Patient safety organizations and health care accreditation agencies recognize the significance of clinical alarm hazards. The Association for the Advancement of Medical Instrumentation, a nonprofit organization focused on development and use of safe and effective medical equipment, identifies alarm management as a major issue for health care organizations. ECRI Institute, a nonprofit organization that researches approaches for improving patient safety and quality of care, identifies alarm hazards as the most significant of the “Top Ten Health Technology Hazards” for 2014. A new Joint Commission National Patient Safety Goal focusing on clinical alarm safety contains new requirements for accredited hospitals to be fully implemented by 2016. Through a fictional unfolding case study, this article reviews selected contributing factors to clinical alarm hazards present in inpatient, high-acuity settings. Understanding these factors improves contributions by nurses to clinical alarm safety practice. (Critical Care Nurse. 2015;35[4]:45-57)
Impact of Alarm Hazards in Health Care

The true impact of alarm hazards in health care is unknown. Although at least 4 major reviews of suspected alarm-related deaths have been completed since 2002, investigators emphasize that the true incidence of alarm-related events and related trends are difficult to determine.4,10-13 Regardless of these difficulties, the hazard is well recognized. As stated by the Institute of Safe Medication Practices,14 “awareness of the problem is not an issue—the absence of meaningful action is.”

Common Perceptions About Alarms

Knowledge deficits and misperceptions about alarms exist among clinicians, hospital leaders, and laypersons.13,15 Mainstream media and patient safety literature contain language with the potential to be misconstrued or oversimplify alarm hazards. Nurses (and other device users) have been described as “overwhelmed,” “complacent,” “negligent,” and “apathetic” providers who “ignore” alarms and “abandon” patients. In addition, alarm fatigue is often identified as the cause of an alarm-related event, without acknowledgment of additional related factors (eg, device design).

Understanding Alarm-Related Events: A Team Effort

Every alarm-related event (and potential alarm-related event) exists within a unique set of interrelated variables, which may include organizational culture, device audibility, user characteristics, and unit layout.16,17 Organizations often fail to consider these and other key contributors to alarm safety.13 This article addresses several selected contributing factors. Table 2 contains additional examples, contributing factors, and associated strategies for improving safety.18-24 Alarm hazards and reviews of alarm-related events, which may occur prospectively or retrospectively, require collaboration between clinicians, including nurses, and nonclinical experts (eg, biomedical engineers).25,26

The case study illustrates several selected contributing factors, and the importance of interdisciplinary teamwork during the event review.

Alarms and Alerts in the Clinical Setting

A 68-year-old patient, admitted after esophageal stricture dilation, is found unconscious and apneic in his bed. He sustains a severe anoxic brain injury and dies after his family withdraws life-sustaining treatment. In a report to the patient safety department, a registered nurse writes, “the monitors did not alarm, which delayed initiation of resuscitation.” As required by TJC, leadership initiates a review of the event from a systems perspective (ie, a root cause analysis [RCA]). Jackie, a nurse from the unit, participates in the RCA. During the first meeting, she talks about the unit: “I’ve worked on this unit for 16 years. Over the past few years, the patients have become sicker, and it’s now a constant bombardment of alarms, beeps, and jingles. It can feel overwhelming, especially when the unit is busy. When I’m trying to get work done, I think sometimes I just block out the noise.”

Jackie’s description of clinical alarms in her unit resonates with most nurses; a walk through a progressive or critical care unit reveals an array of devices with alarms.

SIDEBAR

National Patient Safety Goal 06.01.01 “Improve the safety of clinical alarm systems”

