IMPACT OF DAILY ELECTROCARDIOGRAPHIC ELECTRODE CHANGES UPON TECHNICAL RELATED CARDIAC MONITOR ALARM EVENTS

by

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Abstract

Alarm fatigue occurs when excessive alarms cause nurses to disregard alarms posing a significant patient safety threat. This quality improvement project utilized the plan-do-check-act approach to examine the impact of daily electrocardiographic electrode changes on the frequency of technical related cardiac monitor alarm events on two adult nursing units. All technical related cardiac monitor alarm events decreased during the intervention period; specifically, by 20.6% and 71.0% on the first and second nursing unit respectively.
Medical monitoring devices are often used to augment patient assessment, evaluate response to prescribed therapy, and assist in the early recognition of a potentially critical change in a patient’s clinical condition, such as a lethal cardiac dysrhythmia. An assortment of monitoring devices with a multitude of audible alarm capabilities may exist in a typical patient care room translating into hundreds or more alarms throughout the hospital on a daily basis. The majority of these audible alarms are false or clinically irrelevant requiring no actionable response.1,2,3 The constant bombardment of differing alarms desensitizes the nurses resulting in a phenomenon known as alarm fatigue.4 Alarm fatigue which occurs when excessive alarms cause nurses to disregard alarms, poses a significant threat to patient safety.5,6 In an attempt to manage the false or irrelevant alarms, nurses may inappropriately adjust, deactivate or silence alarms, or fail to respond promptly resulting in serious or fatal consequences.

Alarm fatigue is a complex problem that has real consequences for nurses, patients, and the organization. Alarm fatigue has resulted in many alarm related sentinel events.7,8,9 In 2002, recognizing the risk associated with patient safety, The Joint Commission (TJC) published a sentinel event alert citing adverse events involving patients receiving mechanical ventilator support. According to Sendelbach, 65% of these events were attributed to alarm mismanagement or malfunction.10 The following year in 2003, TJC developed and issued a two-part national patient safety goal; mandating compliance by January, 2016. In 2005, clinical alarm safety and management became part of the TJC Environment of Care Standards.11

Additional agencies have presented data related to alarm monitoring events. Utilizing data retrieved from the Manufacturer and User Facility Device (MAUDE) database, the Food and Drug Administration (FDA) reported more than 550 alarm hazards related to cardiac monitor alarms, resulting in 35 deaths between 2005 and June 2010.8 The Pennsylvania Patient Safety
Authority reported 194 serious events related to cardiac monitoring, involving 12 deaths between June 2004 and December 2008. In 2011, the Boston Globe published a series of articles highlighting the growing issue of alarm fatigue, subsequently reporting 119 deaths between 2005 and May 2011 due to failure to respond in a timely manner to a monitor alarm. Furthermore, according to TJC’s Sentinel Event database, 98 alarm related events were recorded between 2009 and June 2012. Of these reported events, 80 resulted in a patient’s death.

Several collaborative, multidisciplinary workshops and summits addressed the problem of alarm fatigue. These include a 2011 workshop entitled, “Too Many Alarms? Too Few Alarms?” sponsored by the German Association of Biomedical Engineering, and a Medical Device Alarms Summit convened by the Association for the Advancement of Medical Instrumentation (AAMI) in 2011 in association with the Food and Drug Administration (FDA), the Economic Cycle Research Institute (ECRI), the American College of Clinical Engineers (AACE), and The Joint Commission (TJC) calling upon key safety and professional stakeholders to address the issue of alarm fatigue. Several major themes were identified and recommendations regarding alarm fatigue were published in the “Top 10 Actions You Can Take Now” monograph. These recommendations include a multidisciplinary approach with leadership presence and support, optimization of alarm capabilities and alarm management education. Similarly, the ECRI identified alarm hazards as the number one technology related problem in both 2012 and 2013, in its annual publication, entitled, “Top 10 Health Technology Hazards”. In addition to this joint group of industry leaders, leading nursing organizations have initiated efforts to reduce alarm fatigue.

