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Healthcare Technology Safety Institute

Safety Innovations

Clinical Practice Changes Associated with Alarm Standardization

The Boston Medical Center Experience

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About the Healthcare Technology Safety Institute (HTSI)

Founded within the AAMI Foundation, the 501(c) (3) charitable arm of AAMI, the HTSI is a community of leaders throughout the healthcare system who are dedicated to one common vision: "No patient will be harmed by medical technology." HTSI's mission is "To engage the entire healthcare community in multidisciplinary safety initiatives that strengthen the development, management, and use of medical technology for improved patient outcomes." HTSI engages the

healthcare community in research, education, consensus, and partnerships related to the challenges facing healthcare technology industries, regulatory and accrediting bodies, clinicians, caregivers, and patients.

ALARM CONDITION

State of the ALARM SYSTEM when it has determined that a potential or actual HAZARDOUS situation exists for which OPERATOR awareness or response is required.

NOTE 1 An ALARM CONDITION can be invalid, i.e. a FALSE POSITIVE ALARM CONDITION.

NOTE 2 An ALARM CONDITION can be missed, i.e. a FALSE NEGATIVE ALARM CONDITION.

ALARM SIGNAL

Type of signal generated by the ALARM SYSTEM to indicate the presence (or occurrence) of an ALARM CONDITION

From IEC 60601-1-8:2006+A1:2012, Medical electrical equipment – Part 1-8: General requirements for basic safety and essential performance – Collateral Standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems

Clinical Practice Changes Associated with Alarm Standardization

At a Glance

Subject: Boston Medical Center (BMC

Location: Boston MA

Size: Boston Medical Center is a 496-bed academic medical center. The hospital is the primary teaching affiliate for the Boston University School of Medicine.

BMC's alarm journey began in 2008 with the standardization of all cardiac monitoring equipment across the medical center. A multidisciplinary Telemetry Task Force (TTF) reviewed the manufacturer's defaults and individualized the alarms to Boston Medical Center prior to the installation of the equipment utilizing all four levels of alarms of the manufacturer (Crisis, Warning, Advisory and Message). In 2011 with increasing focus nationally on alarm fatigue and the report of sentinel events from missed alarms, BMC reconvened its multidisciplinary task force to look at opportunities to decrease the volume of audible alarms particularly on its medical surgical units. General medical surgical units were felt to be the most vulnerable units for missed alarms given the number of patients cared for on telemetry at any given time, the larger patient to nurse ratio, and the general absence of bedside monitors. Each medical surgical unit had (and still has) a central nurses' station at which nurses respond to telemetry alarms for that unit. Noise and frequency of the alarms on these units could be overwhelming. Maintaining standardization of alarms and defaults was felt to be critical so that nurses could float among these units easily recognizing alarms signals and their meaning.

Alarms on BMC's medical surgical nursing units are visualized at a central console at each nursing station, the only location at which alarms may be answered and parameters altered. There are also two to three additional view only displays at various locations on each unit and alarms are also highlighted for staff via a hallway marquee system. For telemetry monitoring, there are no monitors within the patient room. Patient may, however, be attached to portable bedside monitors that transmit to the central station when additional bedside monitoring of heart rate/rhythm, blood pressure or oxygen saturation is required.

Through direct observation of staff and mining alarm data, the TTF saw opportunities to make changes to heart rate (HR) and heart rhythm alarms that had the potential to significantly decrease the volume of audible alarms on general medical surgical nursing units. To assess the impact of the proposed changes, a cardiology medical nursing unit was selected to pilot the proposed changes.

As part of the pilot, one type of alarm priority utilized by the manufacturer (warning alarms) was removed for all heart rate and heart rhythm alarm violations. Warning alarms self-reset which the TTF felt led to these alarms often reoccurring: parameters then not individualized by staff

to suit the patient's condition led to reoccurrence of alarms that were often clinically insignificant. Of note, approximately 2/3rds of warning alarms stemmed from HR violations. For the pilot, warning alarms for heart rate and heart rhythm violations were changed from their 2008 defaults as Warning alarms to Crisis alarms requiring action by RN staff. The changes made, along with the resulting decrease in the number of alarms, have already been well documented (*Journal of Cardiovascular Nursing and the NPR story about article*); therefore, this article while highlighting those changes will focus on how BMC went about communicating the need for changes to staff and incorporating the cultural adjustments necessary to make the changes successful and sustainable..

