AAMI FOUNDATION

Safety Innovations

Fighting Alarm Fatigue with Data-Driven Interventions

The NCH Healthcare Device Eco-System Experience

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About the AAMI Foundation

The AAMI Foundation is the 501(c) (3) charitable arm of AAMI, whose mission is to promote the safe adoption and safe use of healthcare technology. The AAMI Foundation works with clinicians, healthcare technology professionals, patient advocates, regulators, accreditors, industry, and other important stakeholder groups to identify and address issues from today's complex medical environment that have the potential to threaten positive patient outcomes.

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The National Coalition for Alarm Management Safety was founded by the AAMI Foundation in 2014. This coalition brings together stakeholders from different groups to share what they have learned, build synergies, and create common ground on how to set default parameters and other strategies to improve alarm management. Members of the coalition include more than 25 national hospitals that are well along on the alarm-system-management road, as well as industry, the Food and Drug Administration, The Joint Commission, and professional societies.

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At a Glance

Subject: NCH Healthcare System

Location: Naples, FL. In addition to two hospitals—Downtown and North Naples—the health system includes the NCH Physician Group with 17 locations in the region.

Introduction

In June 2013, The Joint Commission (TJC) issued National Patient Safety Goal NPSG.06.01.01 to address alarm management in relation to patient safety and clinical workload in the hospital environment. Alarms are essential for alerting caregivers to critical patient needs but can compromise patient safety if not managed properly. The frequency and noise of alarms, many of which are nonactionable, can cause staff to become desensitized to them, leading to missed critical events or delayed responses. TJC's goal involved a two-phase implementation plan requiring hospitals, effective January 2014, to establish alarm management as an organizational priority and to identify the most important alarms to focus on based on their own situations. Beginning in January 2016, hospitals were required to have developed and implemented policies and procedures for alarm management and to have begun educating staff about alarm safety management.

At NCH Healthcare System, several initiatives designed to enhance patient monitoring and improve alarm safety were underway prior to TJC issuing its alarm goal. NCH was aware of alarm fatigue and the growing concerns related to patient safety. In fact, as Kevin Smith, BSN, RN, CNML, CVRN-BC, director II, Cardiac Services, explained, "The health system has been actively operating in an environment of technological innovation that focuses on patient and clinician needs, thanks to a partnership with Cerner [hereafter referred to as 'vendor'] that dates back to the early 1990s." Since 2009, a full vendor team has worked onsite at NCH and provides remote hosting to manage the electronic health record (EHR) platform and offers other services.

Attention Turns to Alarm Management

In 2012 and 2013, NCH phased in implementation of its vendor's technologies, which give NCH the capability to connect medical devices (i.e., monitors) to one another, as well as to a patient interactive TV, to communicate device information, and report the device data to the nurse from a single middleware platform—a platform that can obtain data from multiple systems to enable notification of critical patient events. This level of integration provides immediate vital sign documentation into the EHR and real-time dashboard views in the nursing station, along with many other functions.

In response to TJC's goal to improve alarm management, the NCH official alarm management committee kicked off its work in February 2014. The committee included representatives from across the health system: nursing leadership, education, respiratory therapy, biomed, regulatory compliance, quality, and risk management. The chief nursing officer, Michele Thoman, MBA, RN, chairs the committee, whose formal mandate is to manage alarms and devices to care safely for patients, while protecting staff from alarm fatigue. A vendor representative also serves on the alarm management committee. This person supports the committee's work to ensure NCH is compliant with the alarm management goal, provides the current best practice recommendations, and assists with analysis of operational reports from the device integration system.

Lesson One: 'Learn' the Data

When the NCH alarm management committee first came together, it lacked fundamental information necessary to make critical decisions regarding alarm safety. "There was minimal alarm data to drive the direction of the team," Smith said. "Secondary alerting from the primary devices through the middleware needed to be fine-tuned. We also had to 'learn' the data — what was it showing, and how could we reduce nonactionable alarms. Then, ultimately, we needed to move the lessons out of the committee room and to the point of care so the clinicians could use the information to manage the alarm environment."

