THE ALARM SAFETY HANDBOOK
Strategies, Tools, and Guidance

ECRI Institute
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Jon Treadwell, PhD

OTHER CONTRIBUTING STAFF
Media Services
Tara A. Kolb, BFA
Manager, Media Services
Kristin Finger, BS
Suzanne R. Gehris
Marlene P. Hartzell
Benjamin Pauldine, MS
Michael Wroblewski, BS
Copyediting
Samantha Cardimon, BA
Client Management Services
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Library
Evelyn H. Kuserk, MLS
Supervisor
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Preface

Many medical devices incorporate alarms to warn caregivers of relevant changes in the patient’s condition or of circumstances that could adversely affect the patient. These warnings have saved many lives. But alarm-related adverse incidents do sometimes occur, and such incidents can lead to patient harm. (See Chapter 1 for some noteworthy statistics.)

This risk of harm—from a feature that is supposed to help prevent it—has been recognized as a key patient safety issue, and healthcare facilities are expected to develop programs to assess and improve how clinical alarms are managed. A critical early step in that process is to form a multidisciplinary team to learn about the issue, to identify safety vulnerabilities within each care area, and to guide the organization’s improvement efforts. The resources in this Handbook and in the accompanying Workbook will help team members work through that process.

In addition to protecting patients, improving the way you manage clinical alarms can yield other significant benefits. It can help you create a more restful environment for your patients, which may help their recovery and also may improve their overall experience—a factor that might be observed in higher patient satisfaction scores. And it can help you create a less stressful and more productive working environment for your staff, which can improve their satisfaction as well.

What Are Clinical Alarm Hazards?

We use the term “clinical alarm hazard” to refer to any circumstance during the care of a patient that could result in the failure of staff (1) to be informed of a valid alarm condition in a timely manner or (2) to take appropriate action in response to the alarm.

Alarm fatigue—in which healthcare workers can become overwhelmed by, distracted by, or desensitized to the numbers of alarms that activate—is one commonly cited concern. However, the issue of alarm hazards extends well beyond alarm fatigue. Preventing alarm-related adverse events requires scrutinizing all aspects of how alarms are initiated, how they are communicated, and how staff respond.

This guide will help you assess all these processes so that you can identify risks and craft solutions that are both realistically implementable and effective for your specific environment of care. As outlined below, such actions are needed to protect patients from a top health technology hazard and to comply with new Joint Commission requirements.
The issue extends well beyond alarm fatigue. Preventing alarm-related adverse events requires scrutinizing all aspects of how alarms are initiated, how they are communicated, and how staff respond.

**A Top 10 Hazard**

Clinical alarm hazards have been at or near the top of ECRI Institute’s Top 10 list of health technology hazards every year since the list’s inception in 2007. This list is published each fall to highlight the technology safety topics that we believe warrant particular attention for the coming year.

Alarm hazards again top the list for 2014. The reason?

1. Alarm hazards are ubiquitous. The potential for alarm-related incidents leading to patient harm exists every minute of every day in virtually all healthcare facilities.

2. Alarm hazards put patients at risk. Some patients have died and others have suffered significant harm as a result of staff not being informed of valid alarm conditions in a timely manner or not taking appropriate action in response to the alarms.

3. Alarm hazards are difficult to eliminate. Reducing clinical alarm hazards requires improving the manner in which alarms are managed—and that is a complex and lengthy process. In most hospitals, the number of alarms that will be active at any given time is staggering. And the optimal strategies for managing those alarms will vary from one care area to the next, and sometimes from one patient to the next.

With a concerted effort, however, healthcare facilities can make headway against this high-priority hazard.

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* To access an abridged version of the report, see [https://www.ecri.org/2014hazards](https://www.ecri.org/2014hazards). Members of certain ECRI Institute programs can access the comprehensive report through their member web page at [www.ecri.org](http://www.ecri.org).
of alarm hazards extends beyond alarm fatigue.

Preventing alarm-related adverse events requires scrutinizing all aspects of how alarms are initiated, how they are communicated, and how staff respond.

**A National Patient Safety Goal**

To compel healthcare organizations to work toward addressing clinical alarm hazards, the Joint Commission announced in June 2013 that alarm management would be established as a National Patient Safety Goal, with certain provisions taking effect during 2014. The new goal is intended to address “clinical alarms that can compromise patient safety if they are not properly managed.”

During 2014, accredited organizations are expected to establish alarm system safety as a priority and to identify the alarm hazards that they will address based on their individual situations. Organizations will then have until 2016 to develop and implement specific policies and procedures to combat identified hazards and to educate their staff accordingly.

chapter

Making Alarm Management a Patient Safety Priority
The beeping, chirping, and pinging of medical device alarms form the soundtrack of many patient care areas. These tones are critically important safety features that can make the difference between timely, life-saving interventions and serious injury or death. For example:

- Physiologic monitors alarm to warn caregivers when the patient’s heart rate, blood pressure, or blood oxygenation falls outside specified alarm limits or when an abnormal heart rhythm develops.
- Ventilators alarm to warn of breathing circuit disconnections or occlusions.
- Infusion pumps alarm when air is in the line or a drug bag is empty.
- Bed-exit alarms notify the caregiver when a patient has gotten out of bed and may be at risk of falling.

These are just a few of the many devices and conditions that can generate clinical alarms to keep patients safe. In addition, nurse call systems and other technologies used in the care area issue audible tones to inform healthcare workers that the patient or some circumstance needs their attention.

However, it is possible to have too much of a good thing. Excessive numbers of alarms—particularly alarms for conditions that aren’t clinically significant or for conditions that could be avoided, such as alarms that result from poor contact between an ECG electrode and the patient’s skin—can lead to alarm fatigue, and ultimately patient harm. That is:

- Clinical staff can become overwhelmed, unable to respond to all alarms or to distinguish among simultaneously sounding alarms.
They can become distracted, with alarms interrupting their thought processes or diverting their attention from other important patient care activities.

They can become desensitized, possibly missing an important alarm because the sounds cease to be distinct or because too many previous alarms proved to be insignificant.

In addition, the noise from excessive alarms can hinder a patient’s ability to rest and recuperate, it can increase anxiety among family members, and it can create a more stressful work environment for staff. Such factors may prompt caregivers to take unsafe actions, such as decreasing the alarm volume to an inaudible level or even turning off the alarm completely.

Beyond alarm fatigue, patients could be put at risk if any of the following occurs:

- An alarm does not activate when it should. This may occur, for example, if the patient is not connected to the device properly, if the device is not configured correctly for the care area or patient, or if the alarms have been inappropriately silenced or suspended.

- The alarm signal is not successfully communicated to staff. The reason may be as basic as the patient’s door being closed or nurses at one end of a long corridor being unable to hear or see alarms originating at the other end. Or the problem could be much more complex, resulting from some fault in a complicated alarm notification chain involving information transfer through multiple technologies.

- The alarm signal does not include sufficient information about the alarm condition—for example, if an ancillary alarm notification system does not communicate the nature or priority of the alarm.

- The caregiver who receives the alarm signal is unable to respond in a timely fashion. If the patient’s nurse is unable to leave another patient, and no backup coverage has been established, an alarm could go unheeded.

- Clinical staff do not respond to the alarm for some other reason. This might occur, for example, if staff are unclear about who has responsibility for responding to the alarm or are unaware of the importance of a particular alarm.

Any of these conditions could lead to a clinical alarm hazard—that is, the failure of staff to be informed of a valid alarm condition in a timely manner or to take appropriate action in response to the alarm.
Alarm Hazards by the Numbers

Figures reported in the clinical literature and elsewhere help demonstrate why healthcare facilities need to take the time to assess and improve how clinical alarms are managed.

▶ From analyses of the U.S. Food and Drug Administration’s (FDA) Manufacturer and User Facility Device Experience (MAUDE) database:

566 alarm-related patient deaths were identified in FDA’s MAUDE database from 2005 through 2008 (Weil 2009). In its 2013 Sentinel Event Alert, the Joint Commission notes that industry experts believe this figure likely underrepresents the actual number of incidents (Joint Commission 2013).

216 deaths involving physiologic monitor alarms alone were identified in FDA’s MAUDE database (from January 2005 through December 2010) when searching using the terms “alarm” and “death” (ECRI Institute 2013).

▶ As reported by the Joint Commission in an April 2013 Sentinel Event Alert:

80 of the 98 alarm-related events reported to the Joint Commission’s Sentinel Event database over a three-and-a-half-year period involved a patient death, and 13 of the events resulted in a patient’s permanent loss of function.

Alarm-Related Events in the Joint Commission Sentinel Event Database (Jan 2009–Jun 2012)

- 80 Resulted in death
- 13 Resulted in permanent loss of function
- 5 Resulted in unexpected additional care or extended stay
From a 2012 study by Varpio et al.:

70% of the more than 400 alarms studied received no response from nurses.

41% of the 34 significant (potentially life-threatening) alarms received no immediate response. Nurses in this study described feeling overwhelmed by frequent alarms and reported developing workaround strategies, such as ignoring alarms they judged to be clinically insignificant.

From a 2011 Healthcare Technology Foundation survey:

Nearly 1 in 5 institutions reported that they had experienced alarm-related adverse patient events during the preceding two years (n = 3,740). Furthermore, approximately half of the respondents indicated that they were unsure if any events had occurred.

Has your institution experienced adverse patient events in the last two years related to clinical alarm problems?

(HTF Survey, Question No. 29)

- Yes 18%
- No 33%
- Not sure 49%
From analyses of ECRI Institute problem reporting databases:

12% of 2,200 reports in ECRI Institute’s problem reporting network (2000–2006) were related to alarms (ECRI Institute 2013).

72 alarm-related hazards, recalls, and alerts were published in ECRI Institute’s Health Devices Alerts database from January 2012 through June 4, 2014. Of those reports, 72% involved patient monitor, infusion pump, ventilator, or bed/bed-exit alarms. The types of problems reported include alarms not activating or becoming disabled, delayed or failed delivery of alarms to ancillary notification systems, inaudible alarms, and erroneous alarms.

Number of Alarm-Related Hazards, Recalls, and Alerts by Device Type
(Health Devices Alerts Database, 2012 Jan 1 - 2014 Jun 4)
From an instant poll conducted during ECRI Institute’s August 2013 alarm management web conference (ECRI Institute 2013):

53% of 359 respondents to a poll question said that alarm issues have impacted their facility’s patient satisfaction scores—and an additional 34% were not sure.

Sources:
The Joint Commission’s Requirements

Background

As noted in the preceding section, the Joint Commission’s April 2013 Sentinel Event Alert cited 98 reports of alarm-related events over a three-and-a-half-year period, with 80 of those events resulting in death and 13 in permanent loss of function.* Then, on June 25, 2013, the organization issued a Prepublication Standards document establishing alarm management as a 2014 National Patient Safety Goal (NPSG) for hospitals and critical access hospitals.

The NPSG, which focuses on the management of “clinical alarm systems that have the most direct relationship to patient safety,” is being implemented in two phases:

- **Phase 1:** During 2014, accredited organizations are expected to establish alarm system safety as a priority (as of July 1, 2014) and to identify the alarm hazards that they will address based on their individual situations.

- **Phase 2:** As of January 1, 2016, organizations will be expected to develop and implement specific policies and procedures to combat identified hazards and to educate their staffs accordingly.

