

Clinical Alarm Management *Compendium*

AAMI FOUNDATION

About the AAMI Foundation

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

To learn more about the Foundation and ways to become involved visit
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Contents

5	Acknowledgments
6	What We Know
10	List of Alarm Management Challenges
12	10 Ideas for Safe Alarm Management
34	Sample Default Parameter Settings
35	For Adults
42	For Pediatrics
50	Appendix
50	The Johns Hopkins Hospital/ Alarm Burden and Management Toolkit
54	Goals of the AAMI Foundation National Coalition for Alarm Management Safety

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What We Know



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“Use alarms safely.” Those three little words are a succinct call to action by The Joint Commission in a 2014 National Patient Safety Goal (NPSG) for hospitals.

Three little words can evoke layers of meanings, all deeply influenced by the histories and dynamics and cultures of particular individuals—or institutions. How can you “reduce the harm associated with clinical alarm systems,” as the NPSG urges hospitals to do, in your hospital or healthcare system?

Whether you are just beginning or well on your way in this quest, you’ll quickly discover that there is no template or set of instructions for enacting policies, processes, or practices that will mitigate the risks of non-actionable clinical alarms. That’s because alarm management issues “vary greatly among hospitals and even within different units in a single hospital,” as the NPSG states. There is no definitive body of research that makes this work simple, either.

That doesn’t mean there are no resources available. Alarm management is a challenge that AAMI has been working on for a number of years, in concert with other leading organizations and practitioners.

Learn from Leading Practitioners

This compendium synthesizes substantial knowledge, experiences, and advice from leading practitioners who have invested considerable time into inquiry, trial and error, and continuous improvement to make progress on alarm challenges. No single institution has all the answers. No single path is the “right” one that can be turned into an off-the-shelf solution.

Even so, you can learn from these leading practitioners now, starting with the recognition that alarm management is actually a whole set of complex challenges and processes, as shown on page 10. Leading practitioners address identified challenges in their own institutions with a clear mission focused on patient safety and have implemented one or more of these 10 ideas for safety innovations in alarm management, as shown on page 12.

As you’ll see in the following pages, the ideas they implemented weren’t always planned in advance and weren’t necessarily implemented in sequence. In fact, leading practitioners often engaged in concurrent work on multiple ideas. Tactics differed and sometimes shifted. Virtually every leading practitioner, however, used—and continues to use—these ideas in the drive to improve alarm management.

In addition to the 10 ideas for alarm management, this compendium presents a set of default alarm parameters reported in a survey conducted by the AAMI Foundation, which represents responses from 17 of the 25 hospitals and healthcare systems in the National Coalition for Alarm Management Safety. These parameters could be used to benchmark settings on alarm systems for specific adult and pediatric patient populations.

The National Coalition for Alarm Management Safety has set a goal of advancing patient safety by sparing each and every hospital the challenge of developing alarm management techniques and methods in a silo. We urge you, and your hospital or healthcare system, to use this compendium to launch and guide an alarm management initiative, or strengthen one in progress.

Please let us know how your journey progresses. We want to share your lessons learned, so all may continue to improve patient safety with alarm management!



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Learn More

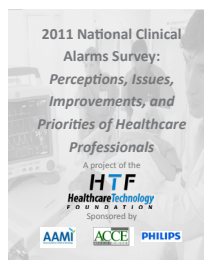
Visit the AAMI Foundation website at www.aami.org/foundation to learn more about its work to improve the safety of clinical alarms you can access:

- Alarm Best Practices Library, a compilation of research on alarm management
- Alarm Parameter Inventory, which is useful for complying with The Joint Commission's 2014 National Patient Safety Goal
- Safety Innovation Series reports, white papers, seminar recordings, presentations, and handouts profiling the alarm management ideas of leading practitioners
- *Clinical Alarms*, the 2011 Medical Device Alarm Summit publication, which includes seven clarion themes and priority actions for alarm safety and Top 10 Actions to Take Now
- Proceedings from the groundbreaking April 2014 kickoff meeting for the National Coalition for Alarm Management Safety
- Monthly seminars during which coalition hospitals continue to share techniques to improve alarm management

The Joint Commission National Patient Safety Goal on Clinical Alarm Safety

Phased Implementation

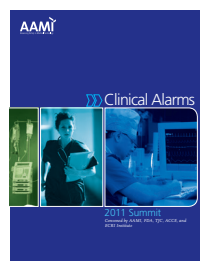
1. Phase I, which was effective on Jan. 1, 2014, required hospitals to establish alarm safety as an organizational priority by July 1, 2014, and to identify during 2014 the most important alarms to manage based on their own internal situations.
2. Phase II, which begins Jan. 1, 2016, hospitals are expected to establish and implement specific components of policies and procedures for managing the alarms identified in Phase I and to begin educating staff about the purpose and proper operation of alarm systems for which they are responsible.



