# Beyond Sound: *Using Systems Integration to Advance Alarm Functionality*

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You could say that 2002 was a bad year for clinical alarms. That was the year that the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) (now The Joint Commission) assessed 23 reports of deaths or injuries related to long-term ventilation and determined that 15 (65%) were related to "the malfunction or misuse of an alarm or an inadequate alarm."

No doubt, that number is sobering. But it's also nearly a decade old. Has alarm management improved? Gotten back its good name? Not necessarily. In fact, clinical alarms have taken either first or second place for the past three years on the ECRI Institute's annual list of Top 10 Health Technology Hazards.

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## The Sound Problem

Why aren't alarms working? Mark R. Rosekind, a psychologist, member of the National Transportation Safety Board, and former operations specialist at NASA, believes he knows the answer, or at least part of it. Rosekind has seen everyone from air traffic controllers to nuclear plant operators to astronauts ignore alarms, exhibiting what many today refer to as alarm fatigue.

"The volume of alarms desensitizes people," Rosekind told *The New York Times* in August 2010.[1] "They learn to ignore them. There's so much information overload. If that alarm doesn't have meaning for that user, that operator, they're going to start ignoring it. It doesn't matter what environment you're in."

Today's clinician operates in an alarm-heavy environment. A 2010 *Critical Care Medicine* piece titled, "Intensive Care Alarms—How Many Do We Need?"[2] stated that 40% of all alarms do not correctly describe the patient condition and can be classified as technically false; only 15% of all alarms can be considered clinically relevant. Of course, alarm validity fluctuates based on the device in question and the environment in which it is being used. But in general, nuisance alarms, or false-positive alarms, are incredibly problematic.

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How problematic? The American College of Clinical Engineering (ACCE) Healthcare Technology Foundation surveyed 1,327 clinicians, engineers, technical staff and managers in 2004.[3] The majority agreed or strongly agreed that nuisance alarms occur too frequently (81%); disrupt patient care (77%); and reduce trust in alarms and cause caregivers to disable them (78%).

## The Good News

Clinical alarms should be useful tools for caregivers, not something they are driven to disable. And they can be. Many hospitals have dramatically reduced nuisance alarms and increased alarm utility through evaluation and inventory.

These efforts certainly go a long way in reducing alarm fatigue. But to further advance alarm systems requires a change in thinking, or a shift towards integration. As is the case in almost any organization, the integration of efforts and information enhances workflows and efficiencies. Consider the ways in which connectivity between devices, communications systems, and information systems within hospitals augments alarm systems in the following scenarios.

## Scenario #1: The Perfectly Configured Alarm That No One Hears

Ideally, patients connected to medical devices such as monitors, pumps and ventilators would be confined to critical care units—units designed for high acuity. However, overcrowding in hospitals and the general trend of rising patient acuity has led to variable acuity units or environments. In these units, nurse-staffing levels are low, making medical device alarms essential.

But alarm audibility can be challenging in these makeshift spaces; large rooms, long hallways, and rooms with doors are not ideal for ensuring audibility. So what happens when a perfectly configured, clinically relevant alarm sounds behind a closed door in a room at one end of an L-shaped, variable acuity unit and the clinician is at the other end of the L?

### Solution

In response to these challenges, a variety of alarm extensions have been developed. These solutions complement, or extend, the alarm when the appropriate clinician is out of range of an audible alarm. These alarm extension technologies route or channel the device alarm to a variety of systems, including nurse call systems, paging systems, enunciation systems, or cell phones via an internal, secure, wireless network.

In a similar fashion, some patient monitors have the ability to provide clinicians with information about alarms that are sounding for other patients. So when you are looking at the patient monitor for patient X and you hear an alarm sound for patient Y, you can use patient X's monitor to view information about the alarm for patient Y.

In variable acuity settings, these alarm extension technologies benefit both clinicians and patients. Unattended alarms can greatly affect a patient's perceived level of care, especially if that patient feels isolated behind a closed door at the end of a hallway.

It's important to note that, if device parameters aren't set correctly, alarm fatigue will still occur; it's just as frustrating to receive repeated text messages about clinically irrelevant events as it is to hear alarms about them.

## Scenario #2: Choosing Between Two Patients

A patient's heart rate exceeds her predetermined threshold, and the monitor sounds an alarm. The clinician hears her alarm sounding,

### Minimize Nuisance Alarms by Taking Inventory

Many hospitals have dramatically reduced nuisance alarms through evaluation and inventory. For example, The Johns Hopkins Hospital in Maryland began a pilot project in December 2005 to reduce clinical alarm fatigue. The hospital formed a task force to examine the purpose and accuracy of each alarm. Default alarm settings were adjusted to appropriate levels, and staff members underwent alarm management training.

The result? A 43% decrease in critical alarms. It should be noted that improvements of this kind demand a hospital-wide effort. Nurses alone cannot be expected to configure countless devices from countless manufacturers—especially since each device requires unique operator knowledge. Instead, hospital management must allocate the appropriate resources to the task.

but he is down the hall serving another patient in moderate need of care.

This creates a quandary for our clinician: How quickly should he respond? Should he stop serving the patient he's with to go inspect the sounding alarm that may or may not be clinically relevant? Or, should he take 30 seconds to finish what he's doing and then go check the patient?