The Joint Commission’s National Patient Safety Goal (NPSG) 06.01.01, “Improve the safety of clinical alarm systems,” contains 2 phases. The first phase, to be implemented by July 2014, requires accredited hospitals to establish alarms as an organizational priority, and to identify the most important alarms through a comprehensive risk assessment. Phase II, to be implemented by January 2016, compels accredited hospitals to implement policies and procedures containing specific elements related to alarm safety (eg, who can set, change, or discontinue monitoring).
Table 1  Glossary of alarm-related terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm</td>
<td>A device that signals a deviation from a predetermined “normal” status.</td>
</tr>
<tr>
<td>Alarm escalation plan</td>
<td>Written guidance that defines (1) which caregivers receive initial alarm notification, (2) who receives secondary (and subsequent) notifications if an alarm is not initially responded to in a specific period of time, and (3) when each notification occurs. For example, 1 publication outlines the following plan: If a critical alarm sounds, the patient’s primary nurse is notified. If the primary nurse does not acknowledge the notification within 20 seconds (eg, by suspending alarm at the point of care), a predesignated back-up nurse is notified. If this follow-up notification is not acknowledged within 60 seconds, the charge nurse is notified.</td>
</tr>
<tr>
<td>Alarm fatigue</td>
<td>A situation wherein people become desensitized to alarms in response to excessive exposure. The constant state of readiness that is generated by persistent alarms and alerts results in the lowering of one’s attention threshold, reducing the urgency of response.</td>
</tr>
<tr>
<td>Alarm inventory</td>
<td>Comprehensive list of the devices in an organization that generate alarms; an accurate alarm inventory is essential for effective alarm management.</td>
</tr>
<tr>
<td>Alarm management</td>
<td>Comprehensive approach to mitigating alarm-related hazards, improving alarm response, and ensuring prompt and effective alarm verification. Integrates organizational and unit culture, data from organizational alarm inventory, policy, procedures, and management strategies.</td>
</tr>
<tr>
<td>Alarm signal</td>
<td>The notification of presence of a monitored condition or deviation from normal status. Clinical alarms traditionally employ acoustic and/or visual signals, but integration of vibrotactile cues (eg, vibration) is increasing.</td>
</tr>
<tr>
<td>Alert</td>
<td>Advisory systems that do not inherently require immediate response or awareness; for example, the single tone emitted at the completion of a secondary infusion is an alert.</td>
</tr>
<tr>
<td>Device alarm</td>
<td>Alarm designed to indicate equipment malfunction or variation from a normal device condition. A variety of medical devices, from life-sustaining equipment to less critical equipment (eg, hand-held thermometers), incorporate device alarms. For example, the “air in line” message that is activated during an intravenous infusion due to the presence of bubbles in the fluid stream is a device alarm. These are also known as technical alarms.</td>
</tr>
<tr>
<td>Direct notification alarm system devices</td>
<td>Devices (eg, pagers) that enable communication of alarm signals to a specific person.</td>
</tr>
<tr>
<td>False alarm</td>
<td>An alarm generated that indicates the presence of a physiological event when no true event has occurred. See false-negative and false-positive alarms.</td>
</tr>
<tr>
<td>False-negative alarm</td>
<td>Absence of an alarm when a valid triggering event is present. A false negative may occur when signal acquisition technology does not detect an arrhythmia; for example, when a patient is asystolic but no alarm sounds. A false-negative alarm may also be referred to as a “true alarm missed” or simply, “a miss.”</td>
</tr>
<tr>
<td>False-positive alarm</td>
<td>A technically incorrect alarm that indicates that a given condition has been fulfilled, when in fact the triggering condition is not present; for example, a ventricular tachycardia alarm activated by the use of an electric toothbrush.</td>
</tr>
<tr>
<td>High sensitivity</td>
<td>Highly sensitive alarm systems are designed to ensure a low incidence of false-negative alarms by detecting signals and generating alarms for events that may be significant, but may also be artifact.</td>
</tr>
<tr>
<td>Low specificity</td>
<td>Specificity refers to the ability of a system to correctly exclude a condition. Low-specificity systems are characterized by higher numbers of false-positive alarms than high-specificity systems.</td>
</tr>
<tr>
<td>Nuisance alarm</td>
<td>Also known as nonactionable alarms, these are technically correct alarms that have no clinical significance; for example, a high-pressure alarm on a ventilator triggered by an isolated cough and requiring no clinical response or corrective action may be a nuisance alarm.</td>
</tr>
<tr>
<td>Physiological alarm</td>
<td>Integrated into systems that monitor individual or aggregate biological parameters, these signals occur when the monitored variable(s) fall outside of a predetermined limit or pattern; for example, a physiological alarm may occur for tachycardia, bradycardia, or upon recognition of asystole.</td>
</tr>
<tr>
<td>Point-of-care alarm system devices</td>
<td>Devices that enable communication of alarm signals at the patient’s bedside.</td>
</tr>
</tbody>
</table>

* These definitions are adapted from multiple sources and are based on the best available evidence. ** Interdisciplinary consensus does not exist for many alarm-related terms.
### Table 2: Examples of alarm-related events, potential contributing factors, and strategies for reducing likelihood of alarm-related events