Professional nursing associations also provided recommendations to reduce the impact of alarm fatigue. As part of the 2013 National Teaching Institute & Critical Care Exposition (NTI),
the American Association of Critical Care Nurses (AACN) identified alarm fatigue as 1 of 4 topics of the Patient Safety Summit discussion forum, subsequently issuing a practice alert on alarm management outlining recommendations for enhanced alarm monitoring processes. Also, the American Nurses Association (ANA) convened a special discussion panel to extend over a 6 month period concluding in February 2014 to explore alarm fatigue. At the same time, TJC released a Sentinel Event Alert citing the 2010 death of a 60-year-old Massachusetts patient who died due to lack of response to a clinical alarm. Consequently, in 2013, improvement in clinical alarm systems become one of The Joint Commission’s 2014 National Patient Safety Goals (NPSG) for hospitals aimed towards prompting organizational leads to make alarm safety a top priority. These collective efforts highlight the urgency to implement changes in alarm management systems to help mitigate alarm fatigue.

In response to TJC’s 2014 National Patient Safety Goal (NPSG) imperative and the risk of staff experiencing alarm fatigue, a quality improvement project was conducted on two medical surgical telemetry nursing units in an acute care community hospital located in the state of Florida. The specific aim of the quality improvement project using the plan-do-check-act approach was to evaluate the impact of daily electrocardiographic electrode changes on the frequency of technical related cardiac monitor alarm events. Technical related cardiac monitor alarm alerts are those attributed to the cardiac monitoring equipment, such as electrodes poorly adhered to the skin resulting in sensory artifact generating a leads off alarm alert, which is classified as a false or clinically irrelevant monitor alarm signal.

False or clinically irrelevant alarms are considered a low priority, requiring no immediate clinical action and are a major cause of alarm desensitization. While a leads off event would generate a low priority alert, it’s imperative that clinicians recognize the significance of such an
event as the patient would be unmonitored and any subsequent potentially clinical significant event would not be promptly detected. According to Walsh-Irwin and Jurgens, lack of proper skin preparation, incorrect electrode placement and infrequent changing of the electrodes leads to false alarms. Daily changing of electrodes, along with proper skin preparation are key factors to reducing the incidence of false alarms.

The significance to nursing of this project is threefold. First, it exemplifies how nurses have the ability to use current evidence to make a significant improvement in patient care. Second, the project enhances the nurses’ practice environment, and lastly, the effort meets the needs of TJC national patient safety goals.

LITERATURE REVIEW

The literature highlights several projects aimed towards improving alarm management channeled through daily changing of electrodes, as well as expert opinion suggested interventions to reduce false or clinically irrelevant alarms. Johns Hopkins Hospital implemented a process improvement project to reduce the number of nonactionable, clinically irrelevant alarms. The process change involved daily sensory electrode changes, changes in default settings, staff education and a policy outlining accountability for alarm response time and actions, if indicated. These efforts resulted in a hospital wide reduction in alarm alerts of 43% in high priority alarms, a 47% reduction in alarm conditions per bed per day in two pilot studies, and a 24% to 74% reduction of alarms from the default setting changes in two ICUs.

Implementing changes in the cardiac monitoring system at Beth Israel Deaconess Medical Center, such as suspension of the monitoring when a patient was off the nursing unit resulted in a 30% reduction in overall alarm alerts. Furthermore, a decrease in response time to clinically significant alarms from a mean of 45 seconds to 10 to 15 seconds with a decrease in
response time for leads off alarm alerts from three minutes to between one and two minutes was noted.²³