In order to move forward with the goal of minimizing alarm fatigue, NCH began to utilize the alarm data provided by its middleware platform. The reports that were developed were based on retrospective data representing the alarm volumes by type and by unit.

An initial analysis of alarm data from the monitors gave NCH a better understanding of what Smith called the NCH "device ecosystem." Based on the alarm management data, feedback from the staff and the interdisciplinary alarm management team,

NCH chose to focus on the following alarms as part of their compliance with TJC's initiative: tachycardia, premature ventricular contraction (PVC) high, Sp02 probe, and Sp02 low.

"These alarms were chosen based on several factors," Smith said. "They were high volume alarms, as evidenced within the data collected from the middleware. They were occurring on telemetry units where recent workflow practices had taken place. There was industry evidence to support the opportunity to improve current practice with these specific alarms.[1,2] And a review of adverse event reports did not indicate there were other, more pressing, alarm issues to be addressed."

The list of alarms was approved by the NCH medical executive staff. A plan was developed to create a pilot unit, understand the data from that unit, implement evidenced-based best practices, and educate the staff. Included was a process to roll out the practices to other units once adoption and improvements had been achieved, and the team felt the process could be reproduced.

Taking on Tachycardia

NCH chose tachycardia as the first initiative for the pilot unit in August 2014, and this paper will focus on how NCH successfully reduced the number of nonactionable tachycardia alarms. To start, baseline alarm conditions were documented, and conditions contributing to the number of alarms were identified for safety improvement. Smith said the interventions employed included improving lead hygiene by implementing daily electrode changes, keeping the electrode pads in airtight packaging, and making sure the skin was prepped and the electrodes were in the correct place. The training focused on customizing patient alarm settings based on each patient's specific needs. For example, Smith explained, if a patient's typical heart rate is 120, the high heart rate limit, which triggers the alarm, is set at 130.

Smith and the clinical unit educators taught the nurses about the new lead hygiene policy and procedure and how to better manage the telemetry central station

and patient-specific alarm settings. For example, just as NCH managed the high heart rate limit for tachycardia, it applied that same principle to low heart rate limits for patients who typically run a lower rate.

Within the first two weeks, tachycardia alarms were reduced by more than 30% (see Figure 1).

"We also began looking not only at data trended over time by months and weeks, but at the data hour by hour (see Figure 2) and began to pull the data into the form of 'heat maps,'" Smith said. "The data is easy to drill into, so we began looking at multiple alarms at the room level to discern exactly which rooms had the patients generating the most alarms. Thus, we began to utilize near real-time data."

NCH developed a near real-time "heat map" of room level alarms as a key component of its alarm management plan (see Figure 3). This graphic indicates which patient is generating the most alarms — the larger the square, the more alarms are being triggered in that particular room. "It helps us identify that minority of patients generating the most alarms, a situation seen in many hospital units," Smith said. "These are the patients who may need to have the parameter defaults customized. The heat maps keep us focused on where the nurses should expend their energies to reduce nonactionable alarms."

Moving Data to Decision-Making

The goal of the NCH alarm management committee was to ensure the data gathered from analysis of the alarm environment would find its way to frontline caregivers and managers. "The ability to drill into the data kept pushing us to raise the bar as to how we could operationalize the data and get it into the staff's hands," Smith explained. "So we began looking at the shift report. This report allows the clinical team to focus on setting patient specific alarm limits based on the patient's condition."