In an R3 Report issued on December 11, 2013, the Joint Commission explained its expectations for the two phases:**

During phase 1, The Joint Commission will monitor emerging evidence about leading practices, will solicit feedback from hospitals on their experiences with the requirements of the NPSG, and will obtain feedback from surveyors about implementation issues and leading practices observed during surveys. The Joint Commission is aware of efforts currently underway that will support the field in implementing the second phase of the NPSG requirements. This includes an AAMI initiative to identify best practices in setting alarm parameters. It is important to note, therefore, that before they are implemented on January 1, 2016, the proposed phase II requirements may be enhanced based on new knowledge.

Further, the R3 Report describes the intended scope of the NPSG:

> This NPSG addresses clinical alarms that can compromise patient safety if they are not properly managed. This includes alarms from equipment such as cardiac monitors, IV machines, ventilators, etc. that have visual and/or auditory components. In general, this does not include items such as nurse call systems, alerts from computerized provider order entry (CPOE), or other information technology (IT) systems.

Elements of Performance for NPSG.06.01.01

The goal, which is designated as NPSG.06.01.01, encompasses four “elements of performance.” The first two must be completed during Phase 1. The remaining two—which may be subject to change, as noted above—must be addressed during Phase 2. For reference, we have reprinted these requirements below from the R3 Report. (The full text of the NPSG can be accessed through the Joint Commission’s website at the URLs presented at the end of this section.)

**NPSG.06.01.01:** Improve the safety of clinical alarm systems.

**EP 1:** As of July 1, 2014, leaders establish alarm system safety as a hospital priority.

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EP 2: During 2014, identify the most important alarm signals to manage based on the following:

- Input from the medical staff and clinical departments
- Risk to patients if the alarm signal is not attended to or if it malfunctions
- Whether specific alarm signals are needed or unnecessarily contribute to alarm noise and alarm fatigue
- Potential for patient harm based on internal incident history
- Published best practices and guidelines

(For more information on managing medical equipment risks, refer to Standard EC.02.04.01.)

EP 3: As of January 1, 2016, establish policies and procedures for managing the alarms identified in EP 2 above that, at a minimum, address the following:

- Clinically appropriate settings for alarm signals
- When alarm signals can be disabled
- When alarm parameters can be changed
- Who in the organization has the authority to set alarm parameters
- Who in the organization has the authority to change alarm parameters
- Who in the organization has the authority to set alarm parameters to “off”
- Monitoring and responding to alarm signals
- Checking individual alarm signals for accurate settings, proper operation, and detectability

(For more information, refer to Standard EC.02.04.03)

EP 4: As of January 1, 2016, educate staff and licensed independent practitioners about the purpose and proper operation of alarm systems for which they are responsible.

Links for 2014 National Patient Safety Goals

- Main page: http://www.jointcommission.org/standards_information/npsgs.aspx
- For Critical Access Hospitals:
  - Link page: http://www.jointcommission.org/cah_2014_npsgs
- For Hospitals
  - Link page: http://www.jointcommission.org/hap_2014_npsgs
  - The full chapter (PDF): http://www.jointcommission.org/assets/1/6/HAP_NPSG_Chapter_2014.pdf
Addressing the Hazard

Addressing clinical alarm hazards is not simply a matter of making sure that alarms are turned on or that the alarm volume is set appropriately. It requires a comprehensive alarm management program involving stakeholders from throughout the organization. The facility must dedicate long-term effort to developing and implementing the program, to assessing and refining its functionality, and to adapting the program to changing clinical practices and medical technologies.

Goals for an alarm management program will include both (1) minimizing the number of clinically insignificant or avoidable alarms so that the conditions that truly require attention can better be recognized and (2) optimizing alarm initiation, notification, and response protocols so that the patient receives the appropriate care at the time it’s needed.

Our experience helping healthcare facilities achieve these goals has revealed seven keys to success:

1. Recognizing that alarm hazards are not just a technology problem—issues of organizational culture and processes must also be examined. Leadership must demonstrate a readiness to tackle the problem, and everyone involved must understand the full scope of the hazard.

2. Addressing the problem through a coordinated, multidisciplinary effort. Lasting improvements cannot be achieved by departments acting in isolation; thus, a key early step will be to form a multidisciplinary alarm management team.

3. Investing the time to understand how alarms are used at your facility. A successful program will require identifying where your vulnerabilities lie and developing appropriate strategies to limit hazards. Activities that can help with this effort include:
   - Observing how the many different alarms are handled in each care area. Much can be learned by walking around, observing what happens on the nursing floor, and engaging frontline staff about their concerns.
   - Reviewing your reports of adverse events and near misses.
   - Collecting and analyzing alarm data—for example, obtaining a measure of the number and types of alarms that activate per bed per day within a care area. The more data you can collect (and make sense of), the better you can target strategies to improve alarm management. However, even comparatively brief snapshots of data can yield useful information.

4. Considering the needs of each care area individually. Although reducing clinical alarm hazards will require an organization-wide effort, the risks will vary from one care area to the next, and the solutions will need to be tailored to each area individually. That is, there is no one-size-fits-all answer.

   Numerous factors can play a role in whether alarms in a particular care area or for a particular device or patient will warrant attention. These include:
   - the acuity of the patient,
   - the technologies being used in the treatment of the patient,
— the technologies being used to communicate alarms,
— the nurse-to-patient ratio,
— the care model employed, and
— the architectural layout of the care area.

5 Involving frontline staff in identifying and implementing improvement strategies to help match the strategies to the needs of, and the workflow in, each clinical environment.

6 Assessing the effect of the strategies that are implemented, and revising or refining the program as needed.

7 Promoting your successes. Doing so can help staff see the value of any new approach and can keep the organization focused on this important patient safety program.

In This Handbook

▷ In Chapter 2, we present a conceptual model to help healthcare workers and administrators gain a deeper understanding of the issue. We identify the points in the patient care process where alarm hazards can occur, and we offer some advice on how to prevent such problems from developing.

▷ In Chapter 3, we outline a plan that healthcare facilities can put into action to help them improve how they manage clinical alarms—and thus to help them reduce clinical alarm hazards.

▷ In Chapters 4 and 5 and in the accompanying Workbook, we provide resources and tools to help you fine-tune your plan and put the plan into action.
chapter 2

Understanding Clinical Alarm Hazards—A Conceptual Model
The Life Cycle of an Alarm

Many medical devices incorporate alarms to help caregivers identify and respond to a patient need. But whether an alarm activates, as well as whether caregivers recognize the alarm and take appropriate action to help the patient, will be the result of many individual decisions. Some of these will be made during the patient’s care, such as whether an alarm-equipped device will be used in caring for the patient and what alarm settings will be used. But some will be made well in advance, such as when designing clinical care areas, developing care plans, implementing technology, or establishing alarm notification and response protocols.

Poor decisions in any of these areas can lead to clinical alarm hazards—that is, the failure of staff to be informed of a valid alarm condition in a timely manner or to take appropriate action in response to the alarm. With the Joint Commission establishing clinical alarm safety as a National Patient Safety Goal, healthcare facilities need to take steps now to reduce the risks of an alarm-related adverse event.

In this chapter, we aim to help you understand where in your process alarm hazards can occur and identify the decision points where a change could help reduce the likelihood of an adverse event.

One way to visualize where the decision points reside is to walk through the “life cycle” of an alarm, from the time an alarm condition develops until the condition is resolved. This view of the process highlights the kinds of questions that alarm management teams or committees should be asking, and answering, for each alarm that may sound.

The basics of the life cycle will be similar for different kinds of alarm-equipped devices, within different
THE LIFE CYCLE OF AN ALARM
Identifying Failure Points in Alarm Safety

A patient or device condition exists that crosses a set threshold

The alarm signal should be communicated through the established notification channels

The alarm should indicate a condition that requires a staff response

The alarm is resolved

The caregiver should know how to respond to the alarm and should respond appropriately

Sufficient information should be communicated so that caregivers understand the nature of the alarm

If this doesn’t . . .
Examine whether the information communicated by the alarm (e.g., location, alarm condition, priority) is clear and unambiguous. Consider whether to standardize alarm priority levels and tones across care areas, so that a certain tone signals an alarm of a certain urgency.

If it isn’t . . .
Verify that staff are clear on who has responsibility for responding to an alarm or how quickly a response is expected. Periodically assess staff’s knowledge of the policies, as well as their competence with the equipment in use.

If this doesn’t happen . . .
Ensure that response protocols establish backup coverage (e.g., a buddy nurse), in case the primary nurse is unable to respond. Also consider whether the alarm priority should be escalated if the alarm condition is not resolved within a predefined time.

If not . . .
Examine whether the information communicated by the alarm (e.g., location, alarm condition, priority) is clear and unambiguous. Consider whether to standardize alarm priority levels and tones across care areas, so that a certain tone signals an alarm of a certain urgency.

If it this doesn’t happen . . .
Ensure that response protocols establish backup coverage (e.g., a buddy nurse), in case the primary nurse is unable to respond. Also consider whether the alarm priority should be escalated if the alarm condition is not resolved within a predefined time.

If not . . .
Examine whether the information communicated by the alarm (e.g., location, alarm condition, priority) is clear and unambiguous. Consider whether to standardize alarm priority levels and tones across care areas, so that a certain tone signals an alarm of a certain urgency.

The alarm information should reach a caregiver who is available to respond

If this doesn’t happen . . .
Ensure that response protocols establish backup coverage (e.g., a buddy nurse), in case the primary nurse is unable to respond. Also consider whether the alarm priority should be escalated if the alarm condition is not resolved within a predefined time.

If not . . .
Examine whether the information communicated by the alarm (e.g., location, alarm condition, priority) is clear and unambiguous. Consider whether to standardize alarm priority levels and tones across care areas, so that a certain tone signals an alarm of a certain urgency.

If it this doesn’t happen . . .
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Ensure that response protocols establish backup coverage (e.g., a buddy nurse), in case the primary nurse is unable to respond. Also consider whether the alarm priority should be escalated if the alarm condition is not resolved within a predefined time.

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care units, and for different parameters that are to be monitored. (A diagram of these basics can be found on page 25.) However, the specifics associated with each life-cycle stage can vary for each of those alternatives. Thus, the alarm process must be analyzed individually for each care area, and sometimes on a device-by-device or even an alarm-by-alarm basis.

With a solid understanding of the alarm process, the various stakeholders within a healthcare facility will be better positioned to identify areas of concern and implement appropriate measures to reduce the hazards.

So, starting at the beginning . . .

SCOPE OF THIS DISCUSSION

The noise associated with audible alarms is perhaps the most readily identifiable indicator that a particular care area could benefit from improved alarm management strategies. Thus, we often focus on audible alarms in our discussion. However, the cumulative effect of all alarms—both audible and visual—should be considered when addressing hazards such as alarm fatigue.

In addition, much of our discussion focuses on alarms associated with physiologic monitoring systems. These systems can generate both a large number and a complex variety of alarms; thus, they will require particular attention in an alarm management program. However, alarm hazards aren’t limited to physiologic monitoring systems. Ventilators, infusion pumps, and a host of other alarm-equipped medical devices must also be considered in an alarm management program. Many of the principles we discuss within the context of physiologic monitoring systems can likewise be applied to clinical alarms from other devices.
When set up correctly and functioning properly, a medical device will activate an alarm when it identifies a relevant change in the patient’s status or in the status of the equipment being used in the patient’s care—for example:

- An alarm will activate if a set threshold is crossed, such as when a physiologic monitor identifies that the patient’s heart rate has dropped below a predetermined level.

- An alarm will activate if a particular condition exists, such as a ventilator breathing circuit becoming disconnected or a bed-exit monitor identifying that the patient has gotten out of bed.