In 2005 and 2011, AAMI co-sponsored national surveys of healthcare professionals in acute care hospitals to identify clinical alarm perceptions, issues, improvements, and priorities.



In 2011, AAMI dedicated the spring issue of *Horizons* magazine to improving medical alarm systems.



That fall, AAMI co-convened a Clinical Alarms Summit with the American College of Clinical Engineering, ECRI Institute, The Joint Commission, and the U.S. Food and Drug Administration (FDA).

Tips for Getting Started

- **Start small—just as many large, well-resourced organizations do. Anyone can talk with the nurse manager and nurses on a patient care unit to learn about their experiences with alarm management on a shift.**
- **Tap into the expertise in your facility to build a team.**
- **Focus at first on just one unit and just one type of medical technology with an alarm system.**
- **Look for low-hanging fruit—easy adjustments you can make, such as increasing the volume of audible alarm signals, if necessary.**
- **Reach out to vendors and academic institutions for help.**

Who Will Benefit from this Compendium?

This publication is intended for a multidisciplinary range of leaders and professionals in healthcare delivery organizations, including:

- C-suite and senior administrative executives
- Patient safety, risk, quality improvement, and/or hospital accreditation managers
- Clinical leaders, including medical directors, chief nursing officers, and nursing managers, and clinicians, especially front-line nurses
- Healthcare technology managers (clinical and biomedical engineers and technicians)
- Information technology (IT) professionals
- Consultants who are helping with these issues
- Industry experts who are designing solutions



In 2012, the AAMI Foundation added clinical alarms to its portfolio of multidisciplinary initiatives to advance patient safety and created an Alarm Best Practices Workgroup, which reviews literature and recommends best practices on

alarm management. The Foundation also launched a Safety Innovation Series of white papers, reports, and guides profiling leading healthcare organizations that are solving tough safety issues related to clinical alarms.

In 2013, the AAMI Foundation began a series of recorded seminars, presentations, and checklists on alarm system management.

In 2014, the AAMI Foundation created the National Coalition for Alarm Management Safety, which includes a group of hospitals that are pioneering solutions to alarm management challenges, as well as the clinical community, professional societies, the FDA, The Joint Commission, and the medical device industry.

List of Alarm Management Challenges

Use this list of alarm management challenges as a starting point to examine the particular challenges in your institution. Developed in collaboration with leading practitioners through the clinical alarms initiative of the AAMI Foundation, this list could be used to develop a survey of clinicians, an observation protocol of hospital units, or target areas for data collection and analysis.

Leading practitioners realize that the alarm management “challenge” is actually a whole set of complex challenges that require systemic improvements. After an alarm-signal-related adverse event, near miss, or investigation into a patient safety issue, many quickly converge on likely contributing factors.

Orders of Magnitude

- More and more devices with alarm systems
- More and more patients connected to devices with alarm systems
- Higher-acuity patients creating an increased alarm load

Limitations of Alarm Systems and Devices

- Medical devices with alarm systems do not satisfy the diverse workflow demands across the breadth of care settings.
- Integrated alarm system designs are not standardized across different medical equipment systems and devices.
 - Inconsistent alarm system functions (e.g., alerting, sounds, providing information, suggesting action, directing action, taking action)
 - Inconsistent alarm system characteristics (e.g., terminology, information provided, integration, degree of processing, prioritization)
- Too many false positive (invalid) and non-actionable alarm conditions
- Duplicate alarm conditions (e.g., the same alarm conditions sent from multiple devices, multiple times, in multiple ways, and/or to multiple staff)
- Inaudible alarm signals, particularly on large units and in private rooms