Figure 4 shows how a typical unit alarm management shift report looked before the data was used to reduce the number of
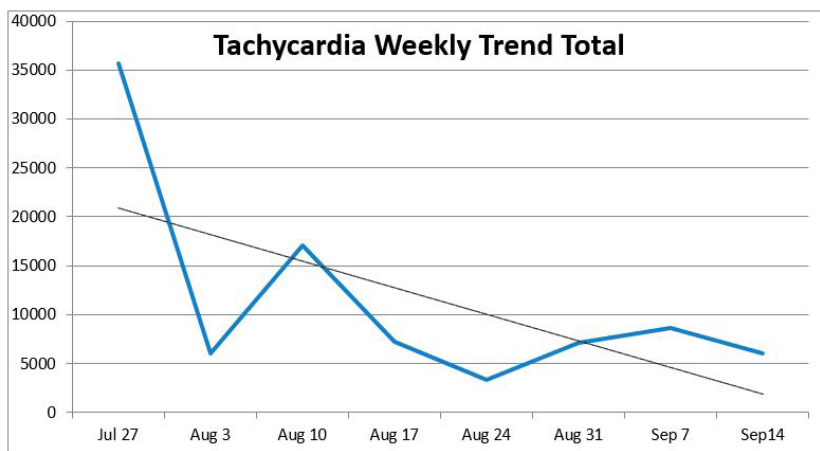

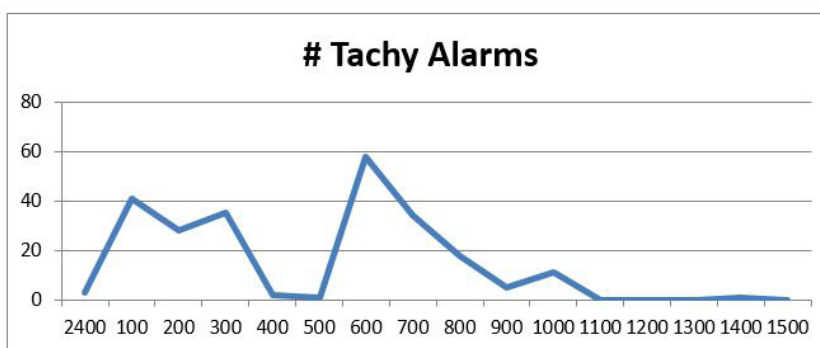**Figure 1.** Tachycardia Alarms, Weekly Trend Total, July 27-September 14, 2014

Figure 2. Number of Tachycardia Alarms by Hour

Figure 3. Heat Map—Alarms at Room Level

nonactionable alarm signals. Figure 5 shows how staff used data from the shift report to minimize the nonactionable alarm signals.

"Once the nurse began the process to assess the patient, manage the lead protocol, and adjusted the alarm limits to be patient specific, you can see significant improvement in the alarm management by 10 a.m.," Smith said. "Over time, the nurse manager, then the charge nurse, and the staff learned to utilize the reports to target the alarms being generated by the patients on the pilot unit."

Smith added, "The shift report has now been rolled out to an ICU and additional telemetry units with the same results, namely a decrease in nonactionable alarms and much quieter environments."

"As you can see in Figure 5," Smith said, "the staff is learning how to use the shift report to reduce the number of nonactionable alarm signals. The tool has made a huge impact on the awareness of alarm management during the patient's stay. We are not limited to retrospective analysis and monthly meetings to target improvement. We target this in near-real time."

Smith explained how the staff is utilizing the data: "When they see a patient has an increase in nonactionable alarm signals, they will assess the patient and then assess if the monitor needs additional management. The data keeps them focused on which patients need to have the alarm parameters customized to their specific physiological responses. The parameters are customized when the patient is admitted to the unit, as therapies change—such as the titration of medications—and at the beginning of each new shift, based on the shift report. The shift report and the discussion at shift change are intended to raise awareness during the handoff if there are patients triggering an increased number of alarm signals. This increase in alarm signals could be technical, such as patients moving around, or clinical, in cases with changes in baseline vital signs or rhythms.