The first point to consider, then, is whether the alarm occurs at all. That is, does a condition that should trigger an alarm actually do so? Patients can be at considerable risk if caregivers aren’t alerted to changes that warrant attention. If an alarm fails to sound, the fault could lie with how the device is set up or is being used. For example, users may fail to properly connect the patient to the device or the patient may become disconnected, users may fail to activate the device’s alarm capability (i.e., may not turn the alarms on), or the device’s alarm limits may not be set to clinically relevant values. (For the purposes of this discussion, we assume that the medical device itself is functioning properly.)

Another factor to consider is whether a particular condition does, in fact, warrant initiating an alarm. That is, is the alarm even necessary? With some technologies, healthcare facilities can specify which conditions generate alarms. Thus, they have some control over how many alarms staff will encounter. We refer to this number of alarms as the alarm load.

As we discuss in the next section, alarms that sound for avoidable reasons or for clinically insignificant conditions also can adversely affect patient care.
Alarm Load

Does the alarm indicate a condition that requires a staff response?

One key factor contributing to alarm hazards is, quite simply, the number of alarms—and more specifically, the number of unnecessary or avoidable alarms. Excessive numbers of alarms that aren’t associated with a true and clinically relevant change in the patient’s condition (or with a circumstance that could affect the patient) can contribute to alarm fatigue and can prompt users to take unsafe actions (e.g., turning the alarm volume to inaudible levels, disconnecting speakers).

In many care areas in many facilities, the number of alarms is overwhelming. The alarm management team at The Johns Hopkins Hospital in Baltimore, Maryland, for example, recorded an average of 771 alarms per bed per day in one of its ICUs before implementing alarm improvement strategies.* Furthermore, the team found that many of the alarms that sounded in its clinical care areas did not signify conditions that required a staff response, or they signaled conditions that could have been avoided. As other research has shown, such findings are not unique; several published studies indicate that 80% or more of the alarms observed in those studies were not clinically significant.**

Minimizing the number of unnecessary or avoidable alarms will be a significant component of any alarm safety initiative. Doing so not only will lighten the nursing staff’s load, but may also help bring to the forefront the alarms that are clinically significant, increasing the likelihood that those alarms will be addressed in a timely manner.

In addition, reducing the alarm load can help pave the way for the introduction of new technologies—such as alarm integration systems—that can further improve the alarm management process. Alarm integration systems incorporate hardware and software (“middleware”) to, for example, coordinate the alarms from multiple devices and support ancillary alarm notification, with the goal of improving overall alarm management. However, applying such technologies without correcting the underlying flaws in the process—such as reducing the number of unnecessary or avoidable alarms—will invariably lead to disappointing results. “Throwing technology” at the alarm problem is not sufficient; you need to fix the process first.

Finally, reducing the number of audible alarms will result in a quieter care area. This can help patients get the rest they require, and it can help reduce anxiety among family members, who may hear an insignificant alarm, worry about the cause, and wonder if somebody should be responding. The result is an overall improved patient experience, which may contribute to higher patient satisfaction scores. Data collected during ECRI Institute’s August 14, 2013, alarm safety web conference illustrates this point: 53% of respondents (n = 359) said that alarm issues have impacted their facility’s patient satisfaction scores.***

A few strategies to consider for reducing the alarm load are presented in the Workbook that accompanies this guide.

* Source: 2012 Health Devices Achievement Award application submitted by The Johns Hopkins Hospital to ECRI Institute.
Alarm Notification

Is the alarm signal communicated through the established notification channels?

In straightforward cases, caregivers will be informed of an alarm condition directly by the alarming device. But other alarm notification models are often required. For example, physiologic monitor alarms for many patients may be communicated through a central station monitor display located at the nurses’ station. Alternatively, monitor watchers stationed in a centralized location (“war room”) may be responsible for observing alarms from several care areas and contacting caregivers when an alarm requires their attention. Or caregivers may be notified of alarms through a software solution that interfaces with the alarming device and transmits alarm information to a pager, wireless phone, or other communications device.

Regardless of the notification model employed, the alarm management team will need to examine whether each type of alarm is reliably communicated from the alarming device through the appropriate notification channels, and whether caregivers reliably receive those alarm notifications.

Factors that could prevent the alarm signal from reaching the caregiver include:

▷ An inadequate notification process—for example:
  - Do staff know who is responsible for responding to alarms for each patient?
  - Have appropriate communication channels been established so that caregivers can be located and notified when an alarm requires their attention?

▷ Failure to use technologies correctly—for example:
  - Is the alarm volume set to an inaudible level at the central station?
  - Could staff forget to connect a medical device to a communications technology, as in the case of a bed-exit alarm that is intended to communicate alarms through the nurse call system?

▷ Limitations of the technologies used—for example:
  - Is the network sufficiently reliable and monitored for traffic and latency issues?
  - Does the device allow priority levels to be adjusted to meet the needs of individual patients, where appropriate?
  - Can depletion of batteries in mobile devices (e.g., telemetry units, pagers) disrupt monitoring or prevent alarm notification?

▷ Environmental factors—for example, do long corridors, blind corners, closed doorways, or noise from visitors prevent staff from either hearing alarms or observing visual displays?

In addition to examining whether an alarm reaches its intended destination, the alarm management team will need to consider what information is communicated by the alarm. We discuss the importance of alarm content in the next section.
Alarm Content

Is sufficient information communicated so that caregivers understand the nature of the alarm?

It’s not enough for an alarm system to simply signal that an alarm condition exists. For clinical staff to respond appropriately, they will need to know what condition triggered the alarm, how urgent it is, and where to go to provide the needed assistance. An ideal alarm will be clear and unambiguous. It will also be noticeable—without being shrill or irritating, which could disrupt communication or prompt unsafe actions*—and it will allow staff to instantly identify the patient affected, the nature of the alarm (e.g., the alarming device and parameter), and the priority of the condition.

Often, audible tones are accompanied by some form of visual indication that provides additional information about the alarm. The visual indicator may, for example, be a dome light over a patient’s doorway, it may be a highlighted parameter numeric or other indicator on a central station monitor or ancillary monitor display, or it may be a message delivered to a pager or phone.

For some devices or systems, the alarm tones and visual indicators can be customized. In such cases, organizations may want to consider standardizing the tones and indicators that are used throughout the facility (or in similar care areas) as a means to help staff quickly identify the nature or urgency of an alarm. Also, the team should consider whether the tones or indicators used for critical medical device alarms could be confused with those from other devices or systems that are used in the area.

One circumstance that can be fraught with complications is when the alarms from a source device are to be communicated through another system, such as using a physiologic monitoring system to send ventilator alarms from the bedside to the central station or using an ancillary notification system to convey bedside monitor alarms to a pager or other portable device carried by the caregiver. The transfer of information between systems is not always a straightforward, one-to-one process—the information that is available on the source device may not be available in the same manner on the receiving device. Questions to address include:

- Is alarm information accurately communicated?
  As we described in the May 2012 issue of Health Devices, when ventilator alarms are communicated through a physiologic monitoring system, important information from the alarming device may not be communicated through the monitoring system.**

- Could ancillary alarm notification systems or associated middleware cause alarms to be dropped if too many activate at once?

- Has validation testing been performed to ensure that all relevant information consistently reaches the end user?

Regardless of the quality of the information, however, an alarm won’t be effective if it does not reach a caregiver who is able to respond. In the next section, we discuss the need for clear response protocols and the importance of establishing backup coverage.

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Alarm Escalation/Backup

Does the information reach a caregiver who is available to respond?

Each care area needs to define response protocols that describe who is responsible for responding to the various alarms that may sound for the patients in that area.

In specific circumstances, it may be appropriate for all nurses to share the responsibility to respond to an alarm. (For example, in a small care area, all available nurses may be expected to respond to a crisis alarm.) However, in most circumstances, this sort of diffuse responsibility could unnecessarily increase the alarm load, since more nurses are exposed to alarms than would be needed to respond to them. It also can lead to delayed responses, if all nurses assume that someone else will respond.

Alternatively, a patient’s primary nurse may be responsible for responding to any alarms for that patient. This method clarifies the communication channel, but it alone isn’t always sufficient. If the patient’s primary nurse is involved with another patient or otherwise unavailable, an alarm could go unheeded. This can be of particular concern in care areas where alarm-equipped devices are often in use and nurses are responsible for more than one or two patients.

Thus, there needs to be a means of providing backup coverage—for example, a system under which an alarm that is not addressed within a predefined period will escalate to other caregivers. Such a protocol might involve forwarding an alarm to a buddy nurse who is paired with the primary nurse, or to a nurse manager, or to all other nurses on the unit, depending on how the care area is set up and the nature of the alarm. Also, the care area may employ a system in which the priority of an alarm escalates if the alarm condition is not resolved within a predefined time.

For the purposes of assessing alarm response, the alarm management team should not expect all areas to conform to a single approach; different protocols will be appropriate for different care areas. However, prompt and reliable responses should be the universal goal.

Furthermore, it’s crucial that team members not only familiarize themselves with the defined response protocols in each care area, but also that they observe how the process works in actual practice. What’s written in the manual may not accurately describe what happens in the care area. As discussed in the next section, such discrepancies should be identified and resolved so that all parties understand what’s required to deliver high-quality patient care.
Policies/Staff Education

Do caregivers know how to respond to the alarm, and do they respond appropriately?

Staff need to understand the facility’s alarm policies, they need to be educated about the correct procedures, and they need to be trained in the proper use of alarm-equipped medical devices and communications equipment. To ensure consistent performance over time, staff competence in these areas should be assessed periodically.

Questions for the alarm management team to consider include:

▶ Are the policies for each care area complete? For example:
  — Do the policies offer guidance for setting alarms?
  — Do they define the response protocol, providing for both primary and backup coverage?
  — Do they detail whether and when it’s appropriate for alarms to be disabled or silenced?
  — Do they address transport considerations, describing the process for suspending monitoring when a patient leaves the unit and reinitiating it when the patient returns?

▶ Are policies current, and do they align with the clinical reality? For example, do they reflect the technologies and care models currently in use in that area? Do they describe the actual practices, or might they send conflicting messages (by describing a process that is not used in practice)?

▶ Are staff familiar with the policies, and do they follow them? Do they understand the notification channels? Do they know who is responsible for responding to alarms and how quickly a response is expected? And do they demonstrate this in practice?

▶ Are nurses, physicians, and any related staff (e.g., monitor technicians) trained in the proper use of alarm-equipped medical devices and communications equipment (e.g., pagers, wireless phones, remote displays) that are used in the care area? Circumstances to consider include:

— When personnel are new to the care area or when new equipment is introduced. Users can benefit from being able to interact with unfamiliar equipment, such as a physiologic monitoring system, in a simulated setting to become proficient at using the various functions (admit, discharge, history review, etc.).

— When the use of existing equipment is extended to new areas. If cardiac telemetry monitoring, for example, is extended to a care area where it hadn’t previously been used, the staff on that unit will need to be trained on the use of the monitoring equipment.

will be the result
Alarm Resolution

Is the alarm routinely resolved in a timely fashion?

If all the preceding steps in the process are completed appropriately, the alarm condition will be addressed effectively and efficiently, minimizing the risk of patient harm.

Whether an alarm activates, as well as whether caregivers recognize the alarm and take appropriate action to help the patient, is of many individual decisions . . .
Creating an Action Plan
Reducing clinical alarm hazards through better alarm management is a complex and lengthy process. To navigate this critical patient safety issue—and thus to comply with the Joint Commission’s National Patient Safety Goal on alarm management—ECRI Institute recommends the plan outlined in this chapter.