- Indistinguishable alarm signals
- Inadequate interface design (e.g., not intuitive to navigate, difficult to customize)
- Lack of actionable intelligence (e.g., useful information about how to respond to alarm conditions with appropriate patient care or device management)
- Difficulty obtaining data from alarm systems
- Challenges in implementing middleware for secondary alarm notifications (e.g., paging, phone, data retrieval, workflow, and remote monitoring systems)

Alarm Burden and Alarm Fatigue

- Too many alarm signals or high frequencies of alarm signals—or both—many of which are false or non-actionable, which results in staff taking inappropriate actions, such as silencing or ignoring these signals
- Alarm noise, which creates an unpleasant environment for patients, families, and staff and may lead to:
 - Desensitization to “white noise” as staff become accustomed to the sound
 - Distraction resulting in errors
 - Delayed response time
 - Alarm conditions perceived as “nuisance alarms” (e.g., “leads-off” alarm conditions, when, in reality, these can be significant and require action)
- Effects of noise on patients, families, and staff
 - Physiological effects of noise on patient recovery
 - Families lose trust in staff when they don’t respond in a timely manner
 - Staff develop stress symptoms from unpleasant work conditions

Alarm Management, Knowledge, and Education

- Lack of evidence-based literature and shared best practices on alarm management
- Unclear and inconsistent alarm system accountability
 - Who is responsible for creating and managing alarm system policies and protocols?
 - Who is responsible for responding to alarm signals on every unit and every shift?
 - Inconsistent clinician response to alarm conditions and/or lengthy response time
 - Lack of a backup or escalation plan to ensure that clinicians hear and/or see alarm signals and respond to alarm conditions promptly, with a rapid response team or other specialist(s) on standby to attend quickly to serious patient conditions or emergencies
 - Too much trust in alarm systems e.g., “scope creep”—multiple medical devices with alarm systems—can lead to an inflated sense of security and overreliance on monitors to inform clinicians of patient conditions
 - Lack of trust in alarm systems, e.g., too many false positives, false negatives, insignificant, non-actionable, and “nuisance” alarm signals and conditions can undermine appropriate response to true alarm conditions
 - Competing priorities for clinicians’ attention
- Inconsistent or inadequate alarm system management
 - Lack of standardization of alarm system default settings
 - Inconsistent use of alarm system features
 - Alarm system limits set too tight
 - Inadequate battery management, resulting in “low battery” alarms, e.g., forgetting to plug in medical equipment, such as infusion pumps, ventilators, and physiological monitors, to charge batteries for safety and reliability
- Lack of knowledge and competency in alarm systems
 - Lack of knowledge/best practice about how alarm systems can be customized to individual patients or set to actionable limits to better manage patient monitoring and care
 - Lack of training in alarm management policies and protocols
 - Poor skin preparation for EKGs, electrode placement, and finger probe placement for pulse oximetry on patients

Top Five Gaps in Alarm-Management-Related Knowledge

Maria Cvach, assistant director of Nursing, Clinical Standards, at Johns Hopkins Hospital, presented her take on the top five alarm-related knowledge gaps to the AAMI Foundation’s National Coalition for Alarm Management Safety kickoff meeting in April 2014.

1. Lack of documentation and data to analyze reported events and near misses to understand root problem(s)
2. Lack of evidence-based rationale for the configurations of alarm settings
3. Lack of understanding of the best types of alarm signals to elicit a response
4. Lack of knowledge regarding who should be monitored and for how long
5. Lack of understanding about the best secondary alarm notification systems

www.aami.org/NCAMS/

10 Ideas for Safe Alarm Management

The ideas that follow are synthesized from the AAMI Foundation's *Safety Innovation Series* of reports, white papers, seminar recordings, meeting presentations, and handouts profiling the alarm management strategies of leading practitioners.

These ideas represent approaches common to robust, multidisciplinary teams. Healthcare systems and hospitals carried out these approaches in a variety of ways—a reflection of different challenges, goals, and institutional cultures. Consider how you can use some or all of these 10 ideas to make your alarm management initiative successful:

1. Issue a call to action, championed by executive leadership, which recognizes the challenges and risks—and opportunities—of alarm management and commit to solving them.
2. Bring together a multidisciplinary team to spearhead action and build consensus.
3. Gather data and intelligence to identify challenges and opportunities—and be open to surprises.
4. Prioritize the patient safety vulnerabilities and risks to target with alarm management improvements.
5. Set and share goals, objectives, and activities to address patient safety vulnerabilities and risks.
6. Develop and pilot potential solutions.
7. Evaluate the effectiveness of improvements and make adjustments as needed.
8. Develop policies and procedures.
9. Educate to build and maintain staff competencies.
10. Scale up and sustain by creating ownership at the unit level and with continuous improvement.