Much like when the pain assessment became the 'fifth vital sign,' Smith stated,

Shift Reports - Initial Alarms

Date Range: All to next 24 hours.
Last Run: 3/3/2015 7:30:35 PM

Room	Event Type	Date 03/02/2015						Date 03/03/2015																			Sum	%
	Hour	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	Sum	%
4148	ACCELERATED_VENT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	0.02
	BRADY	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	5	6	-	-	-	-	-	1	2	16	0.25
	HEART_RATE_HIGH	-	-	-	-	74	189	186	199	201	213	193	165	186	183	180	168	25	-	-	-	-	1	1	-	-	2,164	33.2
	HEART_RATE_LOW	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	3	3	1	-	-	-	1	-	10	0.15
	NO_TELEM	10	14	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	0.4
	PVC_HI	16	29	29	9	16	31	39	40	33	29	25	13	14	9	18	20	2	2	15	23	41	36	14	36	16	555	8.51
	SILENCE	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	2	4	-	-	1	-	-	1	-	2	13	0.2
	TACHY	-	-	-	-	123	358	426	365	335	392	328	232	276	215	264	340	59	-	-	-	-	-	1	-	-	3,714	56.97
	UNSILENCE	-	-	-	-	-	-	1	1	1	-	-	-	-	-	1	2	-	-	1	-	-	-	-	-	1	8	0.12
	V_TACH	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	0.02
	VT_HIGH	-	-	-	-	3	1	-	1	-	-	-	-	-	-	-	1	-	-	2	1	-	-	1	-	1	11	0.17
4149	BRADY	106	176	129	70	87	17	3	-	-	-	1	-	1	4	8	91	9	8	-	2	4	-	-	3	-	719	61.19
	HEART_RATE_LOW	56	100	73	39	46	9	2	1	-	-	-	-	2	3	4	43	4	7	-	1	5	-	-	2	-	397	33.79
	NO_TELEM	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	11	29	-	-	-	41	3.49
	NURSE_CALL	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.17
	SILENCE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	6	0.51
	TACHY	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.17
	UNSILENCE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	6	0.51
	VT_HIGH	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.17

Figure 4. Alarm Management Shift Report—Initial Alarms

Shift Reports - Initial Alarms

Date Range: All to next 24 hours.
Last Run: 3/20/2015 7:30:09 AM

Room	Event Type	03/19/2015																		03/20/2015							Sum	%
	Hour	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	Sum	%
4113	PVC_HI	-	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	100
4114	HEART_RATE_HIGH	-	-	-	1	11	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	39.39
	NO_TELEM	-	-	-	-	-	-	-	-	-	9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	30.3
	SILENCE	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3.03
	TACHY	-	-	-	1	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	18.18
	UNSILENCE	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3.03
	VT_HIGH	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2	6.06
4115	ACCELERATED_VENT	-	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	4	36.36
	BRADY	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	4	36.36
	HEART_RATE_LOW	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	18.18
	PVC_HI	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	9.09
4116	HEART_RATE_HIGH	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	1	-	1	-	4	6.35
	NO_TELEM	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	16	-	-	27	42.86
	SILENCE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	3	4.76
	TACHY	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	1	2	-	-	-	-	1	-	-	6	9.52
	UNSILENCE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1.59
	V_TACH	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	4	6.35
	VT_HIGH	-	1	1	2	-	1	-	-	-	2	2	-	2	-	-	-	-	2	1	1	-	1	-	1	1	18	28.57

Figure 5. Alarm Management Shift Report—Initial Alarms, with Improved Alarm Management

"We want our culture to accept alarm signals as the 'sixth vital sign.' The staff should have the alarm signal status as part of the daily handoff at a minimum."

Additionally, since early 2015, after successfully piloting the sharing of alarm-reports at shift change, there is now tighter control over patient-specific alarm-parameter defaults. Following the pilot, a communication went out to staff that included the following guidance: *"The unit team leaders will begin to make the oncoming shift aware of the parameters set in the telemetry unit. We realize you are currently reviewing the parameters when your shift begins but we wanted to provide you with a printed alarm sheet. Please review the sheet, made available by the US [Unit Secretary] with your assignment sheet, at the start of your shift and adjust the parameters based on the patient's assessment. For example, if your patient is tachy and has a PRN [as needed] medication for sustained HR>135, consider adjusting the HR parameter to 135. This way, when the alarm goes off you can look for the sustainability of the rate and make an assessment based judgment on administering the PRN medication."*

Sending Only the Most Important Alerts to Nurses

The nurses are notified in real time of actionable alarm signals via a secondary alerting system to their work iPhones. They use role-based communication with prioritization and escalation paths for rapid notification. The primary alarm signals continue to sound at the primary device; however, those alarms have been drastically reduced due to the alarm management initiative. Only critical alerts are sent to the nurses' iPhones to minimize alert overload.