Two studies reviewed highlight the benefits of changing peripheral monitoring equipment. The first of these studies was a quality improvement pilot study conducted among a progressive and critical care unit in an acute care setting.¹⁷ The study was conducted over an eight-day period gathering baseline and intervention data. The intervention involved a daily change of the electrographic electrodes during the hours of 8 a.m. and 12 p.m. Monitor alarms were prioritized as high, medium or low level of urgency. Daily electrode changes reduced the average of cardiac monitor alarms events per beds by 46%. The second study was a cluster randomized, controlled, blinded trial using a crossover design to evaluate the differences in alarm events between disposable and reusable electrocardiographic lead wires (EKG-LWs).²⁴ The study was conducted in four 24 bed cardiac telemetry units alternating use of disposable and reusable EKG-LWs for a period of 4 months involving a total of 1,611 patients. Frequency and time of alarm events were recorded. The results of the study revealed that rates of alarms for no telemetry, leads failure, or leads off were lower in the disposable EKG-LWs ($P < .001$), monitoring alarms were significantly non-inferior ($P = .02$), and disposable EKG-LWs were non-inferior to reusable EKG-LWs for all false-alarm events ($P = .002$).²⁴ The authors concluded that the disposable EKG-LWs with a special patented push button feature demonstrated superior performance in reducing alarms generated by no telemetry, leads failure, or leads off and significant non-inferiority in all false-alarm rates when compared with the reusable EKG-LWs.

In 2013, The American Association of Critical Care Nurses issued a practice alert providing recommendations for enhanced alarm monitoring processes.¹⁵ These recommendations include nursing actions focused on providing provisions for skin preparation and application of
electrocardiographic electrodes with daily changes of the electrodes; customization of alarm parameters, including threshold settings; initial and ongoing education; continued interdisciplinary collaboration; and, protocols outlining the clinical parameters for monitoring.\textsuperscript{15}

A plethora of literature addresses the problem of alarm fatigue, and the list of recommendations and strategies continues to grow. However, rigorous studies to identify best practices to reduce and or eliminate false or nonactionable alarms are lacking. Additionally, the majority of existing studies have been conducted within the intensive care settings with less attention being given to medical surgical telemetry nursing units where the use of cardiac monitoring continues to increase.\textsuperscript{11}

A vast amount of literature, including research studies and antidotal data exists supporting the existence of alarm fatigue. The majority of the evidence supports the contention that the major contributing factor to alarm fatigue is false and clinically insignificant alarms.\textsuperscript{3,6,12,25,26,27} Practice change solutions geared towards optimization of alarm management systems should be based upon available and current evidence and best practices. The results of this quality improvement project utilizing the plan-do-check-act approach were shared with the key stakeholders of the project hospital to assist in organizational decision making regarding alarm management efforts.

**THEORETICAL FRAMEWORK**

The theory of planned behavior focuses upon a person’s behavior and intent to perform a specific or proposed behavior.\textsuperscript{28} The intent informs the individual’s readiness to perform the specific or proposed behavior. Intentions are mediated by attitude, subjective norm and perceived behavior control.\textsuperscript{28} People are more likely to demonstrate a specific behavior if it is determined
to be positive and beneficial, when social pressure dictates participation in the behavior, and that
the behavior is considered doable and under their control. The nursing staff’s belief or disbelief
of the benefit of the daily changing of electrocardiographic electrodes, the belief of peer
expectations, and the belief or disbelief associated with the factors promoting or discouraging the
behavior will determine the intent to change the electrodes daily. The project included education,
ongoing support and monitoring. Presenting and discussing the available evidence to support
daily changing of the electrodes during the educational sessions will improve attitudes and
behaviors.\textsuperscript{29} The theory of planned behavior asserts that by fostering a positive attitude towards
the proposed practice change channeled through evidence-based findings, education and
organizational support will lead to a stronger intent to comply.\textsuperscript{30,31}

\section*{METHODS}

\textbf{Purpose}

The purpose of this quality improvement project was to collect and evaluate the
frequencies of the technical related cardiac monitor alarm events to answer the practice question:
In hospitalized adults receiving cardiac monitoring services, how does changing the
electrocardiographic (ECG) sensory electrodes or pads every 24 hours compared to no actionable
change affect the reduction of technical related cardiac monitor alarms events over a 14-day
timeframe?