This plan, in conjunction with the resources provided throughout this publication, is intended to serve as a model from which hospitals can create their own alarm management programs. Because the “most important alarm signals to manage,” to use the Joint Commission’s phrase, will vary from one hospital to the next—and thus the efforts required to effectively manage those signals will vary—this plan (or any other) will need to be adapted to address local factors.

The approach we recommend, while not the only valid path, is based on

- Completed projects in which we’ve helped healthcare facilities improve their management of clinical alarms. (See page 51 for more information.)
- Our research into the initiatives implemented at other healthcare facilities.
- Our more than 40-year history evaluating the performance and safety of alarm-equipped medical technologies.

Following is our step-by-step guide for improving clinical alarm management and reducing alarm hazards. A collection of tools to help you complete specific steps is provided in Chapters 4 and 5 and in the accompanying Workbook.
THE PATH TOWARD REDUCING CLINICAL ALARM HAZARDS

1. Leadership demonstrates a readiness to tackle the problem

2. A multidisciplinary alarm safety/management team is formed

3. The team prioritizes the care areas, devices, and alarms to be addressed and identifies ways to track progress

4. The team conducts an alarm audit to assess the risks specific to each care area

5. The team works with frontline staff to identify and implement the most appropriate strategies for each care area

6. The team assesses the effects of the improvement strategies and determines whether refinements are needed
1. Set the Tone

Leadership demonstrates a readiness to tackle the problem

Because of the time involved and the complexity of the issue, an alarm management program must be supported from the top of the organization. In fact, the first Element of Performance specified in the Joint Commission’s National Patient Safety Goal on alarm safety is that leaders must establish alarm system safety as an organizational priority.

To set the proper tone, leaders must recognize that the technology and processes used at the frontlines of patient care are not the only considerations. ECRI Institute has found that the culture of the organization can be just as important to the success of an alarm management program.

When assessing the culture at your organization, consider questions like the following:

- Are staff comfortable talking about safety problems, or are they reluctant to report adverse incidents or near misses? Fear of reprisals, for example, may dissuade staff from reporting safety problems.

- Are staff across multiple departments willing and able to work together, or do real or perceived barriers prevent multidisciplinary cooperation? Stakeholders from throughout the organization must be willing and able to work together to effect meaningful change.

- Are individuals at all levels of the organization open to new ways of managing alarms? Alarm improvement efforts can require philosophical shifts in terms of how technologies are implemented, which patients are monitored, what alarm settings are used, which conditions will activate an audible alarm, and how alarms are communicated to staff.

Many healthcare facilities find it helpful to contract with an independent organization to assess the culture and to bring together stakeholders from various departments to develop a coordinated, institution-wide strategy for improving the management of clinical alarms. Consulting organizations with experience in this area can direct you toward strategies that have been proven effective at other facilities.*

* ECRI Institute is one of several organizations that offers this kind of customized, on-site assistance. Our Applied Solutions Group has worked with world-renowned healthcare facilities and health systems to identify and address clinical alarm hazards. See page 51 for contact information.
TOOLS IN THE WORKBOOK

Sample Announcement from Leadership (Workbook, part A). This sample letter can serve as a guide to assist hospital leadership in announcing the alarm management effort and in communicating its importance to staff.

KEY POINTS

Leadership sets the tone:

- Establishes alarm safety as an organizational priority
- Creates a culture in which staff are comfortable talking about safety problems
- Fosters collaboration among departments (bridges silos)
- Advocates for new approaches that reflect best practices.

...are facilities find it helpful... to develop a coordinated, institution-wide strategy for improving the management of clinical alarms.
2. Form a Multidisciplinary Team

The organization establishes a multidisciplinary alarm management team

With the support of leadership, a team should be formed consisting of individuals across many disciplines whose work touches on the management of alarms. That team will then coordinate the facility’s efforts. Participation from nursing and clinical engineering will be essential, with other important roles to be played by key medical personnel and representatives from patient safety/risk management and IT.

The team should be supported by one or more champions from the administration, or by others with authority, who can help mobilize the resources needed to move the program forward. In addition, local unit champions (e.g., nurse managers, physicians) will be needed to ensure that improvement efforts proceed according to the plan that the team develops.

The key point here: Lasting improvements cannot be achieved by departments acting in isolation. A coordinated, multidisciplinary effort will be required.

Following is a suggested roster for the team:

- **Team leader(s).** The team should be led by one or two senior-level employees with ultimate responsibility for coordinating the efforts of the clinical alarm management team. Leaders should have strong delegation and project management skills. A nursing or medical background may be helpful, although a clinical engineer—who, by the nature of the job, is likely to have extensive knowledge of clinical alarm systems—may also be a strong candidate.

- **Executive sponsor.** Although this individual may not participate in the routine duties of the team, the executive sponsor helps recruit the resources required by the team to perform its tasks. Potential candidates could include the Medical Director or the Nursing Director.

- **Nursing staff.** The team is likely to require multiple representatives from nursing to provide perspective related to current nursing practice and policies, standards, staffing, workflows, and patient care. Candidates may include frontline staff nurses, nurse managers, and clinical nurse specialists. Strongly consider having at least one member with extensive experience working in alarm-intensive care areas, such as a step-down unit. Note that at various times during the team’s work, it will likely be useful to invite caregivers from specific care areas to participate in the team’s activities. While not permanent members of the team, these caregivers can be called upon when needed to share detailed knowledge about how alarms are managed in their care area and to serve as local unit champions, promoting the team within their care area and helping reduce resistance to its efforts.

- **Clinical engineer.** Even if not chosen as a team leader, a member of the clinical engineering staff should be included from the outset to provide the team with expertise on alarm systems and the medical devices that use alarms. This individual will also play a central role in tasks that are associated with the 2016 elements of NPSG.06.01.01 (and, more broadly, in any effective alarm management program), such as the creation of a clinical alarm inventory and the collection of alarm data, particularly when that involves compiling and analyzing alarm histories from medical devices.
Medical staff. Consider including one or more members of the medical staff on the team to provide expert input on the clinical importance of alarm signals, the risks imposed by improper management, and the feasibility and efficacy of possible changes proposed by the team. Alternatively, different members of the medical staff can be consulted on an as-needed basis—for example, when the team is working on alarms within their area of expertise—or can be recruited at the appropriate time to serve as local unit champions to help facilitate the work of the team within a particular care area.

Risk management/patient safety/quality improvement staff. These individuals provide experience in conducting safety/risk assessments and improvement programs. Involvement of risk management may be helpful to ensure that information (e.g., from incident reports or staff surveys) is used in a manner that complies with requirements related to confidentiality, privacy, and liability.

Information technology staff. Many efforts of the alarm management team will require the expertise of an IT professional. Examples include assisting in (or, at minimum, assessing the feasibility of) data collection from alarm systems, providing in-depth knowledge of health IT networks (upon which medical devices are becoming increasingly reliant), and contributing to solutions that have an IT component.

Other staff. Once the team identifies the most important alarm signals, it may become obvious that involvement of other clinical or support staff is necessary. For instance, efforts involving ventilator alarms will require significant input from the respiratory care department. The team leader(s) can decide at that time whether such staff should become permanent members of the alarm management team or if it is sufficient to seek their input on an as-needed basis.
TOOLS IN THE WORKBOOK

**Alarm Management Team Roster** (Workbook, part B). This document outlines the structure for a multidisciplinary alarm management team.

KEY POINTS

- Support from the executive level is essential, as is nursing and clinical engineering participation.

- Team members might include:
  - Administrative sponsor (e.g., VP Quality)
  - Key medical staff
  - Nurse managers
  - Frontline nurses
  - Monitor technicians
  - Patient safety/risk manager
  - Clinical engineering staff
  - IT staff

- Champions will need to be recruited to muster resources and to gain cooperation within care areas.
3. Establish Priorities
The team prioritizes the care areas, devices, and alarms to be addressed and identifies measures for tracking progress

The Joint Commission’s National Patient Safety Goal specifies that, during 2014, healthcare facilities must “identify the most important alarm signals to manage.” To make the most efficient use of limited resources, the alarm management team will want to prioritize its efforts. A facility may decide to start by targeting one or more care areas where alarm hazards are deemed to be significant (e.g., a med/surg unit). Alternatively, it may decide to focus on specific types of devices (e.g., telemetry monitors) or even specific alarm conditions (e.g., ECG leads-off alarms). Or it may conclude that some other approach would allow it to achieve the most significant gains. Ultimately, the determination will depend on local factors—that is, the best approach for one facility may not be the best for another.

To identify the care areas and alarms that require attention, we recommend the following:

▷ Observe each care area.
  - Is the unit quiet or noisy?
  - Do alarms for particular patients sound frequently? Occasionally? Infrequently?
  - Are alarms resolved promptly, or are they allowed to reset automatically, sounding again and again?
  - Do you notice any obstacles that could prevent staff from receiving alarms or that could hinder their ability to respond in a timely manner?

▷ Ask your staff.
  - Do nurses feel overwhelmed by the number of alarms?
  - Have they observed hazardous behaviors—such as staff members turning the alarm volume down or turning the alarm off—or do they feel patients are sometimes put at risk?
  - Do staff question the clinical value of certain alarms?
  - Do they perceive any obstacles that could prevent effective alarm communication or response?

▷ Look at your problem reports.
  - Where are the reports coming from?
  - What devices or alarm signals are involved?

Reports of alarm-related adverse events and near misses in a particular care area or with specific technologies may illustrate that improvements in alarm management are needed.

Interestingly, the places with the most alarms are not necessarily the places with the most alarm problems. For example, an ICU has many alarm-equipped devices. However, such units have a higher nurse-to-patient ratio than many other care areas (one nurse for every one or two patients), and the nurses in these units typically are highly trained, are very familiar with the technologies that are used, and are stationed near the patients to whom they are assigned. Thus, an alarm may be less likely to be missed. Greater risks may exist in a unit that
is more physically spread out and in which each nurse needs to care for a greater number of patients—cardiac telemetry units, for example.

Within a care area, certain alarm-equipped devices may pose greater challenges than others. Physiologic monitors, for example, will account for a larger number of alarms in many care areas than other devices, and significant harm to the patient is possible if an alarm is missed. Thus, these devices will likely warrant particular attention in an alarm management improvement program.

In addition, reducing clinically insignificant alarms from physiologic monitors can have residual benefits for other alarm-equipped devices and systems. For example, a team from Boston Medical Center reported that once significant reductions in the number of physiologic monitor alarms had been achieved, staff also began observing that fewer nurse call alarms were sounding. The team speculated that the reduction in alarms from the physiologic monitors allowed staff to spend more time with their patients, thus preventing the need for a call in the first place, and also allowing them to hear and respond to nurse call alarms when they were first activated, resulting in fewer repeat activations of the alarms.*

When assessing other types of alarm-equipped devices, consider the likelihood and extent of possible harm to the patient if an alarm doesn’t reach staff or if staff don’t respond in a timely manner. Ventilators, for example, may warrant high-priority status since severe patient harm is possible if an alarm is missed. Similarly, infusion pumps that are delivering high-alert medications can involve significant risk. Again, observe the devices in operation, ask your staff, and look at your problem reporting data to identify the technologies that pose the greatest risk. For example, if reports show that patient falls have been a concern within a particular care unit, consider whether your bed-exit monitors are reliably notifying staff and whether staff are responding appropriately to the alarms from those systems.

Another role for the team will be to identify (or create) appropriate tools and quality measures that can be used both to assess the facility’s current situation and to measure the progress of alarm improvement initiatives in a comprehensive and consistent manner.