This process provides the staff with a "safety net" and connects the care provider directly to a compromised patient. If the direct care provider is not available, the alert rolls over to the appropriate care team member. There is a 60-second delay within the escalation protocol, so if the primary nurse doesn't respond to the critical alert, the staff assignment system routes the alert to the secondary nurse assigned to the patient. Smith said, "Having access to the alarm data from the primary device and the data from the secondary alerts going to the iPhones is key in this model to prevent alarm fatigue."
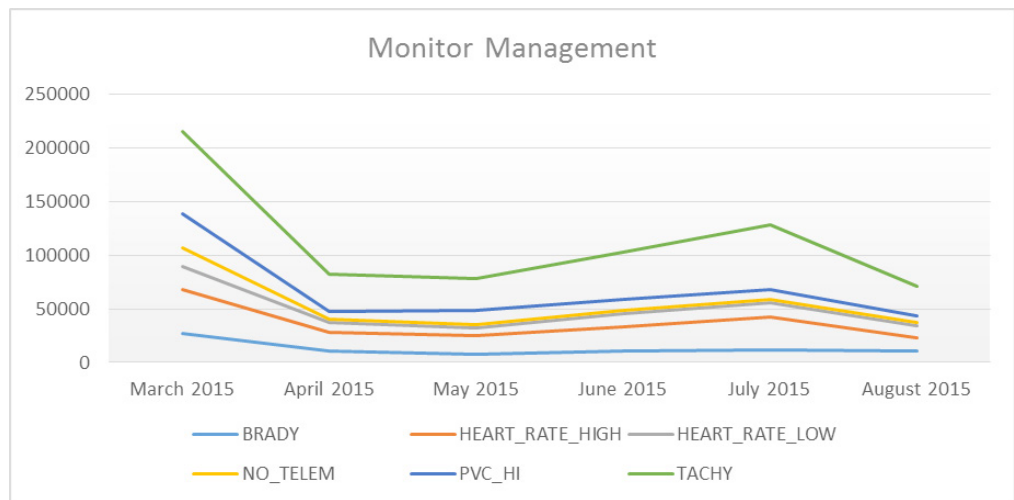
Figure 6. Monitor Management

NCH discovered that a key factor in successful alarm management is continuing education for basic monitor and device management when setting device alarms. Thus, ongoing, real-time training on how to customize alarm parameters for individual patients is provided at the central station by Smith and the nurse educators. Access to the EMR and relevant patient condition data is available at the central station.

NCH's monitor management report (see Figure 6) indicates how a focus on the management of the patient-specific alarm settings has decreased the number of nonactionable alarm signals over time. The utilization of the shift report, which as noted earlier began in early 2015, continues to provide data to help the clinical team identify the source of nuisance alarm signals and provide better alarm management. When correlated with an increased census, the average number of alarms/beds/days did not indicate an increase in overall alarm load.

Alarm Management Now Part of State-of-the-Art System

NCH is taking full advantage of its technology by wrapping tools for alarm management into its overall solutions for care management. As a result of this "state-of-the-art" system, NCH is leveraging its vendor middleware to power its Smart Room integration—referring to the more effective and cohesive use of technology in patient rooms—and to document medical device data into the EHR, according to Smith. "The single platform allows us to access that EHR data via our iPhones, provides our secondary alerts to the care team, and supplies our alarm management data repository with the device data for near-real-time reporting."