\textbf{Design}

The design of the project was a quality improvement using a plan-do-check-act approach.
The project was designed and implemented in three phases. The first phase involved the baseline
data collection. The second phase was characterized by education of the nursing staff,
implementation of the quality improvement intervention and collection of additional data. The
last phase involved the evaluation of the data collected before and after the intervention.

Sample / Setting

The target population included all nursing staff practicing on two medical surgical telemetry units at an acute care community hospital located in the state of Florida. The potential sample number was 80. The inclusion criteria included all nursing staff employed as registered nurses or cardiac monitoring technicians practicing on the units at the time of the project. The exclusion criteria included nursing students.

The setting included two inpatient medical surgical nursing units. The first nursing unit is a general medical surgical nursing unit with an average daily census is 17. The second nursing unit is also a general medical surgical nursing unit with an average daily census of 12. Both nursing units provide care and cardiac monitoring services to similar patient populations

Procedures

The project was submitted for approval to the hospital’s institutional review board and was granted approval in May, 2016. Upon approval of the project, the manager of the units and key stakeholders were contacted to discuss the project, staff education and distribution of project materials. The unit manager and educators announced the project at unit staff meetings. A nineteen-question survey utilizing a standardized Likert scale was developed to collect demographic data. Surveys were provided to the staff on each nursing unit. The staff were instructed not to include any identifying information on the surveys and were assured that their responses were anonymous and would remain confidential. Completed surveys were placed in a sealed and labeled envelope and stored in a locked filing cabinet accessible only to the DNP candidate. Copies of an informational letter containing the purpose of the project, the indicated practice change procedure and contact information was posted in highly visible areas throughout
both nursing units. The DNP candidate was on site to answer questions and provide clarification before the project.

Education was provided to the nursing staff regarding the project and practice change. The practice change intervention included performing daily electrocardiographic electrode changes during the night shift between the hours of 8 p.m. and 12 a.m. The change was completed by the ancillary staff as they obtained the patients’ beginning of shift vital signs; however, the electrodes were also changed by the Registered Nurse (RN) as indicated.

**Data Collection**

The staff survey tool was adopted from a national Clinical Alarms Survey questionnaire utilized by the Healthcare Technology Foundation (HTF) with permission. No reliability or validity testing of the HTF survey has been reported in the literature. However, several technical, engineering and clinical entities, including the American Association for Critical Care Nurses provided input into the development of the survey, which explored current attitudes and practices related to alarm management. A panel of five nursing professionals established face and content validity for the modified tool. Feedback relevant to the construct being measured was received from members of the organization’s Alarm Fatigue Committee and integrated into the final version of the tool.

The cardiac monitor alarm events were captured and recorded based upon the alarm types supported and displayed by the Mineray™ cardiac monitoring system for all monitored patients. Cardiac monitoring alarm events were collected every 24 hours on both study units for a timeframe of 14 days before and after the intervention.

**Measurement of Data**

The alarm event data was calculated using frequency percentages and examined with an
emphasis on distribution. The Poisson distribution method was conducted to compare the number and types of alarms before and after the daily change of the electrocardiographic electrodes to determine whether there was a decrease in the rate of technical related cardiac monitor alarm events post intervention.

**Ethical Considerations**

The results of the survey responses remained anonymous. The surveys remained in a locked file accessible only by the project coordinator. No identifying data were requested or collected. To ensure the protection of human rights and privileges, approval was sought and granted via the hospital’s Institutional Review Board (IRB) before the implementation of the practice change project. The project hospital encourages implementation of evidence based practice at the bedside.