TOOLS IN THE WORKBOOK

Care Area Assessment Checklist (Workbook, part C). This sample checklist suggests issues for members of the alarm management team to consider when assessing individual care areas for factors that can impede effective alarm management.

Nursing Staff Survey (Workbook, part D). Every alarm management effort should involve obtaining feedback directly from frontline caregivers—particularly from nursing staff. This tool is intended to capture information from nursing staff about alarm-related issues for the care area in which they work.

Incident-Report Review Form (Workbook, part E). This document is intended to guide the team through some of the issues to consider when reviewing incident reports and problem reports to assess the degree of risk associated with particular alarm signals.

Alarm Review Tool (Workbook, part F). This tool illustrates the structure of a spreadsheet for storing and analyzing the information that you collect using the tools listed above.

Starter List of Alarm Signals (Workbook, part G). This document lists some of the medical devices and associated alarm signals that will likely warrant attention in an alarm management program. While the list is not comprehensive—and your team ultimately may determine that managing other signals is more important—this list provides a good starting point.

KEY POINTS

- Determine where your greatest vulnerabilities lie by
  - Observing how alarms are handled
  - Asking your staff
  - Looking at problem reports

- When assessing care areas, consider, for example: areas where the number of alarms could lead to alarm fatigue, areas where critical alarms could go unnoticed

- When assessing devices and alarms, consider, for example: devices that sound frequent false or nuisance alarms, alarm conditions that activate frequently, alarms that sound for conditions that do not require an immediate response

- Identify appropriate tools and quality measures to assess your current situation and to measure progress in a comprehensive and consistent manner
4. Conduct an Alarm Audit

The team conducts an alarm audit to assess the risks specific to each care area

To identify vulnerabilities or failures that could lead to patient harm, members of an alarm management team will need to inventory and analyze the devices that incorporate clinical alarms and all the conditions for which an alarm might activate. Because the circumstances will vary in different care areas, separate analyses will be required for each.

This process can be greatly facilitated if alarm data can be exported from a medical device (e.g., from the alarm log) for analysis. For example, alarm data may reveal a large number of alarms for a clinically insignificant condition that frequently resolves on its own, without any intervention from staff. In such cases, to reduce unnecessary alarms your medical personnel may recommend instituting a brief delay before transmitting an alarm for that condition to staff; if the condition does not resolve itself within the defined period, an alarm would then sound. Or, if alarm data reveals a pattern of minor alarm limit transgressions that do not require a staff response, your medical personnel may determine that the alarm limits should be adjusted to more clinically significant values. Such approaches can help reduce the number of alarms that don’t require a staff response, while still protecting the patient.

Organizing and analyzing alarm data can be quite time-consuming, however, and may not be feasible with all alarm-equipped devices. Fortunately, useful information about alarms can also be collected through less technological means. In some cases, it may be possible to manually collect smaller “snapshots” of data. Also, observing and documenting how alarms are handled in a care area—perhaps using a checklist or some other tool to guide the process—can be effective, as can reviewing reports of adverse events and near misses.

A thorough audit would address all aspects of how alarms are initiated, how they are communicated, and how staff respond, considering factors such as the following (as outlined in Chapter 2):

- Alarm activation—investigating whether alarms reliably activate when a valid alarm condition exists.
- Alarm load—ascertaining the number of alarms to which caregivers are exposed. As part of your alarm audit, obtain a measure of how many alarms are activating. Knowing how many alarms occur per bed or per patient over the course of an hour, or a shift, or a day will help you identify potential problem areas. This figure also provides a metric that can later be used to gauge the effectiveness of any improvement strategies that are implemented. Alarms that activate for conditions that do not require staff action should receive particular scrutiny.
- Alarm notification—identifying whether alarms are reliably communicated from the medical device to staff.
- Alarm content—reviewing the information that is passed to the caregiver along with the alarm signal.
- Alarm escalation/backup—examining whether other caregivers are notified if an alarm is not addressed within a reasonable time.
- Policies/staff education—scrutinizing the documentation of practices and assessing staff’s knowledge of and ability to execute alarm policies.
- Alarm resolution—determining whether alarms are successfully resolved, as opposed to being missed or being allowed to continually reset, for example. Consider measuring the time it takes for alarms of various priority levels to be resolved; this information can help you identify problem areas and can provide a measure against which improvement efforts can be judged.
TOOLS IN THE WORKBOOK

Information collected by using the tools associated with Step 3 will provide useful context for your alarm audit. For example, the Nursing Staff Survey (Workbook, part D) is designed to capture information from frontline nurses about safety vulnerabilities associated with specific alarm signals in their care area.

KEY POINTS

- For care areas identified to be at risk for alarm hazards, conduct an alarm audit analyzing the full life cycle of the alarms for each monitored condition or parameter from each type of device within the care area.

- As detailed in Chapter 2, this includes examining:
  - Alarm activation
  - Alarm load
  - Alarm notification
  - Alarm content
  - Alarm escalation/backup
  - Policies/staff education
  - Alarm resolution

- Information can be gathered by:
  - Collecting and analyzing alarm data
  - Observing how alarms are handled and speaking with staff
  - Reviewing events and near misses
5. Identify and Implement Strategies

The team works with frontline staff to identify and implement the most appropriate strategies for each care area

The Joint Commission’s National Patient Safety Goal specifies that organizations have until January 1, 2016, to develop and implement specific policies and procedures to combat identified hazards and to educate their staffs accordingly.

When investigating strategies to address the risks that you’ve identified, recognize that there is no one-size-fits-all, institution-wide solution to addressing alarm hazards. Because the needs of each care area are unique, the team will need to understand the particular risks present in each area and develop strategies that address those risks. “Solutions” that aren’t well matched to the environment or workflow of a care area will likely prove to be ineffective—and worse, they could erode staff confidence in the team’s work. Thus, input from frontline workers will be invaluable in assessing which strategies are practicable and which aren’t.

Ask nurses, physicians, and other stakeholders what they feel are the biggest impediments to controlling alarm events. Use their observations, along with data obtained during your alarm audit and information gleaned from resources describing best practices, to frame discussions about alarm management strategies and to help identify improvements that are suitable for your individual setting.

Improving the management of clinical alarms may ultimately include introducing new technologies, such as integrated monitoring and communication systems. However, technology is not a panacea. Overlaying new technologies on a broken process rarely achieves the desired results. Strategies should focus first on correcting the underlying flaws in the process (e.g., reducing the number of unnecessary or avoidable alarms).

TOOLS IN THE WORKBOOK

Strategies for Reducing the Alarm Load (Workbook, part H). This list describes several strategies that healthcare facilities have used to help reduce the number of alarms that staff encounter.

KEY POINTS

- The needs of each care area are unique—clinical alarm hazards can depend on the care model, the technologies used, the associated alarm notification process, the architectural layout of the unit, etc.
- Thus, improvement strategies that work in one area may not work in another
- Input from frontline workers is key so that the improvement strategy is matched to the needs of, and the workflow in, the clinical environment
6. Assess, Refine, and Repeat

The team assesses the effects of the improvement strategies and determines whether refinements are needed.

After a strategy has been implemented and taken root, the team should reassess the care area to identify whether alarm problems persist and whether additional changes are needed.

Data should again be collected—using the same metrics as in the planning stages—so that changes can be measured. Being able to compare “before” and “after” measurements of the number of alarms of a certain type in a certain care area, or the response time, or whatever metrics are relevant, provides powerful proof of the effectiveness of certain interventions or the need for additional adjustments.

Be aware that effort will be required to sustain any improvements that have been achieved. Continuing education can help in this regard, as can initiatives to promote your successes. Staff may be more likely to revert to previous practices if they don’t recognize the risks associated with those practices or if they aren’t aware of the improvements associated with a new approach. Promoting successes can also help maintain an organization-wide focus on this patient safety issue.

Finally, use the lessons learned from the implementation to improve your process, which will then be repeated in other care areas. While the needs of each newly examined care area may differ, and thus the optimal strategies will vary, the process you’ve developed will lead you to the appropriate solutions.

**KEY POINTS**

- Reassess the care area after changes have been implemented and taken root
- Compare “before” and “after” data to identify whether interventions have been effective or whether additional adjustments or new strategies are needed
- Watch out for backsliding: over time, staff may revert to previous practices; continuing education will likely be necessary
- Promote your successes—doing so can help staff see the value of any new approach and can keep the organization focused on this important patient safety program
- Use lessons learned to improve your program as you apply it to other care areas.
Closing Remarks

Before starting on the journey to improve clinical alarm management, recognize that the path can be a long one, taking years before institution-wide improvements have been made.

In truth, the work of an alarm management team may never end: With technologies and standards of care continually evolving, the path will not have a defined endpoint, a time when all alarm hazards have been eliminated. Rather, the team will be instituting a mindset and a process that continually assesses risks and reduces the likelihood of adverse events.

With this approach, the healthcare facility will be moving purposefully in the direction of continuous improvement, resulting in better patient care.

... there is no one-size-fits-all solution.

The team will need to understand the particular risks present in each care area and develop strategies that address those risks.
It’s time to implement an alarm management safety plan. But don’t be overwhelmed. ECRI Institute’s alarm management safety experts are here to help.

Our on-site consulting team has extensive experience working with world-renowned healthcare facilities and systems to identify their clinical alarm hazards, analyze current practices, and craft proven, practical alarm management strategies.

And, we can help you. Together, we’ll review the four pillars of alarm management safety as they pertain to your hospital:

- **Culture**: What is your organization’s attitude about alarm safety?
- **Infrastructure**: Does the hospital have the optimal layout, care model, and policies?
- **Practices**: What are you doing now and what should you be doing differently?
- **Technology**: Does your technology support your clinical needs?

Start making changes to your hospital’s alarm management safety practices today. To learn more about our customized services, call (610) 825-6000, ext. 5655, e-mail consultants@ecri.org, or visit www.ecri.org/alarmsafety.
chapter 4

Putting the Plan into Action
Using ECRI Institute Tools and Resources

Perhaps the first step in putting your plan into action is to bring all members of the alarm management team—and other key personnel throughout the organization—to the same baseline of understanding about clinical alarm safety. The guidance assembled in this handbook can help with that effort. To help with subsequent steps, ECRI Institute developed the tools and resources described in this chapter and presented in the accompanying Workbook.

**Purpose and use.** Alarm management teams can use these tools and resources as they work to improve clinical alarm safety and thus meet the Joint Commission’s National Patient Safety Goal on Alarm Management (NPSG.06.01.01, hereafter referred to as the goal).

In developing these tools, we focused on the Joint Commission’s 2014 requirements—that is, on the first two Elements of Performance outlined in the goal. Although meeting all requirements of the goal will require effort beyond that discussed here, the intent of these tools is to assist hospitals in tackling the most immediate steps. For many hospitals, deciding how to begin may be a big challenge.

Note that this Handbook is not intended to serve as a comprehensive, cookbook approach to meeting the goal; nor is it intended to represent the only valid path. Rather, ECRI Institute developed this material to serve as a model or starting point from which hospitals can begin to create their own alarm management programs. Hospitals can choose to adopt whichever tools will meet their needs, or they can incorporate individual elements into their own tools. In fact, we encourage hospitals to customize the information presented to develop tools tailored to their facility.

**Tips.** Remember that alarm signals need to be assessed within the context of a specific care area. Staff in different care areas may consider the same alarm signal “important to manage” (as specified in the second Element of Performance) but for very different reasons. Additionally, risk associated with an alarm signal may be amplified in one care area by conditions (e.g., high alarm load) that don’t exist in another.