<table>
<thead>
<tr>
<th>Alarm-related event* (adapted from published reports)</th>
<th>Potential contributing factors (based on factors for similar events)</th>
<th>Strategies for reducing likelihood of alarm-related events</th>
</tr>
</thead>
</table>
| A life-threatening arrhythmia occurs, yet neither an audio nor a visual physiological alarm is activated because the dysrhythmia processing function on the monitoring system has been turned off by a user.† | **Device design**  
User could easily turn off dysrhythmia processing function | Provide quick-glance, user-centric reference guides |
| A patient is admitted with chest pain and shortness of breath. Shortly after admission, the “leads off” alert sounds. When a nurse checks on the patient more than 1 hour later, he is unresponsive.† | **Patient characteristics**  
Diaphoretic and/or hairy patient whose leads continuously detach | Standardize unit practices for electrode and lead inspection and replacement (refer to AACN practice alert referenced in Table 3)  
Establish periodic refreshers on medical devices, including advanced functions  
Validate users’ competencies in a standardized manner |
| Frequent cough triggers a high-pressure alarm. Nurse changes the pressure limit to a very high limit to reduce the number of true-positive nuisance alarms. Occlusion of airway not detected.‡ | **Equipment characteristics**  
Poor quality, inexpensive leads and/or electrodes contribute to frequent detachment of leads | Purchase high-quality leads and electrodes |
| **User characteristics**  
Owing to high number of false alarms and nuisance alarms on the unit, the nurse experiences distress and takes an unsafe action in an attempt to reduce the number of alarm signals | Review unit-level data about false-positive and true-positive but “nuisance” alarms to guide unit-specific interventions for reducing the number of clinically insignificant alarms |
| **Device design**  
Device permits the high-pressure alarm to be set to unsafe levels  
Signal acquisition and interpretation not sophisticated enough to differentiate between an intermittent peak airway pressure from a cough, versus a prolonged occlusion from a mucous plug or malposition of patient | Identify device-specific risks before and after implementation  
• Actively participate in critical assessment of devices |
| **Device design**  
Device user is unable to easily detect that the monitor is in an unsafe mode (ie, cannot readily tell by looking at the display that the audio alarm has been turned to “off,” status icons not intuitive)  
Device permits audible alarms to be turned off for extended periods | Identify device-specific risks before and after implementation  
• Actively participate in critical assessment of devices |
| A provider turns off the audible alarm signal on a physiological monitor during a procedure to reduce distractions. The patient experiences an undetected respiratory event, because the alarm is not audible to providers.§ | **Device design**  
Device settings did not automatically default to safe settings (potentially unsafe settings could be retained, and could be undetected) | Identify device-specific risks before and after implementation  
• Actively participate in critical assessment of devices |
| A ventilator becomes disconnected, but the alarm volume had been turned down during the previous procedure and had not been reset.‡ | **User characteristics**  
Initial user lacked clinical alarm management skills and turned down the alarm volume instead of modifying parameters to reflect the clinical situation | Explicitly train users to actively manage alarms within the system, not just rely on intrinsically acquired skills—this is a skill, like organization or leadership—“response to high risk areas,” not just training re: individual devices  
• Webinars and other educational tools are available from multiple organizations |

*Continued*
In the most basic terms, an **alarm** is intended to call attention to a deviation from a predetermined “normal” status. Response to a clinical **alarm signal** requires (1) noting its presence, (2) identification of the source, (3) interpretation of the meaning within context, and (4) response.13,27 There are 2 main types of clinical alarms (**device alarms** and **physiological alarms**). Alerts, which differ from alarms, also contribute to noise in clinical settings. In some cases, when alerts are not addressed, a life-threatening situation may develop. For example, patients have reportedly been found unresponsive or dead after failures to respond to the “low battery” or “leads off” alerts generated by remote telemetry monitoring equipment.23,28,29

### A Multitude of Alarms: Everything Makes Noise

The number of devices that alarm continues to increase from “up to 6” in 1983, to 40 or more devices in 2012.26 Increasing complexity of patients’ conditions and the introduction of more critically ill patients into intermediate and general care environments contributes to the increasing number of alarms in settings outside intensive care units (ICUs).21,25 **Point-of-care and direct notification alarm systems**, and personal technology belonging to health care workers, patients, and their visitors also contribute to the overall noise profile of a unit.