**RESULTS**

**Staff Survey**

The nineteen-question survey consisted of two demographic questions, six cardiac monitoring practice questions, ten Likert questions, and one open ended question. The response rate for the first nursing unit was 57% (23 surveys completed) while the return rate for the second nursing unit was 48% (19 surveys completed).

An analysis of the staff survey related to cardiac monitoring and alarms reveal that more than 76% (32) of the respondents practice in a medical surgical telemetry unit. A majority (25 or 60%) of the respondents reported having less than two years of nursing or monitoring experience while only five or 12% reported having more than eight years of experience. A review of the alarm management practices indicates that 24% (10) of the participants change their patients’ electrocardiographic electrodes daily whereas 40% or 17 change the electrodes only when
necessary (Figure 1). This suggests inconsistent application of the current practice policy, which specifies that the electrodes should be changed every 48 hours and as indicated. Only seven or 17% of the respondents indicated changing the electrodes every 48 hours and as indicated. The responses to the application of electrode practices questions indicate a variation in practices, to include 33% or 14 respondents not performing any type of skin preparation prior to application of the electrodes to 12% who clip the hair and 17% who both clips the hair and attach the lead wires before electrode application.

Thirty three percent of the respondents indicated they provide education at the time of initial electrode application while slightly more than a fourth (12 or 29%) of the participants provide education both at the time of initial application and as needed. Almost half or 48% of the participants reported the continued assessment of the need for cardiac monitoring services. A majority or 86% (36) of the participants responded they completed a telemetry or cardiac arrhythmia course. Furthermore, an overwhelming majority or 95% (40) of the respondents indicated receiving training regarding the correct anatomical location for the placement of electrodes.

Fifty-seven percent of the participants revealed that they strongly agree with the statement that there is adequate communication between the staff and the monitoring telemetry technician. This finding does not directly correlate with the responses noted on the open-ended question, which implies that enhanced communication is indicated. Responses to the alarm management issues questions denote that 38% or 15 of the participants ranked recognizing the priority of an alarm as most important (rank of 1) and difficulty in setting the alarms as least important (2 or 5%) with a ranking of 5. This finding may indicate that the staff is unaware of the value of setting default parameters based upon the patient care situation. The literature
suggests that customizing alarm default parameters based upon the ongoing clinical status of the patient reduces alarm events, including nonsignificant or low priority alarms with the intended benefit of increasing response based upon an increase in true-positive alarm events. Meaning, a greater number of the alarm events would be categorized as clinically significant, appropriately alerting the staff of the need for immediate intervention.

**Practice Change**

Tables 1 and 2 reveal the number of technical or electrode cardiac related monitoring alarm events and nontechnical cardiac related alarm events pre- and post-practice change intervention on both of the nursing units respectfully. Technical related cardiac monitor alarm events include arrhythmia suspended, leads fail, and respiratory rate leads fail. Non-electrode related events include all other alarms, such as pulse oximetry probe sensor events, noninvasive blood pressure reading too low or high, and or cardiac dysrhythmias, such as tachycardia. All of the electrode related cardiac monitor alarm events decreased during the intervention timeframe. Arrhythmia suspended technical or electrode related alarm events were reduced by 33.4% on the first nursing unit and 52.1% on the second nursing unit. Leads fail related monitor alarm events reduced by 43.9% and on both units respectively. Respiratory rate leads fail alarm events decreased by 61.4% for the first nursing unit and 77.3% on the second nursing unit. Total technical or electrode related alarm events decreased by 20.6% on the first nursing unit and on the second unit by 71% (Tables 1 and 2).