Also, we have not provided a tool specifically designed to solicit input from medical staff regarding the importance of alarm signals. ECRI Institute does recommend, however, that the alarm management team’s medical representative help identify alarm signals that medical staff consider important. Medical personnel should also be asked to assess the importance of (i.e., assign a rating to) alarm signals identified through the use of the tools provided in the accompanying Workbook (e.g., nursing survey, review of incidents) or from other sources.
Workbook Contents

The tools described below are presented in the Workbook that accompanies this guide. Editable versions of relevant tools can be downloaded along with the electronic version of the guide.

TOOL FOR STEP 1—SETTING THE TONE

A. Sample Announcement from Leadership

The goal’s first Element of Performance requires that “leaders establish alarm system safety as a hospital priority” by July 1, 2014.* We created this sample letter to serve as a guide to assist hospital leadership in announcing the alarm management effort and in communicating its importance to staff.

TOOL FOR STEP 2—FORMING A TEAM

B. Alarm Management Team Roster

One of the first steps in complying with the goal—and, more broadly, in managing clinical alarms—is the creation of a multidisciplinary alarm management team. This document outlines the structure for such a team.

TOOLS FOR STEP 3—ESTABLISHING PRIORITIES

The bulk of the team’s work to meet the Joint Commission’s 2014 requirements will focus on Element of Performance 2, which states:

During 2014, identify the most important alarm signals to manage based on the following:

- Input from the medical staff and clinical departments
- Risk to patients if the alarm signal is not attended to or if it malfunctions
- Whether specific alarm signals are needed or unnecessarily contribute to alarm noise and alarm fatigue
- Potential for patient harm based on internal incident history
- Published best practices and guidelines

Note that to truly understand risk associated with alarm signals, you need information about the care area within which the alarm signal sounds, not just details about the signal itself. Therefore, ECRI Institute recommends that two additional measures, specific to each care area, be taken into account. These are:

- Alarm load, which refers to the total number of all alarm signals that caregivers are exposed to as they work. Alarm loads that are too high can lead to alarm fatigue, which affects the nursing response to—and, therefore, the risk associated with—all alarm signals in the care area.

- Obstacles to effective alarm communication and response. Effective patient care requires that alarm signals be reliably conveyed to the appropriate nursing staff and that staff be able to respond in a timely manner. Factors that inhibit these requirements (e.g., a physical layout that obscures visible alarm signals, inadequate staffing levels)

can amplify the risk associated with each alarm signal within the care area.

To help hospitals assess the above measures—and, by doing so, identify alarm signals and care areas that may warrant the highest priority for improved management—we developed the following tools:

**C. Care Area Assessment Checklist**

This sample checklist suggests issues for members of the alarm management team to consider when assessing individual care areas for factors that can impede effective alarm management.

**D. Nursing Staff Survey**

Every alarm management effort should involve obtaining feedback directly from frontline caregivers—particularly from nursing staff. This tool is intended to capture information from nursing staff about alarm-related issues for the care area in which they work.

**E. Incident-Report Review Form**

As noted in the NPSG, the involvement of an alarm signal in incidents at your facility is a potential measure of importance. This sample form is intended to guide the team through some of the issues to think about during its review of incident reports and problem reports (which are also a potentially valuable source of information) to determine what degree of risk a particular alarm signal may present.

**F. Alarm Review Tool**

To analyze the information that you collect when using any or all of the above tools, it will be helpful to create a repository where this data can be reviewed and manipulated. We developed our Alarm Review Tool as an Excel spreadsheet so that you can record the information you collect and then use functions such as filter and sort to facilitate simultaneous review of ratings that your team has assigned to all the unique alarm signals under consideration. The structure for this spreadsheet is illustrated in the Workbook.

**ADDITIONAL TOOLS AND RESOURCES**

The tools provided for Step 3 facilitate collecting information to help you identify where to focus your efforts (i.e., establish priorities). Once you have identified the most important alarm signals to manage, you will begin the work of understanding the vulnerabilities that exist in those care areas, identifying appropriate improvement strategies, and implementing those strategies. The Joint Commission requires that this work be completed by January 1, 2016.

The information you collected using the tools above will provide useful context for these steps. The tools can also be used after improvement strategies have been implemented as a way to gauge their effectiveness. For example, the Alarm Review Tool (F) can facilitate a “before” and “after” analysis.

In addition, we have developed two additional resources to help with particular aspects of putting your plan into practice:

**G. Starter List of Alarm Signals**

Sometimes knowing where to start is the hardest part. This document lists some of the medical devices and associated alarm signals that you will likely need to consider when initiating an alarms management program. Note that this list is not comprehensive. Even if your team eventually determines that...
managing other signals is more important, we recommend that you initially spend some time thinking about the items on this list.

H. Strategies for Reducing the Alarm Load

Because reducing the number of clinically insignificant alarms that activate is such a key aspect of alarm management improvement efforts, we present a few strategies that healthcare facilities have used to help reduce the number of alarms that staff encounter.

In addition, the list of Useful Resources and the Case Studies presented in Chapter 5 include a wealth of information to help you fine-tune your plan and put the plan into action.

Perhaps the first step in putting your plan into action is to bring key personnel... the same baseline of understanding about clinical alarm safety.
Identifying Best Practices
The Joint Commission instructs hospitals to consult published best practices and guidelines to help determine the “most important alarm signals to manage.” Unfortunately, there is no widespread consensus about approaches that constitute best practices for alarm management. In fact, within the NPSG itself the Joint Commission notes that “as alarm system management solutions are identified, this NPSG will be updated to reflect best practices.”

In the absence of clear guidance, ECRI Institute recommends that you (1) look for recommendations from trusted organizations and (2) investigate ways to learn from the experiences of your peers. To that end, we offer both a starter list of resources and a collection of case studies that describe successful initiatives that have been implemented at other hospitals.

These are just some of the resources that team members can use to improve their understanding of alarm management issues and to learn about what other hospitals are doing. Additional materials will surely be developed as healthcare organizations and researchers work their way through this complicated issue. Thus, team members should continue to keep an eye out for new materials as they are produced.
Useful Resources

GUIDANCE DOCUMENTS

ECRI Institute

In addition to the material included in the preceding chapters, team members may be interested in the following ECRI Institute resources:

- Physiologic monitoring systems: our judgments on eight systems [evaluation]. *Health Devices* 2013 Oct;42(10):310-40. (Alarm-related issues represented a major portion of our findings.)
- Top 10 health technology hazards for 2014 [guidance article]. *Health Devices* 2013 Nov;42(11):357-9. (*Alarm Hazards* were ranked No. 1 on the 2014 list.)

Other Sources


AAMI Foundation HTSI (Healthcare Technology Safety Institute):


TOOLS AND RESOURCE LISTS

In addition to the tools and resources included in this compilation, collections of valuable resources can be found through sources such as the following:

ECRI Institute

Alarm Safety Resource Site: [www.ecri.org/Forms/Pages/Alarm_Safety_Resource.aspx](www.ecri.org/Forms/Pages/Alarm_Safety_Resource.aspx).

Other Sources

Association for the Advancement of Medical Instrumentation (AAMI):


Resources from the 2011 Medical Device Alarm Summit: www.aami.org/meetings/summits/alarms.html.


WEBINARS

Several organizations have produced webinars to share perspectives on alarm management topics and to describe specific initiatives. We list some useful webinars below, divided into topic discussions or case studies, and ordered from newest to oldest. We list the webinar date and topic, the organizations that presented content during the webinar, and the organization(s) that produced the webinar. (Note that the full list of convening organizations for the HTSI webinar series is included on page 63.)

Alarm management topics

2014 Apr 29—Educating and Training Your Staff: Circling Back to Your Policies and Procedures
— Presenting organizations: Boston Medical Center, Charles George VAMC, The Johns Hopkins Hospital, VA Boston Healthcare System
— Organized by: Convening Organizations for the HTSI Webinar Series
— Available from: www.aami.org/meetings/webinars/HTSI/resources.html

2014 Mar 25—Current Challenges with Ventilator Alarms
— Presenting organizations: American Association for Respiratory Care, Children’s Hospital Los Angeles, Dräger Medical GmbH, The Johns Hopkins Hospital
— Organized by: Convening Organizations for the HTSI Webinar Series
— Available from: www.aami.org/meetings/webinars/HTSI/resources.html

2014 Mar 5—Best Practices for Alarm Management
— Presenting organizations: Kaiser Permanente, Children’s National Medical Center, and The Johns Hopkins Hospital
— Organized by: Convening Organizations for the HTSI Webinar Series
— Available from: www.aami.org/meetings/webinars/HTSI/resources.html

2014 Feb 13—Live Q&A: Alarm Management Implementation Revisited
— Presenting organization: The Johns Hopkins Hospital
— Organized by: American Association of Critical-Care Nurses (AACN)

2014 Jan 28—Use of Middleware in Alarm Management: Ancillary Notification and Obtaining Alarm Data
— Presenting organizations: Coss Associates, ECRI Institute, The Johns Hopkins Hospital, Medical Connectivity Consulting
— Organized by: Convening Organizations for the HTSI Webinar Series
— Available from: www.aami.org/meetings/webinars/HTSI/resources.html

2013 Dec 3—How to Manage Alarms at the Bedside
— Presenting organizations: Children’s Hospital Los Angeles, The University of Pennsylvania Health System
— Organized by: Convening Organizations for the HTSI Webinar Series
— Available from: www.aami.org/meetings/webinars/HTSI/resources.html

2013 Oct 30—How to Identify the Most Important Alarm Signals to Manage
— Presenting organizations: CDRH, Crothall Clinical Equipment Solutions, Kaiser Permanente, Philips Electronics North America
— Organized by: Convening Organizations for the HTSI Webinar Series
— Available from: www.aami.org/meetings/webinars/HTSI/resources.html

2013 Sep 25—The Joint Commission’s National Patient Safety Goal on Alarm Management: How Do We Get Started?
— Presenting organizations: Abbott Northwestern Hospital, ECRI Institute, The Joint Commission
— Organized by: Convening Organizations for the HTSI Webinar Series
— Available from: www.aami.org/meetings/webinars/HTSI/resources.html
Convening Organizations for the HTSI Webinar Series

The HTSI Webinar Series on Alarm Systems Management Resources was convened by the following organizations:

- AACN—American Association of Critical-Care Nurses
- AAMI Foundation HTSI—Association for the Advancement of Medical Instrumentation (AAMI) Foundation Healthcare Technology Safety Institute
- ACCE—American College of Clinical Engineering
- AHA—American Hospital Association
- ECRI Institute
- HTF—Healthcare Technology Foundation
- The Joint Commission
- NCPS—VA National Center for Patient Safety
- NPSF—National Patient Safety Foundation

To access recordings of the webinars in this series, the webinar slides, and checklists of key points, see: www.aami.org/meetings/webinars/HTSI/resources.html.
2013 Feb 6—Surveillance Monitoring: Learning from the Dartmouth-Hitchcock Medical Center Experience
— Presenting organization: Dartmouth-Hitchcock Medical Center
— Organized by: AAMI Foundation HTSI, Safety Innovations Webinar Series

2012 Dec 17—Using Data to Drive Alarm System Improvement Efforts by The Johns Hopkins Hospital
— Presenting organization: The Johns Hopkins Hospital
— Organized by: AAMI Foundation HTSI, Safety Innovations Webinar Series

2012 Dec 3—Plan, Do, Check, Act—Using Action Research to Manage Alarm Systems, Signals, and Responses by Beth Israel Deaconess Medical Center
— Presenting organization: Beth Israel Deaconess Medical Center
— Organized by: AAMI Foundation HTSI, Safety Innovations Webinar Series

RESEARCH STUDIES AND OTHER LITERATURE


SUPPLIER ASSISTANCE
Don’t overlook device suppliers as a resource. Instruction manuals will include some information about setting up alarms. In addition, application specialists may be available to help you, for example, configure the system to optimize the management of alarms, obtain (or make sense of) data from the system to help you analyze your alarm load, or conduct in-service training to improve staff competency with the equipment.
Case Study  
Boston Medical Center

Three times in the last several years, Boston Medical Center (Boston MA) has earned recognition as a finalist for the Health Devices Achievement Award for its various alarm-related improvement initiatives. ECRI Institute’s Health Devices Group issues the award each year to highlight exceptional initiatives that member healthcare organizations have undertaken to improve patient safety, reduce costs, or otherwise facilitate better strategic management of health technology.