**Solution**

Thanks to new technologies, clinicians can now receive a text message or email stating, "Patient X's upper threshold for heart rate has been exceeded. The current heart rate is Y." Clearly, this kind of notification provides more context than say, an audible-only notification. The alert not only tells the clinician that a threshold has been crossed, but also, by how much. This additional description provides the clinician with the information he needs to make an informed decision about how to respond.

"If you're an RN, and you're in someone else's room, and you receive an alert indicating that another patient is crashing, that's a lot different than an alert about the $CO_2$ level being a little low,'' says Jena Milan, product manager at device integration company iSirona. "When clinicians have an idea as to why that alarm is sounding, they can prioritize and better manage the care of both patients—the one they're providing care to at the moment as well as the patient whose alarm is sounding."

## Scenario #3: When a Clinician Simply Cannot Respond

A respiratory therapist conducts a vent check in a surgical intensive care unit. She's cleaning out the patient's respiratory airways when she receives a clinically relevant, descriptive text about another patient in extreme need. She knows the alarm condition is critical. But she's already in the middle of a critical procedure. She simply cannot stop what she's doing.

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**Solution**

Integrated patient care communication systems (or integration middleware systems) link communication technologies within a hospital, from nurse call stations to patient bed to clinician cell phones. Though the respiratory therapist in our scenario cannot attend to the patient whose alarm is sounding, she can forward the alert to another clinician via a lightweight badge or communication device.

These communication integration solutions are helpful for clinicians in other ways as well. It is often forgotten that, in addition to providing direct care, caregivers must also coordinate and communicate with physicians, manage processes for outgoing diagnostic tests or therapies, manage visits from outside therapists, and coordinate with social workers. Activities like these and many others must take place in between nurse calls, text messages, overhead pages and medical devices alerts. In this way, integrated communication systems are highly beneficial for clinicians.

## Scenario #4: One Event Drives a Cacophony of Audible Alarms

At the point of care, a patient is connected to several medical devices, each of them performing a variety of tasks, from monitoring heart rates to the delivery of therapy. Each device has its own alarm parameters, categories and methods of annunciation.

An adverse event occurs, and the patient needs attention. Our patient's physiological change triggers duplicate alarms in the various devices to which he or she is connected. As each device sounds off, clinicians are not given a clear message. Instead, they are overcome by flashing lights and a myriad of sounds.

"There can be so many alarms at a given time that the patient care environment becomes dysfunctional," says William Hyman, professor with the department of biomedical engineering, at Texas A&M University. "When environments become excessively noisy, it can become so unbearable that users have been known to sabotage alarms."

**Solution**

Some manufacturers have developed "smart alarms," or alarm systems that integrate parameters from multiple, disparate devices to evaluate the validity of a single alarm. These systems are "smart" enough to emit one

alarm—instead of, say, five—per adverse event, drastically reducing the number of repeat alarms.

Do clinicians and engineers trust these smart alarms? The ACCE-led survey indicated that 80% of respondents support smart alarms. However, according to Tobey Clark, CCE, director of instrumentation and technical services and adjunct faculty member in engineering and nursing/health sciences at the University of Vermont, Burlington, smart alarms have fallen behind the curve. Clark wrote: "In general, 'smart alarm' technological progress has not kept pace with overall medical device advances, in part due to manufacturer reluctance—liability concerns and business factors are at the top of the list."[4]

## Scenario #5: When Device Parameters Aren't Enough

A patient in the ICU is having trouble breathing, and he's on a ventilator. His respiratory therapist receives a "disconnect" ventilator alarm on her smart phone. Most likely, this is a nuisance alarm. But the therapist can't be sure. How is she to interpret the alarm?

### Solution

Ventilator disconnect alarms can be corroborated by oxygen saturation values, which come courtesy of another device. When combined, the disconnect alarm and the oxygen saturation values provide more clinical context than either could individually. Imagine if, in this scenario, the ventilator disconnect alarm was routed to the clinical information system (CIS), which was programmed to bundle the alert with real-time data about the patient's oxygen saturation values before pushing it to the respiratory therapist.

## Discussion

As demonstrated in these scenarios, advances in the areas of alarm extensions, directed notifications with context, integrated communications systems, smart alarms, and device interoperability are changing the face of alarm management. These kinds of advances are possible when, through device connectivity, hospitals are able to channel real-time data from multiple devices into the CIS.

Furthermore, with real-time data in the CIS complementing alarms, algorithms can synthesize data from multiple devices, including latency information, duration of events and frequency. This information can then interact with the patient's medical history. The sky is the limit in this regard, though these advances face many of the regulatory and liability concerns that smart alarms do.

No doubt, the handling of device alarms in clinical environments is a sensitive issue. This is as it should be, as device alarms greatly impact patients' lives. Alarm efficacy can be greatly enhanced through intentional device parameter setting. Additionally, new technologies and communication solutions are undoubtedly changing alarm management for the better.

Ultimately, patient safety is an industry-wide issue; so, too, is improved alarm management. When device designers, manufacturers, buyers, users, and regulatory bodies come together, alarms can be at their best—informing clinicians and protecting patients. ■

## References


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