**DISCUSSION**

The results of this quality improvement project revealed that changing the electrodes on a daily basis significantly ($p = < 0.0001$) decreased the overall number of technical or electrode related cardiac monitor alarm events on both nursing units. The largest reduction was noted in
the respiratory leads fail alarm events with a decrease of 61.4% on the first nursing unit and by 77.3% on the second nursing unit. The explanation for the decrease in total alarm events is that changing electrodes every 24 hours helps to ensure adequate adhesion and conduction medium. Dry electrodes or poor skin contact, or the accumulation of dead skin cells under the electrode impedes the conduction of the current creating artifact and subsequent loss of signal.²¹

Cardiac monitoring systems are valuable patient care tools; however, challenges with the use of monitoring systems have been identified and examined extensively over the past two decades. Specifically, false or nonactionable alarms contribute to a delay in nurse response times. Subsequent delays may result in failure to expeditiously note and manage a clinically significant patient care event.

This quality improvement initiative used the plan-do-check-act approach to reviewing existing evidence to identify and implement a specific process improvement strategy to decrease the frequency of false or clinically irrelevant monitor alarms, thus reducing the risk that the nursing staff will experience alarm fatigue. The results of this project were shared with the key stakeholders at the project hospital to assist in the decision-making process regarding alarm management practices. Additional interventions identified in the literature to reduce the incident of false alarms and the potential consequences of alarm fatigue include ongoing education, individualizing and setting alarm parameters, proper skin preparation and placement, policy development to help ensure sustainability, timely battery changes and utilization of cardiac monitoring services when indicated. This project served as a beneficial starting point for the hospital to consider revising the existing alarm management practices to reflect current evidence and best practice(s).

**Limitations**
There were several limitations to this project. A dearth of reliable and valid surveys related to alarm management practices and fatigue necessitated the creation of a modified staff survey. Although the modified survey was tested for face and content validity by a group of nursing professionals and revised based on these results, the survey was not tested for reliability and validity. Another limitation was the lack of the identification of a common theme in the responses to the open-ended questions. The project was also limited as the data collection represented a two-week timeframe before and after the practice change implementation. Furthermore, the monitor alarm alerts data collected was potentially influenced by the user’s knowledge base and individual interpretation of the alarm events.

**CONCLUSION**

In conclusion, the overall survey return rate was greater than 52.5% (42 surveys). The project results revealed that utilization of an interdisciplinary team to address alarm related issues reduced the number of technical related cardiac monitor alarm events. Reducing false alarms requiring no immediate action optimizes alarm management practices and ensures patient safety.

Patient safety is an increasingly important healthcare topic, driven by the Institute of Medicine (IOM) publications within the last couple of decades.\(^{34,35}\) Nurses’ role in ensuring patient safety is further detailed in an IOM 2011 publication, *The Future of Nursing: Leading Change, Advancing Health*.\(^{36}\) This publication outlines strategies to improve and sustain the practice of nursing. These suggestions include nurses achieving higher levels of education and training, practicing to the fullest extent of this education and training, functioning as full partners of the interdisciplinary healthcare team to restructure healthcare, and workplace planning and policy making to ensure optimal data collection.\(^{36}\) Current recommendations to mitigate the
potential consequences of alarm fatigue are largely based upon a few observational studies, quality improvement projects and similar initiatives, safety organizations and professional nursing associations, such as the AAMI, ECRI, TJC, ANA, and the AACN. Although quality data is lacking to support the recommended changes, the literature supports the growing consensus that organizations must develop and implement policies to highlight the problem of alarm fatigue and change practice to ensure patient safety. Integrating these recommendations with evidence based alarm management suggestions and innovations will ensure effective and safe alarm management practices in the clinical setting.

References


Association for the Advancement of Medical Instrumentation (AAMI) Web site.  