In 2010 and 2011, we recognized Boston Medical Center’s efforts to standardize telemetry alarm defaults and to better train nurses on the use of physiologic monitoring systems at the point of care. In 2013, we highlighted the organization’s efforts to improve the overall management of telemetry alarms. We describe these initiatives below.

STANDARDIZATION OF ALARM DEFAULTS FOR TELEMETRY

The initiative described here earned Boston Medical Center (BMC) recognition as a finalist for the 2010 Health Devices Achievement Award.

DISCUSSION - Like most hospitals, BMC has struggled with alarm management. But the facility was spurred to try a new approach by two separate findings. The first was that clinical engineering staff noted wide disparities in alarm limits across different care areas, a problem that was particularly acute with the facility’s telemetry systems. The second was that care areas that used telemetry experienced a large number of low-level alarms, contributing to the noise in these care areas (and presumably to alarm fatigue).

These findings led the hospital administration to investigate the benefits of standardizing alarm limit defaults to reduce nuisance alarms. When the complexity of the undertaking became clear, BMC created a Telemetry Process Committee, which included the chief medical officer, clinical engineering staff, the nursing director, and representatives from a variety of clinical disciplines, including attending physicians, nurse educators, a chief medical resident, and a nurse practitioner.

The committee was asked to perform a holistic review of telemetry capabilities, process improvements, ownership (in terms of responsibility for telemetry-related decisions), policy enforcement, and education, as well as to develop approaches to address any problems that were identified. The committee agreed on several priorities—including review of alarm settings, development of standardized order sets, and education and oversight of clinicians—as well as several long-term strategies (e.g., addressing methods of alarm communication).

Reviewing and standardizing alarm defaults across the 12 areas that use telemetry was a key task of the
Telemetry Process Committee. The primary goal of the standardization process was to reduce the number of nuisance alarms. Complementing this work was the creation of an enhanced telemetry order set in BMC’s computerized provider order-entry system. The new order set helps ensure that patients receiving telemetry really need it.

The committee also created a telemetry training course for nurses, as well as a telemetry orientation program for medical interns. Development of the training materials was made easier by the fact that the facility had already standardized the way telemetry was used hospital-wide. And having clinicians from across the hospital receive the same training reinforced the principles guiding the standardization.

In addition to reducing nuisance alarms, the work of the Telemetry Process Committee helped BMC efficiently add nearly 100 telemetry beds in two months.

**Best practices.** BMC is not alone in its struggle to manage alarms. The pervasiveness of the kinds of problems that the BMC project addressed is evidenced by the numerous Guidance Articles and Hazard Reports on alarm management and alarm fatigue that we’ve published over the years, as well as the constant presence of this topic on our annual Top 10 list of healthcare technology hazards. It’s interesting to note that alarm management was the subject of the winning submission for the first Health Devices Achievement Award, which was issued to William Beaumont Hospital in 2006 for a project that resulted in a 93% improvement in response times to critical alarms (see the December 2006 issue of *Health Devices* for details about that initiative).

Thus, the problems that BMC addressed with its initiative, including different alarm defaults in different areas of the hospital, will be familiar concerns for many hospitals. Facilities faced with such problems can learn not only from BMC’s actions, but also from the process that it followed: BMC formed a multidisciplinary committee, bringing together nurses, physicians, and clinical engineering staff to develop solutions that the groups might not have discovered separately, but that were acceptable to all.
USING A CART-BASED SYSTEM TO PROVIDE PATIENT MONITORING TRAINING AT THE POINT OF CARE

The initiative described here earned Boston Medical Center recognition as a finalist for the 2011 Health Devices Achievement Award.

DISCUSSION - One of the hurdles that BMC encountered when implementing its project to standardize alarm defaults for telemetry (described above) was the lack of an effective way to train staff about the alarm default changes.

BMC’s solution is a self-contained, cart-based patient monitoring training system that is used both to validate alarm policy changes and to train clinicians on these changes. The system was built using existing monitoring hardware and patient simulators, and recreates key elements of managing a patient on telemetry, such as admission/discharge, alarm setting, alarm annunciation, event review, and storage of patient data. Furthermore, the system is designed to facilitate use within a large urban campus—BMC focused on keeping the system’s size and weight down, as well as making it easy and safe to move.

The system was instrumental in a two-day education program at BMC. The education team, including a representative from the monitoring vendor who was onsite to answer any questions, visited each of the care areas. As questions arose, the team was able to use the mobile education system to demonstrate relevant features rather than just answering in the abstract.

The system is also instrumental in orienting staff to upcoming changes in alarm protocols. With the cart, clinicians are able to practice with a functional system in their normal work area, without having to worry about compromising patient care by practicing on—and inadvertently making improper adjustments to—a monitor that is normally used on patients. BMC has found the system to be extremely helpful in educating staff about new alarm defaults, since staff can compare the current defaults to the new ones. BMC also expects the system to become an important part of developing future changes, as it allows those changes to be tested before being put into place.

Jim Piepenbrink, director of BMC’s department of clinical engineering, had one piece of advice for facilities that may be considering a similar project: The design and ergonomic features are essential aspects of such a system. “We had to ensure that the cart could withstand transportation across campus, was not too heavy to move, and that the devices were secured to the cart to prevent issues during transport.” Piepenbrink added, “We had the education staff evaluate the use of the cart so that they could provide feedback on the various features that would make it a useful system.”

Best practices. Other hospitals that have, like BMC, chosen to address alarm fatigue by making device-related changes may find that a mobile system could be a useful way to educate staff about those changes. In BMC’s case, the cart is composed of monitoring hardware, but hospitals could develop such educational systems for other alarming devices such as ventilators or infusion pumps. Stepping back a bit, BMC’s approach could be a model for clinician education in general, not just for alarm-related issues. When a hospital places relevant hardware on a mobile cart and takes that system to the care areas instead of pulling staff out of their work environment, education becomes a part of patient care and not a separate activity, and clinicians learn about new policies in the context in which they will be implemented.
IMPROVING THE MANAGEMENT OF TELEMETRY ALARMS

The initiative described here earned Boston Medical Center (BMC) recognition as a finalist for the 2013 Health Devices Achievement Award.

DISCUSSION - Telemetry care areas struggle with how best to use cardiac monitor alarms to alert staff to important abnormal heart rates and rhythms. No clinician wants to miss a significant cardiac event. However, if monitoring is implemented in a way that yields more false (or clinically insignificant) alarms than true ones, a culture can emerge in which alarms aren’t always addressed in a timely manner. For instance, clinicians may be reluctant to interrupt other patient care activities to address an alarm that likely will prove to be insignificant.

The danger, of course, is that a truly significant alarm will go unheeded. At BMC, a multidisciplinary telemetry task force is in place to investigate ways to minimize such risks by improving the overall management of telemetry alarms. A recent six-week trial spearheaded by the task force led to its recommending significant changes in how the facility managed cardiac telemetry patients and how various technologies were used in a general cardiology medical care area.

The idea for the study emerged from the task force’s years of work studying alarm metrics and clinician workflow. The task force observed that alarms for life-threatening conditions frequently had to compete for staff attention with large numbers of clinically insignificant alarms. Not only did these insignificant alarms potentially impede staff from recognizing and responding to more critical alarms, they also contributed to noise in and around patient rooms. Patient surveys had shown that noise negatively affected the patient’s overall perception of the quality of the hospital experience.

The team designed a study to test the effect that alarm-feature changes would have on clinicians’ response to alarms and on the environment (e.g., noise levels) within a general cardiology medical care area. The task force obtained alarm data, extracted by the clinical engineering department, to help better understand the alarms in that care area, and used that data to develop a list of changes to default settings that would safely decrease the number of total alarms while still ensuring that alarms would activate for events that required immediate attention. These changes would be implemented in the care area being studied for a six-week trial period.

Although getting the data in a usable form for this analysis was a “laborious process,” James Piepenbrink, BMC’s director of clinical engineering, remarked that having the data really helped the task force get a sense of what was going on. What “jumped off the page,” he noted, was the number of warning-level alarms. These are comparatively low-level alarms that often sounded for nonserious changes in heart rate, for example, and didn’t necessarily require an immediate response. Thus, it was determined that the study would target those alarms. A key principle the hospital applied was that all audible alarms became actionable—that is, any time an alarm sounded, immediate action was expected. Consequently, some of the previous “warning” alarms would be converted from an audible tone to a visual message status, while others would be elevated to “crisis” level to prompt an immediate staff response.

Previously, bradycardia, tachycardia, and high/low heart rate alarms had been set to “warning” status and configured to initiate an audible tone with a self-reset.
capability. This meant that an alarm would sound as long as the alarm condition existed, but then would reset on its own when the alarm condition was no longer met. Artifact—which can result, for example, from poor contact between an ECG electrode and the patient’s skin—was a common cause of such alarms, and staff would often allow the alarm to resolve on its own. The result, however, was that the alarms would activate over and over again, since the underlying cause of the alarm condition was not addressed. For this study, patient electrodes were changed every 24 hours to help reduce instances of artifact, and the alarms for these conditions were set to “crisis” instead of “warning” status. This latter change required that staff immediately view and act on the alarm each time it sounded. The required actions would be to respond to the patient’s need if the alarm was clinically significant or, to eliminate future clinically insignificant crisis alarms, take steps such as adjusting the alarm settings to better reflect the baseline heart rate and rhythm for that patient. A change to the alarm settings required a second nurse’s endorsement, and the physician order would later be obtained for the change.

The study also involved slightly widening the default alarm limits for some parameters. For example, for this study a low heart rate of <45 bpm (lowered from 50 bpm) was used for bradycardia, and a high heart rate of >130 bpm (raised from 120 bpm) was used for tachycardia. These limits were selected recognizing that many patients would have known transient changes in heart rate during certain times of day. The new alarm limit values were supported by physicians, who judged that the slightly widened limits would not compromise patient safety.

During the six weeks of the study, the number of audible alarms dropped from nearly 90,000 per week to just under 10,000—a decrease of 89%—with no negative impact on patient safety. This change caused many nurses to remark on the quietness of the unit and to note that they could now spend more time caring for patients. Improvements were also seen in patient satisfaction scores in several metrics.

Significantly, this approach to process control was instituted with no additional technology or capital investment. The success of the pilot study led to the implementation of this approach in the facility’s nine other telemetry care areas.

**Best practices.** With the Joint Commission establishing alarm management as a new National Patient Safety Goal, many healthcare facilities will need to conduct their own studies to determine which clinical alarms pose a significant risk to patient safety and what strategies can be used to reduce the risks of harm. The initiative described here illustrates many points that such facilities will want to consider. Following are a few of the specific observations shared by the team at BMC:

- Institutions can benefit from looking at their actual alarm data over time, as well as how their nursing staff interacts with alarms on a day-to-day basis.