The Challenge:

Prior to 2008, BMC used a variety of telemetry platforms from several manufacturers for monitoring. Selecting one manufacturer in 2008 established one telemetry platform and allowed TTF to establish consistent alarm settings and defaults across the medical center in 2008.

But even with careful attention to alarms selected and their defaults in 2008, staff and TTF found the volume of audible cardiac monitor alarms excessive, potentially desensitizing staff to real alarms needing their response. Media attention in 2011 highlighted this risk nationally and the ECRI Institute identified alarms as one of the top five technology hazards.

"We [BMC] decided that we didn't want to add personnel resources or layer additional technology to address alarm fatigue; instead we saw alarms from our staff's vantage point. By eliminating the repetitive warning alarms and empowering staff to make changes to better manage all alarms, we could significantly lower the number of audible alarms."

— Deborah Whalen, RNP, MSN, ANP—BC, Clinical Service Manager Cardiology

The Strategies Employed:

Senior leadership at BMC reconvened the multidisciplinary TTF that included BMC's chief medical officer, a cardiologist, physicians from critical care, cardiology, medicine, and surgery, the director of clinical engineering, cardiology's clinical service manager nurse, nursing directors, nurse educators and quality leaders to look at where BMC could reduce its audible cardiac monitoring alarms safely.

The TTF decided to use one floor as a 'pilot' floor to gather baseline data and to implement and assess these strategies. Once changes were piloted and data gathered, the TTF and the institution recognized the significant effect of the new strategies on reducing alarms in a safe and meaningful manner. HR and heart rhythm alarm changes were then rolled out to all other medical surgical units of BMC.

Staff Education: To introduce the telemetry changes on each unit, the telemetry pilot "team" met with groups of staff at least once. The "team" consisted of the Clinical Nursing Director, Cardiology Clinical Service Manager, Director of Clinical Engineering, Nurse Manager of the pilot unit, and Clinical Nurse Educator(s) from the pilot unit and the unit where the changes were being implemented. An overview of the changes was reviewed with the staff and a one page tip sheet describing the alarm monitoring changes was distributed.

Standardized education tools were developed and utilized so that each nurse would receive the same information. Two tools were employed: the one page tip sheet mentioned above and a powerpoint presentation describing the changes in more detail with accompanying illustrations. The Clinical Nurse Educator on each unit ensured that they had met with each RN on the unit to review the changes and validate their understanding. Each unit had a copy of the PowerPoint presentation in a binder on the unit for reference. Each nurse also received the one page tip sheet.

The Cardiology Clinical Service Manager on the pilot unit sent weekly emails of

examples of how alarm parameters were individualized for patients. She also included telemetry strips with explanations.

To reinforce and support the changes as each unit went "live" with the changes, "super-users" were utilized. A core group of nurses received additional training and background information taught by the Cardiology Clinical Service Manager to become a super-user. During the first two weeks of "go live," a super-user was scheduled on each unit from 7a-11p. The super-user was a resource for staff to assist responding to alarms appropriately, answering questions, in individualizing alarm parameters, and ensuring the smooth roll out of the project.

Project Goals: The following project goals were articulated to staff:
- reduce clinician alarm fatigue through better management of audible alarm
- increase patient safety by reducing the number of clinically insignificant cardiac monitor alarms;
- improve staff satisfaction by creating a quieter work environment; and
- improve patient satisfaction scores by creating a quieter patient care environment.
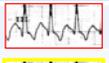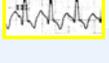
A major change implemented by BMC was to eliminate Warning alarms (see Figures 1 and 2). The two-beep self-resetting "Warning" alarm would no longer be used for heart rate and heart rhythm alarms; heart rate high and heart rate low as well as the arrhythmia alarms for bradycardia and tachycardia would be