### Table 2  Continued

| Alarm-related eventa  
|----------------------|
| (adapted from published reports) | Potential contributing factors  
|----------------------| (based on factors for similar events) | Strategies for reducing likelihood of alarm-related events |
| A patient experiences a prolonged period of prolonged decreased oxygen saturation that is undetected because the pulse oximetry oxygen saturation alarm parameter had been set to alarm at <79%. | Policies and procedures | Nurse did not verify appropriate alarm parameters when assuming care of the patient |
| | | Establish practices wherein the nurse caring for the patient verifies that alarm parameters are appropriate for the clinical context |
| | | Address in policy who may change alarm parameters, and under what circumstances |
| A telemetry monitoring system alerts “low battery” for more than an hour, but no one responds to the alerts. The telemetry box stops transmitting data, and the patient is later found unresponsive.23 | Policies and procedures | Absence of clear guidance about responsibility and expectations about how promptly to respond to low criticality device alerts, leading providers to assume that someone else would address the alert |
| | | Change telemetry monitor box batteries at regular intervals (eg, daily) to prevent low-battery alerts |
| A nurse leaves the clinic unit for a scheduled break, inadvertently leaving her pager on a patient’s bedside table. A physiological alarm sounds at the central nursing station, but no one responds to the event.24 | Environment | Physical characteristics of the unit prevent other providers from hearing a critical alarm signal |
| | | Use additional displays, enunciators and/or point-of-care notification systems strategically for each unit |
| | Communication | Unit lacked a standardized practice for handovers from one nurse to another when one nurse was planning to be off the unit |
| | | If appropriate, preassign coverage and establish a standardized practice for handover whenever a nurse is leaving the unit |
| | | Ensure that appropriate team members (eg, telemetry monitoring technician, charge nurse) are aware when a handover has occurred |
| Policy and procedure | Unit lacked a process to ensure response to unanswered alarms and everyone assumed that someone else would respond to the alarms and/or assumed that the nurse had received a page about the critical alarm |
| | | Ensure escalation plan is established and enforced. Identify clear expectations about response to alarms, including second- and third-line responses |

---

*Events may be combined or slightly altered to clearly illustrate the contributing factor, possible solutions, or both.*
The Wall of Sound: The Frequency of Alarm Signals

The sheer number of alarm signals in hospital settings is overwhelming and increasing. Work groups identify more than 600 alarms per ICU patient bed per day. Extrapolating data about alarm signals, TJC reports hundreds per patient per day, thousands per unit per day, and tens of thousands per hospital per day. Multiple factors contribute to the number of alarm signals, including the following:

- Redundant alarms on a single unit (eg, repeaters, satellite alarm stations, direct notification, and point-of-care systems). Although intended to improve safety and overall response to alarms, these systems can unintentionally increase noise (and risk) unless implemented deliberately.
- Generation of multiple signals by multiple systems in response to a single event (eg, a ventilator and a central monitor may both alarm in response to apnea, creating 2 separate alarms for 1 event). This may occur when alarm systems and devices are not fully integrated (a common situation).
- Monitoring of patients without clinical indication or necessity (ie, overmonitoring) contributes significantly to excess alarms. This overmonitoring occurs in ICUs, cardiac care units, and step-down units.

Based on their understanding of the factors contributing to alarm hazards, the RCA team interviews additional staff from the unit.

Pamela, a nurse, was watching the central telemetry monitors that evening: "I was the nurse caring for the patient until 7PM, and then I signed out to Susan. After signing out, I took over watching the monitors because the telemetry technician called out sick. The patient’s SpO2 [peripheral oxygen saturation] was set to alarm for [a saturation of] less than 86%. Occasionally it would drop to 85% if he took off his BiPAP [bi-level positive airway pressure] mask. When the patient heard the drop to 86% if he took off his BiPAP mask. When he kept his mask on, his SpO2 was 99% to 100%. After 7PM, he was more active, and this [activity] started generating lots of false alarms. I was interpreting rhythm strips for other patients, and I couldn’t concentrate. I suspended his SpO2 at the central station, which should have kept it from alarming for 5 minutes. What I don’t understand is why the central monitors didn’t pick up his changing heart rate as he was becoming hypoxic? That alarm should have gone off. I’m really concerned that the alarm system failed to work properly.”