Figure 1. Alarm Management Practices – Staff Responses to Frequency of Electrode Change
Table 1. Comparison of Technical or Electrode Related Cardiac Monitor Events for 1st Nursing Unit Pre-and Post-Intervention

<table>
<thead>
<tr>
<th>Monitor Alarm Events</th>
<th>Baseline</th>
<th>Baseline Patient Days</th>
<th>Intervention</th>
<th>Intervention Patient Days</th>
<th>Events/Patient Day</th>
<th>% Change, Post-Intervention vs Pre-Intervention</th>
<th>% Change, Post-Intervention Events/Pt. Day vs Pre-Events/Pt. Day</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total electrode related technical events</strong></td>
<td>315</td>
<td>138</td>
<td>2.283</td>
<td>216</td>
<td>226</td>
<td>0.956</td>
<td>-31.4%</td>
<td>-58.1%</td>
</tr>
<tr>
<td>Arrhythmia suspended</td>
<td>218</td>
<td>138</td>
<td>1.580</td>
<td>171</td>
<td>226</td>
<td>0.757</td>
<td>-21.6%</td>
<td>-52.1%</td>
</tr>
<tr>
<td>Leads fail</td>
<td>27</td>
<td>138</td>
<td>0.136</td>
<td>19</td>
<td>226</td>
<td>0.084</td>
<td>-29.6%</td>
<td>-57.0%</td>
</tr>
<tr>
<td>Respiratory rate leads fail</td>
<td>70</td>
<td>138</td>
<td>0.507</td>
<td>26</td>
<td>226</td>
<td>0.115</td>
<td>-62.9%</td>
<td>-77.3%</td>
</tr>
<tr>
<td><strong>Total non-electrode related alarm events</strong></td>
<td>3190</td>
<td>138</td>
<td>23.116</td>
<td>1403</td>
<td>226</td>
<td>6.208</td>
<td>-56.0%</td>
<td>-73.1%</td>
</tr>
<tr>
<td><strong>Total all alarm events</strong></td>
<td>3408</td>
<td>138</td>
<td>24.969</td>
<td>1619</td>
<td>226</td>
<td>7.164</td>
<td>-52.5%</td>
<td>-71.0%</td>
</tr>
</tbody>
</table>

* Non-electrode related alarm events include blood pressure cuff events, such as too high, too low or unable to read; pulse oximetry events, such as too low, failure to sense or artifact; no telemetry and
battery change indicated.
** Total alarm events include all electrode and non-electrode related technical alarms.

Table 2. Comparison of Technical or Electrode Related Cardiac Monitor Events for 2\textsuperscript{nd} Nursing Unit Pre-and Post-Intervention

<table>
<thead>
<tr>
<th>Monitor Alarm Events</th>
<th>Baseline</th>
<th>Intervention</th>
<th>% Change, Post-Intervention vs Pre-Intervention</th>
<th>% Change, Post-Intervention Events/Pt. Day vs Pre-Events/Pt. Day</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Patient Days</td>
<td>Events/Patient Day</td>
<td>Intervention Events</td>
<td>Patient Days</td>
</tr>
<tr>
<td>Total electrode related technical events</td>
<td>97</td>
<td>213</td>
<td>0.455</td>
<td>56</td>
<td>240</td>
</tr>
<tr>
<td>Arrhythmia suspended</td>
<td>32</td>
<td>213</td>
<td>0.150</td>
<td>24</td>
<td>240</td>
</tr>
<tr>
<td>Leads fail</td>
<td>19</td>
<td>213</td>
<td>0.089</td>
<td>12</td>
<td>240</td>
</tr>
<tr>
<td>Respiratory rate leads fail</td>
<td>46</td>
<td>213</td>
<td>0.216</td>
<td>20</td>
<td>240</td>
</tr>
<tr>
<td>Total non-electrode related alarm</td>
<td>621</td>
<td>213</td>
<td>2.915</td>
<td>586</td>
<td>240</td>
</tr>
<tr>
<td>Total all alarm events**</td>
<td>718</td>
<td>213</td>
<td>3.371</td>
<td>642</td>
<td>240</td>
</tr>
</tbody>
</table>

* Non-electrode related alarm events include blood pressure cuff events, such as too high, too low or unable to read; pulse oximetry events, such as too low, failure to sense or artifact; no telemetry and battery change indicated.

** Total alarm events include all electrode and non-electrode related technical alarms.