The data repository is a cloud-based solution that allows NCH to access the data and generate reports as needed. "We can even set up reports like the shift report to be emailed proactively to specific distribution lists like our charge staff," explained Smith.

Indeed, like most health systems, NCH recognized it had a problem with alarm fatigue and the potential it had to negatively impact patient safety. The work of its alarm management committee helped uncover the roots of the problem. This work is invaluable for any hospital or health system dealing with alarm safety. The key culprits for the excessive alarms, according to Smith: poor lead hygiene and lack of patient specific alarm limit settings.

"We needed to better educate the staff on monitor management and connecting the dots between the patient's condition,

therapies, and the number and type of alarm signals associated with the patient," he said. "Without the data to monitor and measure our process, we were shooting in the dark. By driving our alarm management process with data, we know what we need to target and if we're making improvements."

NCH also is working on a dashboard view that will provide a graphical display and icon display of the alarm environment for the unit. The goal is to provide a more complete picture of the patient's condition in relation to the alarms that the bedside nurse will manage. It is also important to have an indication of how the alarm environment impacts the staff at a unit level, Smith asserted.

Conclusions and Tips

Over a four-month period, the pilot unit lowered its total number of alarm signals from 255,912 in January 2015 to 79,486 in April 2015—a 69% reduction without a negative impact to patient safety.

This reduction was not associated with an increase in rapid response calls, code calls, or evidence of patient deterioration. NCH has been successful in sustaining its alarm management process by constantly monitoring and responding to near-real-time alarm data in the shift report.

Clinical adoption and education will be paramount as NCH rolls the process out to additional units "The next step will be to look at bed alarms and how to incorporate fall prevention into the process of secondary notification," Smith said. In addition, NCH is working with its vendor to build alarm messaging into the electronic room signage that is positioned outside the door of the Smart Room to illuminate (with a particular color) when a patient exceeds an alarm threshold or produces a situation of "alarm flood" in which a patient's devices generate 10 or more alarms within 10 minutes.

Based on the NCH experience, here are some tips for other hospitals and healthcare organizations for fighting alarm fatigue:

- **Invite the supplier of your device middleware and/or monitor provider to join your multidisciplinary alarm management committee.** Many times, the vendor will have information on data and timing configurations for your devices and monitors.
- **Analyze the data and determine your "device ecosystem."** This is the crucial first step in reducing alarm fatigue: developing a comprehensive understanding of the devices in your system—what alarm signals and alerts you can and cannot send, how often these alarm signals and alerts are fired, and the cause and the impact of the alarm signals and alerts. What you really need to know is what kind of device noise is generated, why it is generated, when it is generated, and how to use data to understand it.
- **Present the list of most important alarm signals and the rationale for their selection.** Based on the data analysis, present this information to the medical executive staff, and/or chief executive and administrative officers.
- **Share the data gathered from analysis.** Provide frontline caregivers and managers with results of the data from the alarm environment.
- **Make sure alarm data are incorporated into shift reports.** Roll those out to ICUs and additional telemetry units to effectively decrease nonactionable alarm signals and produce much quieter environments.
- **Send only critical alarm signals as secondary alerts to your communication device.** In addition, incorporate an escalation process to the care team.
- **Develop a system that has the ability to pull data into the reports on demand in near-real time,** such as the shift report and alarm dashboard reviews.
- **Develop a dashboard view that provides a graphical and icon display of the alarm environment for the unit.** This will enable the bedside nurse to visualize a more complete picture of the patient's condition.
- **Ensure the alarm history can be viewed from both the patient condition and treatment perspectives.** This will enable staff to safely manage the device sending the alarm and to provide continuity during shift changes.

- **View alarm signal reduction as a continuous improvement project**. Make operational reports, shift reports, and dashboards as much a part of your culture as length of stay, mortality, sepsis, and other outcome reports. Achieving the goal is just the first step. Sustaining the goal will make it a successful process.

If your hospital has successfully utilized a strategy to improve alarm management and you would like to share your story, please contact, Sarah Lombardi, program director at slombardi@aami.org.

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