Clinically Insignificant and False Alarms

Ideally, all alarms in clinical settings should be “actionable and clinically significant.” Actionable alarms are those that require timely intervention. In reality, only a small percentage of clinical alarms signal life-threatening or urgent conditions (eg, ventricular tachycardia) that require a clinical response. Research suggests that 80% to 99% of clinical alarm signals are either clinically insignificant or false alarms (false-positive or false-negative). These false alarms, combined with device alarms, comprise “the most significant sources of excessive alarms” in clinical settings. It is important to distinguish between the 2 types of false alarms during event analysis in order to identify appropriate actions. Technically incorrect (or false-positive) alarms are largely a function of emphasis on high sensitivity and low specificity during system design. In the immediacy, these alarms have limited clinical consequence for the individual patient; however, they contribute to alarm fatigue. False-negative alarms are rare but feared because they offer no opportunity for clinical intervention (eg, a monitored patient is in asystole, no alarm sounds, and the patient is found dead). Nuisance alarms also contribute significantly to the alarm profile of a unit. They frequently result from overly “tight” parameters, generating excessive true-positive but clinically insignificant alarms.

Correct terminology is critical when communicating with others about alarm safety and when addressing required standards for accreditation in NPSG 06.01.01. Because alarm management strategies differ depending on the specific type of alarms needing reduction (Table 2), inconsistent use of terms and/or disagreement about definitions can result in frustration, confusion, and poorly developed corrective actions. In the case study, the following types of alarms were described by the nurse who was observing the monitors:

- False-positive alarms: Patient movement triggers artifact-related alarms.
- (Possible) false-negative alarms: No alarm was heard for hypoxemia-induced bradycardia.
- True-positive, but clinically insignificant, alarms: Intermittent removal of the BiPAP mask triggers
the SpO₂ alarm, but the alarm ceases when the patient self-corrects the condition.

The frequency of false and nuisance alarms directly affects perception of alarm reliability and influences an individual’s response. An alarm perceived as 10% reliable generates a 10% response rate, and an alarm perceived to be 90% reliable generates a 90% response rate. As a result, excessive false and clinically irrelevant alarms increase alarm-related risks in a given clinical setting.

Selected Responses to Alarms: Waiting for Self-Correction, Reducing Distress, and Desensitization

In the case study, the nurses demonstrate common behavioral and cognitive responses to excessive alarms, including waiting for an alarm to self-correct, taking steps to reduce alarm-induced distress, and desensitization to alarms. Each of these responses may generate unintended risks for patients. Initially the nurse who is watching the monitors waits for the patient to resecure his BiPAP mask, self-correcting the alarm. Self-correction may occur when the patient or the patient’s family knowingly or unknowingly takes an action to correct the abnormal circumstance (eg, repositioning of arm to permit an intravenous infusion), or because the event causing an alarm is limited in duration (eg, a cough). Waiting for self-correction is a response based on the inherent tendency of humans to limit extraneous and unnecessary expenditure of cognitive or physical energy. Because of the high prevalence of false and clinically insignificant alarms in many settings, waiting for self-correction is subconsciously perceived as an efficient way to prevent task interruption.

The second response that the nurse demonstrates is an attempt to reduce distress by temporarily suspending the alarm from the central station. Units with incessant alarms have been described as “hostile” to patients, clinicians, and nonclinical workers alike. Any environment with frequent, persistent alarms generates frustration, irritation, and other distressing feelings, which can lead to burnout. Initial orientation to distress, humans take actions (consciously or unconsciously) to reduce or eliminate their negative feelings. These include modifying alarm parameters or silencing, suspending, or disabling alarms and can result in unheard true-positive alarms, or false-negative alarms.

The nurse participating in the RCA mentions that sometimes she does not hear the alarms. In areas with relentless alarms, alarm fatigue, or desensitization, develops. Over time, the excessive noise desensitizes those exposed to the alarms to the point where they unconsciously block out alarm signals, no longer aware of hearing or seeing signals.

Concerned by the possibility of monitoring system malfunction, the biomedical engineer reviews the logs from the devices involved. She also reviews the monitoring system manual, which states that selecting “suspend” from the central station disables audible physiology alarms (but not visual alarms) at the central station. Alarms at the bedside remain activated. The suspension of alarms persists until action is taken to reactivate central alarms. In addition, the suspend function responds differently if activated at the point of care. When this is done, the bedside alarm signal(s) activated at that moment will cease to sound locally for 5 minutes, but central station alarms continue. In this specific clinical case, the nurse believed that she had suspended only the SpO₂ alarm function for a limited time, when in fact she suspended it and the other audible alarms for the selected patient indefinitely. The engineer confirms that a visual icon flashed on the central monitor, but it was apparently not seen by the monitoring nurse.