> **"It is important to communicate the telemetry monitoring parameter changes to staff so they all get the same message and are implementing the changes consistently. The combination of staff in-services and the super user present on each unit during the first two weeks of implementation worked well; it not only provided the information but also had unit-based resources present for questions and advice during 'go-live.'"**
>
> — Charlotte Cuneo, MSN, RN, CCAP, Clinical Educator

elevated from a warning level to the three-beep crisis alarm level, which requires a response by staff to silence the alarm. BMC made this relatively radical change, because they discovered that most of the "Warning Alarms" were usually transitory and often ignored by staff who were involved in other patient care activities and who understood these alarms were often transitory, clinically insignificant violations that would often self-reset.

BMC wanted to ensure that *all audible alarms were actionable and that they were visualized and acted on by staff in real time either by responding to the patient for clinically significant event or by adjusting parameters to more appropriately reflect clinically significant events for their patient.* BMC also communicated to staff that an audible alarm from the telemetry monitors means that one of these two actions needs to be done immediately by RNs on the nursing unit either responding to the patient for a true

Alarm Level	Monitor Response					
Crisis *	**3** beeps	200				
Warning	**2** beeps	200				
Advisory	**1** beep	200				
Message	No tone	200				
Alarm Silenced	Speaker disabled	200				

200	White text in red box
	Colored box around parameter
	Stored in memory
	Automatic graph

Figure 1: This graphic shows the original alarm levels and how they appeared on the monitor

clinical event or appropriately adjusting the alarm limits to eliminate the recurrence of a non-clinically significant alarm. .

The following changes were made to the default alarm settings:

Heart Rate (HR) low to 45 and HR high to 130 (from low 50 to high 120)
- Crisis (high level) Alarm
  – Tachycardia (HR ≥130)
  – Bradycardia (HR ≤ 45)
  – Accelerated Ventricular Rhythm

- Advisory (low level) Alarm
  – Atrial Fibrillation
  – Irregular

NOTE: System alerts remained unchanged (single repetitive foghorn/visual message) but were more easily identifiable by staff. System alerts include:

Alarms (Blood Pressure [BP] and O2 sat) were moved from Advisory (Low) to Warning (Medium) level. Thus now all 2 beep alarms would be recognized as coming from a BP or O2 sat violation

BMC patient monitors are designed to go into an "Arrhythmia Suspend" Advisory Alarm after 20-30 seconds of ECG artifact (perhaps caused by a "Leads OFF" condition) until the artifact goes away. BMC recognized that this could be a significant patient safety hazard; while in the "Arrhythmia Suspend" mode, NO arrhythmia alarms will sound, including Crisis Alarms. As part of the program roll out, staff nurses were taught to react to "Leads Off" or "Arrhythmia Suspend" alarms promptly by moving leads and/or changing electrodes with good skin preparation; this was reinforced by superusers and clinical educators. In addition, the expectation was communicated that the Day Shift RN would change electrodes daily at the time of their initial assessment of their patients.

BMC Policy on Adult Cardiac Rhythm Monitoring specifies that only an RN is the empowered to silence an alarm.

Staff was taught to respond to all crisis alarms by first checking the patient or the central nursing station (depending on which was closer). As part of this project, two RNs collaborating together were empowered to adjust parameters to STOP all inappropriate or repeating crisis alarms using the following protocol.
- Discuss and validate changing the alarm parameters with a second RN. If there is consensus, take one or more of the following actions:
  – Lower HR low to 5-10 beats/min below patient's normal low rate if the patient is repeatedly alarming bradycardia.
  – Transiently increase HR high to value 10 beats/min above known tachycardia or AF rate until rate is controlled, and then lower to default of 130 if the patient is repeatedly alarming tachycardia.
  – Move VT > 2 to Message for patient with known short runs of NSVT (message alarms are not audible and not stored) if the patient has a history of non-

