limit: 20BPM above baseline, not to exceed 200 BPM
        - Low limit: 10BPM less than baseline, not to be less than 35BPM
    - Reassess alarm settings every eight hours and alarms should be adjusted accordingly.
    - Adjusting alarms for individual patient including turning of irregular rhythms or atrial fibrillation alarms if alarms are not actionable.
        - Only those irregular rhythms which have been reported to the physician may be silenced or shut off.
- Assessing and reassessing the need for telemetry monitoring. Ensure there is a proper telemetry monitoring order every shift.
- Only a Registered Nurse who is staff on the unit can silence the alarm based on real time assessment of the patient.
    - Always know what you are silencing: Have I assessed the patient? What can be done? Have I notified the appropriate person of the abnormal event?

Bed Alarms/Call Lights

- Prevention of patients getting out of bed and setting of bed alarms requires assessment of patient's needs prior to leaving the room
- 4 P's
    - Potty: I have time to take you to the bathroom, would you like to do this now?
    - Position: Is there something I can do to make you more comfortable?
    - Pain: Are you having any pain?

    - Personal Needs: Make sure call-bells are within patient reach as well as any belongings they may need. (ex. Water, Tissues, glasses, book)
- Answering call-lights is a team job, all patient's lights should be answered by any staff available at that time.
    - Team effort, do not ignore lights that "aren't your patient"

Test:

- You will now complete the same test you were given pre-education.
- This test will be used in comparison to your first test to ensure knowledge improvement of alarm fatigue and interventions for monitor improvement.

Appendix E

Alarm Tip Sheet

Clinical Alarms

- Daily electrode changes on 7p-7a shift
  - Include proper skin prep
- Change batteries daily on 7p-7a shift
- Set monitor alarm parameters that fit your patient
  - High limit: 20BPM above baseline, not to exceed 200 BPM
  - Low limit: 10BPM less than baseline, not to be less than 35BPM
- Silence alarms based on patient assessment only

Bed and Call Alarms

- Hourly rounding
- Ask about the 4 Ps (Pain, Potty, Position, Personal needs)

AND REMEMBER…

Appendix F

Pre-Test Responses: (Score for Q5-Q10: Appropriate Response Bold)

ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score
1	1	2	2	1	**A**	C	**C**	C	**A**	**C**	**66.7%**
2	1	1	4	2	**A**	C	A	A	D	**C**	**33.3%**
3	3	2	2	2	**A**	**A**	A	A	**A**	**C**	**66.7%**
4	2	5	2	2	**A**	**A**	A	A	D	A	**33.3%**
5	1	1	3	2	**A**	B	**C**	A	**A**	**C**	**66.7%**
6	2	2	2	3	B	**A**	A	A	D	A	**16.7%**
7	2	1	1	2	**A**	D	A	A	**A**	A	**33.3%**
8	2	2	1	2	**A**	B	D	A	**A**	**C**	**50%**
9	2	2	2	1	**A**	C	**C**	A	D	**C**	**33.3%**
10	2	1	2	1	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
11	2	2	3	3	**A**	D	**C**	A	**A**	**C**	**66.7%**
12	1	1	2	3	**A**	**A**	**C**	C	**A**	**C**	**83.3%**
13	1	2	4	2	B	B	A	Q	**A**	D	**16.7%**
14	1	2	1	3	B	**A**	**C**	A	B	**C**	**50%**
15	2	2	2	2	**A**	C	C	A	**A**	**C**	**66.7%**
16	3	1	2	1	**A**	**A**	A	A	**A**	**C**	**66.7%**

Appendix G

Post-Test Responses: (Score for Q5-Q10: Appropriate Response Bold)

ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score
1	1	2	2	1	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
2	1	1	5	1	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
3	3	2	2	2	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
4	2	5	2	2	**A**	**A**	**C**	A	**A**	A	**66.7%**
5	1	1	3	2	**A**	**A**	**C**	C	**A**	**C**	**83.3%**
6	2	1	2	4	**A**	**A**	**C**	**B**	**A**	A	**83.3%**
7	1	1	2	1	**A**	**A**	**C**	D	**A**	**C**	**83.3%**
8	2	2	1	1	**A**	**A**	B	C	**A**	**C**	**66.7%**
9	2	2	2	1	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
10	2	1	2	2	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
11	2	2	3	2	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
12	1	1	1	4	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
13	1	2	4	1	**A**	**A**	**C**	**B**	**A**	**C**	**100%**
14	1	1	2	2	**A**	**A**	**C**	**B**	**A**	**C**	**100%**