Hazard Ahead! The User-Device Interface and Alarm Systems

The device-user interface is critical. The nurse in the case study did not realize that suspending the alarms at the central station produced a different outcome than if she had suspended the alarm at the point of care. Physiological monitoring systems, like many other medical devices, are highly complex. Retrospective analysis of alarm-related events (and proactive assessments) demonstrates that users are often unaware of the intricacies of monitoring systems. In addition, users underestimate their knowledge gaps. Initial orientation to these systems and other devices are rarely sufficient to build strong skills and expertise with complex devices. Even confident, experienced users need ongoing education about medical devices. Informal or ad hoc orientation of new or contingency staff is not adequate to ensure safe use. In the scenario just described, the nurse may have been unaware of (eg, had not been taught or
may have forgotten) the difference between locally and centrally suspending an alarm. The lack of user-friendly reference material exacerbates device complexity. Manuals for health devices are rarely designed with the end user in mind; they are lengthy and highly technical.8,13,26 Quick reference guides for clinician users have been well received in several settings.53

**Settings: Suspended, Disabled, or Silenced?**

In a TJC review of 98 sentinel alarm-related events, 37% involved alarms turned off inappropriately.4 Excessive alarms may prompt users to deliberately change settings, but other scenarios involve inadvertent, unintentional disabling of critical alarms (Table 2). Ideally, it should be difficult (if not impossible) to set parameters to unsafe settings (eg, an apnea alarm allowing a respiratory pause for more than 1 minute).55 Furthermore, system status should be readily displayed and easy to interpret, allowing users to detect unsafe settings quickly.55 In the event described, the consequence of suspending the alarm(s) from the central monitor was not obvious to the user.

The RCA team meets with Susan, the nurse caring for the patient when the event occurred: “I went into his room early in my shift; he was comfortable and tolerating his BiPAP. The unit was loud and he asked me to close the door. I let him know I’d be back shortly, and then I went to perform a dressing change. About 15 minutes later, I went back to his room. As I came down the hall, I heard the BiPAP machine alarming. When I opened the door, I could also hear the bedside [saturation] alarm. He was cyanotic and apneic.”

**Environmental Factors Contributing to Alarm Hazards**

Most alarm-related sentinel events occur in telemetry, ICU, "general medicine," and emergency departments.4 The TJC review of sentinel alarm-related events states that, “alarm signals not audible in all areas” was a contributing factor in 26% of such events.4 Physical unit layout (eg, wall and corridor placement, spatial relationships between workstations and alarms) influences noise transmission. ICUs and other high-acuity environments are rarely designed “logically or properly,” and little attempt is made to mitigate the limited ability of providers to respond to alarms and alerts.51 In addition, strategies for improving energy efficiency, noise reduction, and patients’ privacy (eg, soft wall coverings) can reduce clinical alarm safety. Ambient noise (eg, ventilation and air conditioning systems), and incidental noise (eg, floor cleaning) further limit alarm detection. As a result of environmental factors, alarms may be muted, muffled, and/or difficult to physically locate. Credible evaluation of alarm-related events requires understanding of the real-life conditions on a unit and how those conditions may vary.

Matt, the unit charge nurse, is also interviewed: “I was going to our stockroom to check inventory, and I heard a feeding pump beeping. When I came out, I could still hear it. I had to take an urgent report, but I text-paged both Susan and the other nurse working on that part of the unit. I texted “tube feed beeping in your room?” I now realize I heard the BiPAP. It honestly did not sound like a critical alarm.

**Resisting Distractions and Interruptions**

The charge nurse describes hearing, but not responding to, an alarm that he believed to be noncritical. Although this could be described as “ignoring” the signal, from his perspective, checking a nonurgent alarm at that time would have interrupted his primary task of receiving an urgent report. Because of inherent (human) cognitive traits, nurses may delay response to unexpected events (eg, alarms) if it hampers work flow or interrupts tasks.27,56 Persons performing critical tasks (eg, sterile placement of a urinary catheter) or tasks with high entry demand (eg, tasks requiring full isolation precautions) are particularly prone to resisting or delaying response. Given the frequency of critical tasks, alarms, and alerts, nurses must resist abandoning tasks to accomplish safe, quality care and, in fact, they develop skills to interpret and decide on “appropriate” responses to alarms.27