Arrhythmia Alarm Levels	Factory Default	Pre-Pilot	Pilot
Asystole	Crisis	Crisis	Crisis
Vfib/Vtach	Crisis	Crisis	Crisis
Vtach	Crisis	Crisis	Crisis
VT>2	Crisis	Crisis	Crisis
V Brady	Crisis	Crisis	Crisis
Acc Vent	Advisory	Warning	**Crisis**
Pause	Advisory	Crisis	Crisis
Tachy	Advisory	Warning	**Crisis**
Brady	Message	Warning	**Crisis**
R on T	Message	Message	Message
Couplet	Message	Message	Message
Bigeminy	Message	Message	Message
Trigeminy	Message	Message	Message
PVC	Message	Message	Message
Irregular	Message	Message	**Advisory**
Atrial Fib	Message	Message	**Advisory**
Parameter Limits	**Factory Default**	**Pre-Pilot**	**Pilot**
HR	50 | 150	40 | 150	**45 | 130**
SpO2% R	50 | 150	40 | 150	**45 | 130**
BP	Warning	Warning	**Warning**
PVC/Min	6| Advisory	10| Advisory	**10| Message**
System Status Alarms	**Factory Default**	**Pre-Pilot**	**Pilot**
No Telemetry, Lead Fail, Probe Off	Warning	Warning	**Warning**
Arrythmia Suspend	Warning	Warning	**Warning**

Figure 2 Telemetry alarm summary pre and post pilot changes

In order to enable the RN staff to envision examples of how these changes would affect their clinical practice, the BMC Nursing Educators developed sample scenarios.

Patient Case #1

Your patient has new onset Atrial Fibrillation with Rapid Ventricular Response-HR of 145

You should follow these procedures:

1. Verify stable vital signs.
2. Consider increasing HR alarm to 10 above current rate until heart rate is controlled.
3. Move AF to message until patient converts.
4. Validate suggested change with second RN.
5. Obtain order for change from house staff. Notify attending physician of blood pressure (BP) with suggested order change.
6. Once rate control is achieved, lower to default high heart rate of 130.

Patient Case # 2

Your patient has chronic rate controlled Atrial Fibrillation *(Note After roll-out, AF is now an Advisory (low level) alarm (with one fog horn sound).*

You should follow these procedures:

1. Verify stable vital signs.
2. Consider changing AF to message status.
3. Validate suggested change with second RN.
4. Notify physician of BP with suggested order change

Patient Case # 3

Your patient has a HR of 45 at rest; when sleeping the HR decreases to 38.

You should follow these procedures:

1. Verify stable vital signs.
2. Validate suggested change with second RN.
3. Obtain order for change (Lower HR to 5 below patient's normal rate).(Note: lowering the low HR limit to less than 40 would require approval of the attending MD.)
4. Notify physician of BP with suggested order change.

Patient Case #4

Your patient has cardiomyopathy, baseline cardiac rhythm with multiple Premature Ventricular Contractions (PVCs) (current limit is 10 per minute) has self-limiting short runs of Ventricular Tachycardia (VT), and the VT > 2 crisis alarm is constantly sounding.

You should follow these procedures:

1. Verify stable vital signs.
2. Consider downgrading VT >2 crisis alarm to Message.
3. Validate suggested change with second RN.
4. Obtain order for change.
5. Notify MD of BP with suggested order change.

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sustained VT with stable vital signs.
- Change must be documented in nursing notes and communicated to house staff for endorsement.

TTF felt very confident in empowering two RNs together to make changes to alarms. All RNs at BMC are required to pass a comprehensive Telemetry exam with a score of 90% or greater to be employed at BMC.

In BMC's 2008 defaults, Atrial Fibrillation and Irregular were defaulted to Message level which did not generate a record in alarm history. As a consequence of this, short runs of paroxysmal atrial fibrillation (PAF) could be missed and not recorded. Since patients with PAF are at risk for stroke if not anticoagulated, we felt it was important that PAF be captured in the alarm history. For the pilot, we also changed the alarm for Atrial Fibrillation and Irregular from message to Advisory. For Atrial Fibrillation alarms, the staff was instructed to do the following:
- Notify the clinical team of any new AF and obtain a 12 lead ECG.
- For new AF episodes, downgrade AF to

"message priority" (instead of the normal "advisory priority"), and increase high HR limit to 10 beats/min above patient's rate.
  – *Note: Once rate controlled staff would then lower rate back to 130 and if rhythm converted to sinus rhythm they would move alarm back to Advisory.*
- For chronic AF, downgrade AF to "message" priority.
- Validate the change in alarm settings with a second RN.