  Much can be learned from visiting a unit and observing what’s happening: How noisy is it? How are nurses responding to various types of alarms? Answers to questions like those can help you target where to focus your attention. Relevant data can then be collected and analyzed to help you craft meaningful solutions, such as identifying appropriate changes to alarm levels and parameter limits (e.g., to reduce warning alarms).

  Having the data can also ease the process of initiating change. Telling frontline caregivers that
they need to do things differently can be a hard conversation to have. But reviewing the data with all stakeholders and including them in the process produces more of a collegial discussion than a confrontational event. As Mr. Piepenbrink observed: “Data is binary. It is not emotional.” Further, he stressed that the process at BMC “was very inclusive,” specifying that “we were clear about what we were doing and why, and we shared the results with users.”

Alarms with self-reset capabilities may lead to an excess number of audible alarms. Nurses informed members of the task force that they were reluctant to be drawn away from other important patient care activities to address alarms that often resulted from artifact or were clinically insignificant. Rather, nurses expected that the alarm would self-reset if the condition resolved itself or, if the alarm persisted, that a nurse who was not occupied with other patient care activities would respond. However, the task force observed that noise from these alarms continuously sounding in the background could affect staff’s ability to hear other, important alarms.

Alarm management can improve not only patient safety, but also patient and staff satisfaction. Although the interventions in the study were not targeted to address patient satisfaction scores, higher scores were nevertheless observed when comparing data from before and after the pilot. Nurses remarked that the reduced alarm load allowed them to spend more time with patients, a factor that may have contributed to the improved patient satisfaction scores. In addition, nurses noted that they “felt less drained at the end of their shift,” suggesting that the changes could also positively influence overall staff satisfaction.

Another key element of success, according to Mr. Piepenbrink, was that the task force placed a lot of stock in training and supporting users. For example, a team of super-users was created so that, when questions arose, a nurse could go to a peer on the floor who had a really good understanding of the system and what the goals of the pilot study were. This provided a comfort level for the staff.
DISCUSSION - The 2012 Health Devices Achievement Award was presented to The Johns Hopkins Hospital for its comprehensive study of alarm fatigue. This patient safety initiative has led to demonstrable improvements in the management of clinical alarms within many of the hospital’s care units, reducing the potential for missed alarms and also reducing the noise levels, thereby providing a quieter working environment for caregivers and a safer, more restful environment for patients.

Medical device alarms clearly perform an essential patient safety function. However, the sheer number of alarms in some care areas can itself become a patient safety concern. For example, when capturing baseline alarm data, Johns Hopkins recorded an average of 317 alarms per bed per day in one of its intensive care units, and 771 alarms per bed per day in another (during analyses conducted over seven days). With so many medical devices sounding alarms and issuing alerts, caregivers can too easily become overwhelmed trying to respond to the alarms, or they can become desensitized, which can lead to missed alarms or delayed response. The problem is so pervasive, and the potential consequences so severe, that we have included alarm hazards at or near the top of our annual list of the Top 10 Health Technology Hazards every year since the list’s inception.

To address problems associated with alarm fatigue, The Johns Hopkins Hospital formed a multidisciplinary Alarm Management Committee co-chaired by Maria Cvach, assistant director of nursing; Andrew Currie, director of clinical engineering; and Dr. Adam Sapirstein, a faculty member in Johns Hopkins’s Armstrong Institute for Patient Safety and Quality. The committee studied the type, frequency, and duration of alarms that occur within particular care units and then used this information to develop and apply changes that would positively affect patient care. A key target of the initiative was to reduce the number of nonactionable audible alarms—
alarms that sound for events that do not require staff to intervene. Reducing the number of nonactionable alarms not only reduces the overall alarm load, but also increases the percentage of actionable alarms; thus, nurses are more likely to respond promptly and correctly to the alarms that do sound.

The work of the committee included the following:

- Developing a fault tree analysis to identify all possible failure modes associated with a missed alarm. Analyzing the failure modes created an understanding of the complexity of the alarm management function and the need for redundancy (e.g., secondary notification methods) to prevent a failure.

- Collecting and analyzing baseline data with respect to the number and types of alarms occurring in each monitored care unit, and using this data to inform committee decisions on alarm-reduction strategies. This was no trivial task, as Maria Cvach notes: “It took two years to figure out how to get the data and, more importantly, to understand what it was telling us.” One key strategy for minimizing recurring alarms that desensitize or distract clinicians involved making modest changes to alarm default settings. Working on a unit-by-unit basis, the committee identified safe default setting changes that could help reduce the number of nuisance alarms and other clinically insignificant alarms.

  Additionally, software was purchased that allows the facility to build alarm-escalation algorithms specifying how and when an alarm should be communicated. For a noncrisis alarm condition, for example, a delay could be instituted so that caregivers are notified only if the alarm persists for a specified period of time (e.g., one minute); thus, conditions that quickly self-correct would not send an alert to the care provider.

- Developing an alarm policy and, where practical, standardizing equipment and methods. Consistent with the committee’s goal of simplifying the alarm management approach, the hospital standardized monitoring equipment across the facility and implemented a uniform approach to alarm management. The committee even extended its standardization efforts down to the feature level—for example, alarm tones were standardized whenever possible so that similar conditions would sound similar tones in different care units. Thus, nurses and physicians who float among various care areas can more readily identify the meaning of the alarms they hear.

- Supporting the alarm policy through reeducation and competency training. As part of this effort, the committee assessed the educational needs of clinicians with respect to bedside monitoring.

- Analyzing and implementing methods for adjunct alarm notification. Each care unit was required to establish at least one secondary notification method to ensure that alarms are audible and appropriately managed. The committee recommended a handful of solutions that it had investigated and found to be effective; then, it allowed the individual care units to choose the notification systems that made the most sense for them, considering factors such as the unit’s size and workflow. Thus, the system selected could vary from one care unit to the next.

The committee also collected and analyzed monitor-alarm data after interventions were made in order to
confirm and quantify improvements. For example, the pilot program for this initiative, which was conducted in a 15-bed medical progressive care unit, yielded “a 43% reduction in critical physiologic monitor alarms from the baseline data collected approximately one year prior” (Graham and Cvach 2010). Success in that care area prompted the facility to expand its initiative, looking at other ways to improve alarm management and extending its efforts to other care areas. According to Ms. Cvach, “The beauty of the Alarm Management Committee is that it engages everybody. Members take the lessons that have been learned in other care units and apply them in their own units.”

Best practices. The Johns Hopkins alarm management initiative demonstrates that the number of nonactionable alarms can be reduced—thereby decreasing caregivers’ alarm burden without compromising patient safety—by making modest default parameter changes, standardizing care policies and equipment, and providing reliable secondary alarm notification. According to Ms. Cvach, “The things we did at Johns Hopkins really could be done at any hospital.” All that was required was some hard work and desire: The organization invested the time to understand the problem, studied and tested various solutions, and then shared knowledge among various staff and departments. The project truly was a collaborative effort, involving contributions from nurses, physicians, clinical engineers, and IT personnel, as well as the cooperation of the hospital’s monitor vendor.

Keys to the success of the program, as noted by Ms. Cvach, included:

- Taking the time to understand how the facility’s monitoring systems worked
- Focusing on adjusting alarms to actionable levels
- Having “a great clinical engineering department”; clinical engineering staff were vital in helping committee members gain a true understanding of the facility’s monitors and the implications of making any change
- Establishing an alarm committee “that allowed us to make decisions based on each other’s experiences”
- Involving the frontline caregivers in decisions, allowing care units to select alternatives “that made sense for their particular workflow”

Also, the committee’s thorough approach to collecting and analyzing data, both before and after interventions, allowed Johns Hopkins to measure the effectiveness of its efforts.

References


Case Studies

AAMI Foundation HTSI Safety Innovation Series

Several case studies on alarm management have been published in the Safety Innovations Series produced by the Healthcare Technology Safety Institute (HTSI), an organization formed by the Association for the Advancement of Medical Instrumentation (AAMI) Foundation. We list these case studies below, along with HTSI’s descriptions of each. The Safety Innovations Series can be accessed online through AAMI’s website at www.aami.org/htsi/safety_innovation.html. Note that several of these initiatives have also been described in webinars (see the list in the Useful Resources section of this chapter).

Beth Israel Deaconess Medical Center

- **Citation.** Plan, do, check, act: using action research to manage alarm systems, signals, and responses—the Beth Israel Deaconess Medical Center [white paper]. Safety Innovation Series. Arlington (VA): AAMI; 2012. Also available: www.aami.org/htsi/SI_Series/Beth_Israel_2013.pdf.

- **HTSI description.** In the aftermath of two sentinel events in inpatient rooms at the Beth Israel Deaconess Medical Center in Boston, MA, the hospital’s leadership and the physician, nursing, and clinical engineering staff focused comprehensively on alarmed medical devices. The healthcare center discovered inconsistent cardiac telemetry alarm system management—notably, proliferation of monitoring had resulted in overwhelmed clinicians who had developed an inflated sense of security in the ability of the monitors.

Children’s National Medical Center


- **HTSI description.** A team of nurses, biomedical engineers, physicians, and biostatisticians was assembled to assess the conditions associated with the generation of cardiopulmonary monitor (CPM) alarms, including false positive alarm signals in critically ill children, and to define alternative alarm parameters that would improve CPM alarm performance.
Christiana Care Health System

**Citation.** Recommendations for alarm signal standardization and more innovation—the Christiana Care Health System experience [white paper]. Safety Innovation Series. Arlington (VA): AAMI; 2012. Also available: www.aami.org/htsi/Sl_Series/Christiana_Care_Alarm_Signal.pdf.

**HTSI description.** Christiana Care developed a system-wide alarm policy and protocols that defined its alarm management strategy for alarmed medical equipment, including flex monitors, standard cardiac monitors, pulse oximeters, and infusion pumps.

Dartmouth-Hitchcock Medical Center


**HTSI description.** A series of adverse events led clinicians and researchers at Dartmouth-Hitchcock Medical Center to a humbling conclusion: Healthcare professionals were handicapped by their limited ability to detect signs of patient deterioration and to predict which patients are at risk for adverse events in the first place. Dartmouth-Hitchcock responded with stopgap measures to safeguard patients, including double checks of opioid administration, smart patient-controlled analgesia (PCA) pumps, and rapid response teams.

The Johns Hopkins Hospital

**Citation.** Using data to drive alarm system improvement efforts—the Johns Hopkins Hospital experience [white paper]. Safety Innovation Series. Arlington (VA): AAMI; 2012. Also available: www.aami.org/htsi/Sl_Series/Johns_Hopkins_White_Paper.pdf.

**HTSI description.** The key to reducing alarm signal noise is the collection and analysis of quantitative data to evaluate alarm system management in hospitals.

Note that this initiative is also described in detail within this chapter; see page 71.

University of Pittsburgh Medical Center

**Citation.** Simple solutions for improving patient safety in cardiac monitoring—eight critical elements to monitor alarm competency: University of Pittsburgh Medical Center (UPMC); Presbyterian Hospital [white paper]. Safety Innovation Series. Arlington (VA): AAMI; 2013. Also available: www.aami.org/htsi/Sl_Series/Alarm_Competency%20White_Paper.pdf.

**HTSI description.** The University of Pittsburgh Medical Center (UPMC) realized that improving the utilization and management of non-life threatening arrhythmia alarm conditions could reduce alarm fatigue and preserve patient safety. UPMC Presbyterian launched pilot projects that would result in: decreasing alarm ring time, improving staff response to cardiac monitor alarm signals, and decreasing alarm noise within hospital units that contain a high volume of monitoring equipment.