**Sound Discrimination and Alarms**

The charge nurse heard an alarm, but he misattributed the source and did not accurately identify the location. Studies demonstrate that even experienced clinicians cannot recognize more than 50% of alarms in work settings.8,57-59 In addition, users expect devices to be intuitive49 and users’ perception of alarm urgency (ie, critical or noncritical sounding) directly influences response.9 Optimal acoustic (and visual) alarms ideally occur in a specific sequence or pattern that is readily heard and easy to interpret.55,61,62 Controversy remains
about the exact tone, frequency, and sequencing characteristics of a perfect alarm.9,61 Guidelines and standards for medical device alarm systems often offer conflicting direction and are not always evidence based.9,13,61,63 As a result, alarm signals do not consistently correlate with perceived criticality, and this lack of consistent correlation directly influences response.

Alarm Management As a Skill Set

Proactive alarm management is the best way to reduce alarm hazards, reduce excessive alarms, and prevent alarm fatigue.15 It is incorrect to view alarm management as a skill simply acquired implicitly through time and clinical experience.27 Analyses of alarm-related events often reveal that users do not understand the purpose of the system, did not have an optimal level of knowledge or training before use, or had not had clinical competence validated.12 In the clinical case, both of the nurses who cared for the patient (Pamela and Susan) had opportunities to manage the alarm settings and parameters proactively to reduce the frequency of clinically irrelevant alarms. The RCA also indicates that other, unit-level and facility-level factors contributed to the event, and the RCA team requests the unit and facility policies on alarm management.

The team reviews the policies, looking specifically at roles and responsibilities. A facility-level policy reads: “All staff are expected to respond immediately to all critical alarms.” Jackie, the nurse on the team, raises her eyebrows, “That’s just not practical. We’ve already determined that Matt didn’t know the alarm was critical, while Susan was busy changing a dressing and didn’t even hear it. And how can “all” of the nurses respond to “all” of the alarms all of the time? The team members agree that the facility policy, as written, offers limited meaningful guidance for staff. They also review their unit policy, which states: “Telemetry monitoring technicians may not turn off or otherwise disable critical alarms without verifying with the patient’s assigned [nurse].” Several team members note that it was a nurse, not a technician, who changed the alarms, and that she did not disable the alarm, but “suspended” it. Others point out, however, that she was not the assigned nurse at that time. Jackie reports that her own orientation to the monitors was minimal, and most of her understanding of this particular system was acquired during day-to-day use.

Roles and Responsibilities

Many elements of NPSG 06.01.01 are focused on establishing roles and responsibilities through policy and procedure, including who may make decisions about alarm parameters, who may change alarm settings, and who is responsible for responding to alarms and alerts.5 However, the mere presence of a policy does not translate into improved safety, as noted in the case study. Policy, procedure, and protocols may define responsibility without differentiating clearly between role, title, responsibility, and scope of clinical practice. Such tools may fail to address reasonably expected contingency scenarios (eg, a nurse watching the telemetry monitors). This failure can generate loopholes and inconsistencies in practices. In this case, the nurse watching the monitors is serving in a contingency role (monitor technician). Her decisions are based on clinical context and her clinical expertise; her actions are those of a nurse rather than a technician, and she may be unaware of the specific responsibilities or constraints on the telemetry technician. Based on unit policy, the nurse caring for the patient could reasonably assume that the monitoring technician (nurse or not) would not change alarm parameters. Alternatively, she may have adjusted her practice based on the fact that a nurse, especially one who had previously cared for the patient in question, was serving as the monitor technician.

In the clinical scenario, the facility level policy contains another flaw. Implementing policies that require “everyone” to respond to “all alarms” creates a sense of diffuse responsibility; when all nurses are expected to respond to all alarm signals, each individual may assume that someone else will attend to the alarm.12,64 Strong policies and procedures integrate alarm escalation plans, which delineate multiple levels of responsibility when there is no initial response, as well as time frames for notification.