The Results

Figure 3 shows the dramatic drop in both the number of total telemetry alarms and the average number of alarms per day on the pilot unit. Alarm data in both graphs included all alarm levels message, advisory, warning and crisis alarms. This data was very useful for convincing other floors and physicians to embrace similar changes on other nursing units. Similar data was collected pre- and post-rollout on other floors at BMC with similar dramatic results.

Because of the meticulous preparation and the communication of lessons learned on the pilot floor, the roll-out was exceptionally smooth and well received by staff,. One additional nursing unit at a time implemented the changes. For each of these roll-outs, all staff received training. A "Train the Trainer" methodology was used

for preparing "super-users" on each floor, who stayed with the unit for a week after go-live. For the initial go-live period, a nurse educator and a staff member from the original pilot unit assisted nursing staff from the roll-out unit.

Clinical Engineering (CE) played an essential part in the roll-out. They created a portable, self-contained telemetry system to educate staff about the alarm changes. The system enabled CE to demonstrate current alarms (both visually and audibly) and show staff the changes. Because the system was on a cart, it could be wheeled to wherever needed for education. The system greatly enhanced the educational experience by simulating the changes staff would experience.[1]

During the roll-out on a floor, one of the roles of the super-user was to page staff on the nursing unit if an advisory or warning alarm sounded for more than 2 minutes. A side benefit of the super-user group was that they were able to educate many users on more subtle areas of operating the physiologic monitors, such as how to review what the patient was doing before a crisis alarm happened.

The physiologic monitoring system is designed to only retain the queue of the last 100 alarms in full disclosure memory. Unless users are diligent about deleting insignificant alarms, the memory queue

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[1] Taking Alarm Standardization to the Floors with a Telemetry Training System. AAMI Horizons, Spring 2011, pages 24-28.
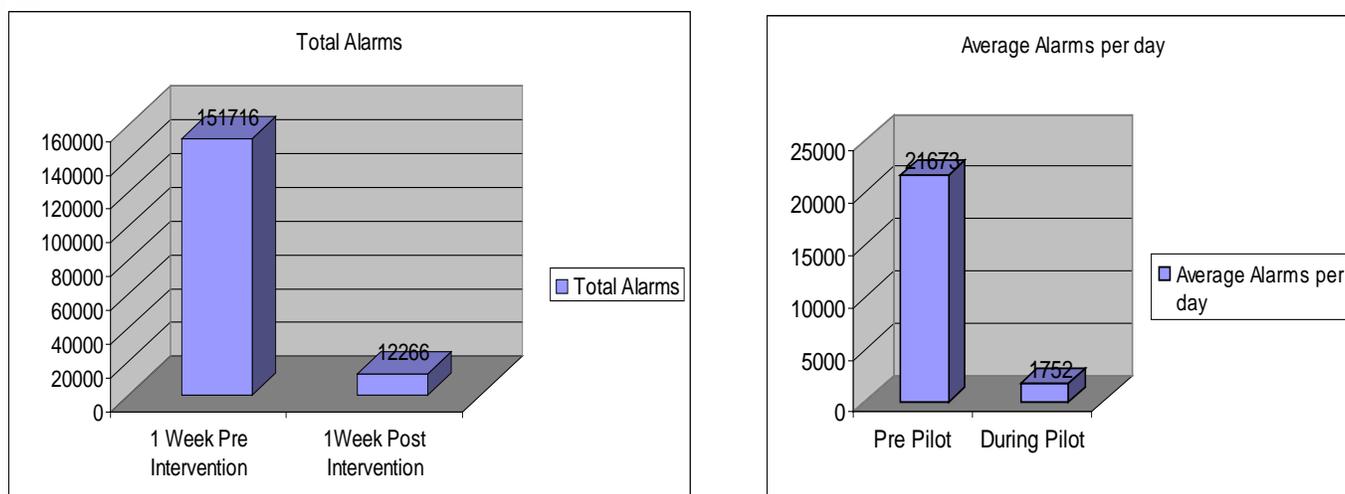