Clinical Alarm Safety: Implications for Nursing

Unit (and facility) level change is possible. Nurses have the opportunity to improve clinical alarm safety by (1) leading improvements in clinical alarm practice,
(2) contributing to the understanding and application of clinical alarm safety practice and evidence, (3) ensuring compliance with NPSG.06.01.01, (4) developing alarm response plans and resources, and (5) participating in retrospective and proactive analyses of alarm safety. Many resources for champions of clinical alarm safety are readily available on the Internet (Table 3), including published unit-level successes, such as those achieved...
These resources offer real-life examples of the commitment and interdisciplinary perseverance required to make sustainable changes in clinical alarm safety. Table 4 summarizes specific unit-level interventions used at some of these organizations.

Summary

Clinical alarm systems in acute and critical care health care settings “challenge human limits for recognition and actions.” Understanding alarm-related terminology and the scope of contributing factors (including, but not limited to, alarm fatigue) will equip nurses to devise and implement appropriate strategies for alarm management at the individual practice level and beyond.

Financial Disclosures

None reported.

Table 4 Unit-level clinical alarm safety interventions

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Unit-level interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ongoing</td>
<td>Document and analyze baseline unit alarm conditions</td>
</tr>
<tr>
<td></td>
<td>Use a quality improvement/process improvement framework and small tests of change</td>
</tr>
<tr>
<td></td>
<td>Prepare for a long-term commitment of months to years</td>
</tr>
<tr>
<td></td>
<td>Provide orientation to devices for all new staff</td>
</tr>
<tr>
<td></td>
<td>Create quick-reference “at a glance” material for each monitor</td>
</tr>
<tr>
<td></td>
<td>Establish interval (eg, annual) clinical alarm management refresher training and/or competency assessment</td>
</tr>
<tr>
<td></td>
<td>Collaborate with health technology experts, including vendors</td>
</tr>
<tr>
<td></td>
<td>Promote “context awareness” (eg, silencing of alarms before routine clinical care)</td>
</tr>
<tr>
<td>Every shift</td>
<td>Conduct multidisciplinary assessment of necessity of monitoring individual patients, asking questions such as:</td>
</tr>
<tr>
<td></td>
<td>Is there a clinical index for physiological monitoring?</td>
</tr>
<tr>
<td></td>
<td>Are the physiological parameters being monitored the optimal choice for the clinical indication?</td>
</tr>
<tr>
<td></td>
<td>Would intermittent monitoring be adequate instead of continuous monitoring?</td>
</tr>
<tr>
<td></td>
<td>What are the criteria/goals for discontinuing or reducing monitoring?</td>
</tr>
<tr>
<td></td>
<td>Clearly define roles and responsibilities for monitoring, communicating, and responding to alarms</td>
</tr>
<tr>
<td></td>
<td>Check individual alarm signals for appropriate parameters for the clinical context, settings, audibility, etc</td>
</tr>
<tr>
<td></td>
<td>Evaluate appropriateness of staffing and monitoring</td>
</tr>
<tr>
<td></td>
<td>Is a different (higher or lower) level of care more appropriate for the clinical situation?</td>
</tr>
<tr>
<td>Daily</td>
<td>Eliminate redundancies in the monitoring systems causing excessive alarms</td>
</tr>
<tr>
<td></td>
<td>Schedule proactive assessment and changing of electrodes, sensors, leads, and remote telemetry monitor batteries</td>
</tr>
<tr>
<td></td>
<td>Use evidence-based skin preparation when applying sensors and electrodes</td>
</tr>
<tr>
<td></td>
<td>Have enough equipment and supplies (eg, batteries, leads)</td>
</tr>
<tr>
<td>Quarterly</td>
<td>Review clinical alarm and monitoring policies and protocols, including those related to patient handovers and transport</td>
</tr>
<tr>
<td></td>
<td>Verify that roles and responsibilities are clearly defined in policy and protocol, and align with current unit practice and staffing strategies</td>
</tr>
<tr>
<td></td>
<td>Complete an inventory to identify any new equipment or retired equipment update procedures as needed</td>
</tr>
<tr>
<td></td>
<td>Identify priority alarms on unit</td>
</tr>
<tr>
<td></td>
<td>Establish algorithm to indicate which are the most important signals to manage</td>
</tr>
</tbody>
</table>

*Multiple high-acuity units have improved clinical alarm safety and published their experiences in peer-reviewed journals and through the Association for Advancement of Medical Instrumentation (AAMI) Safety Innovation series. The AAMI white papers in particular are exceptional resources for units embarking on local improvement activities. These experiences provide valuable information for others seeking to undertake similar projects.*


50. Ewdorthy J. House Call. 2006;97:12-17.