Figure 3. Telemetry alarm volume on 26-bed pilot nursing unit before and after changes (taken from BMC educational material)

will quickly fill up; of course, having many fewer alarms makes this job easier. The BMC Cardiac Monitoring policy requires the nurse responsible for a patient to review Alarm History every 4 hours, retaining a sample of each true positive alarm and discarding all false positive and artifact alarms. Superusers helped staff gain confidence about deleting alarms from alarm history.

Physicians were also part of the extensive education effort. In addition, the Computerized Physician Order Entry (CPOE) system was customized in advance of the roll-out to make it easier for physicians to issue confirming orders when nurses made changes.

The usefulness of the marquee displays increased significantly. Pre-implementation alarms were continuously scrolling across the display. On the pilot unit, BMC learned that once the quantity of alarms was reduced, the displays were useful for directing staff to the room associated with the alarm. This lesson carried through to other nursing units as well.

Rank in Press Ganey Patient Satisfaction Scores increased for both promptness to response to patient call light (rank score increased 41) and personal issues domain (rank increased by 29) on the pilot unit. The pilot floor was quieter with call lights more easily heard and staff felt they had more time to spend with patients.

Some staff quotes after the change:
- *I don't hate the telemetry monitors anymore; they were obnoxious, now they are truly a tool.*
- *The monitor alarms were a necessary irritant; they are no longer seen that way.*
- *The patient telemetry histories are so much better.*
- *I can spend more time on patient care instead of answering meaningless alarms.*
- *The call lights go off less.*
- *It's so much quieter here than other units. I like coming here.*
- *I find myself whispering because it's so quiet.*
- *We don't ever want to go back to the old system do we?*

Figure 4. BMC's marquee systems became much more useful as part of the alarm initiative

BMC's next project will be to look more carefully at SpO2 alarms. They are currently doing additional pilot changes with Upper HR alarms, introducing a 5-second delay before generating a crisis alarm, as well as getting rid of the "Brief Run" advisory message.

The most important lesson learned: Watch the staff and how they interact with alarms; gather data; identify areas for improvement; pilot changes; and analyze results.

"Having the training cart provides the staff with a working telemetry system and is a valuable way to train staff on actual changes (audible, visual and full disclosure). Moreover, as we go through annual competency for Nursing, they have access to the system to educate and evaluate staff."
— Jim Piepenbrink, Director of Clinical Engineering

Awards/ Recognition:

BMC's work has been highlighted by the Joint Commission and the Agency for Healthcare Research and Quality (AHRQ). The results have been dramatic enough that several media outlets) have come to BMC to do news stories about this simple change could have had such an impact in how alarms are managed. Jim Keller, the Vice President of ECRI Institute wrote "one of the most simple yet most important monitoring-related projects that I have seen implemented over the past decade ."

BMC recently won the Gage Award for Quality Improvement at America's Essential Hospitals for their work on alarm safety. On receiving that award, Deborah Whalen, RNP, MSN, MBA; Cardiology Clinical Service Manager at BMC summed up the lessons other organizations should learn as they tackle clinical alarm fatigue, noting the importance of the following:

- observing frontline staff, their work and their challenges;
- hard data to see opportunities;
- teams to effect and sustain change
- senior leadership in creating a culture of staff engagement, such that staff actively seek out opportunities, bring these forward, and with the support of the organization design meaningful answers

for how to do it better as this is where creative, sustainable solutions are found.

Contact Us

Has your healthcare organization implemented any of the strategies discussed in this publication?

Do you know of a healthcare facility that has dealt with a technology-related issue and has a story to share?

If so, we would love to hear from you! Please email slombardi@aami.org.

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