“Hospital pain points equate with solutions.”

—Tim Gee, Principal, Medical
Connectivity Consulting

Idea 1

Issue a call to action, championed by executive leadership, which recognizes the challenges and risks—and opportunities—of alarm management and commit to solving them.

Alarm management is a perennial and growing challenge in healthcare. What motivated leading practitioners to take on this challenge, raise its visibility, and commit to changing practices? What opportunities did they see? These common circumstances jolted people to attention and convinced them of the need for systemic changes in culture, practices, clinician workflow, infrastructure, and technology—not just crisis management or small-scale tinkering:

Internal Motivators

- An adverse event or near miss that harmed, or could have harmed, a patient
- Concerns about patient safety or clinical alarms from clinicians—or from even one clinician with a fresh perspective whose voice mattered
- Opportunities to improve patient care and outcomes and staff working conditions
- Opportunities to integrate alarm management into other initiatives, such as the implementation of new medical technology
- Opportunities to improve patient experiences by reducing noise in the environment

To learn more about the exemplary practices and comprehensive alarm management initiatives of featured healthcare systems and hospitals, www.aami.org/foundation/alarms

External Motivators

Heightened awareness of potential alarm-related safety issues from credible sources, such as:

- The AAMI/FDA Clinical Alarms Summit
- The AAMI Foundation's National Coalition for Alarm Management Safety
- ECRI Institute's Top 10 Technology Health Hazards
- The FDA's Manufacturer and User Facility Device Experience (MAUDE) database for adverse event reporting
- The Joint Commission's National Patient Safety Goal on alarm management for its hospital accreditation program
- Peer-reviewed manuscripts

Exemplary Practices: Calls to Action



- **Kaiser Permanente** heeded reports about alarm challenges from sources such as AAMI and ECRI Institute, and from news accounts of patient deaths linked to alarm fatigue. The healthcare system created an alarm fatigue work group, held its own alarm summit, and engaged national leadership to raise awareness and motivation to solve alarm challenges.
- **Beth Israel Deaconess Medical Center** in Boston, listened when an ICU nurse was transferred to the Emergency Department and called attention to the “loud, chaotic, and noisy place with auditory alarm signals going off all the time.” Long-time staffers had become so accustomed to this environment that it took a fresh perspective from a clinician new to the department to point out that this wasn’t “normal”—and it could compromise patient safety. The medical center’s adoption of the “Lean” philosophy to engage front-line providers in process improvement and encouraging them to speak up created a culture for raising concerns.

Idea 2

Bring together a multidisciplinary team to spearhead action and build consensus.

Whether your hospital is responding to an alarm-related crisis or undertaking a planned alarm management initiative, a diverse range of expertise is critical. Leading practitioners bring together a multidisciplinary team of subject matter experts and professionals to represent their colleagues and key stakeholders, “own” and champion the initiative, and build consensus for improved practices.

Who should be on this team? Consider these ideas as a starting point—and consult with others as appropriate:

- Administrative sponsor (e.g., chief nursing officer, medical director, vice president of quality)
- Clinicians—physicians, respiratory therapists, nurse unit managers, and, especially, front-line nurses
- Patient safety, risk, quality improvement, and/or hospital accreditation managers
- Healthcare technology managers—clinical or biomedical engineers and technicians
- Information technology (IT) professionals
- Human factors experts
- Researchers
- Biostatisticians
- Pharmacists
- Monitor watchers, nurse’s aides, unit technicians
- Facilities managers
- Patient advocates
- Patients
- Medical equipment vendors

Typically, a few core members lead a small task force or steering committee and then expand the group to include perspectives of key stakeholders and talent relevant to the work.

Exemplary Practices: Multidisciplinary Teams



With support from hospital administration, **Johns Hopkins Hospital** in Baltimore, MD, brought together an interdisciplinary monitor alarm committee to reduce hazardous situations related to alarm conditions. The alarm improvement initiative was launched under the hospital’s Comprehensive Unit Safety Program (CUSP), a five-step process to change a unit’s culture and bring about significant safety improvements by empowering staff to assume responsibility for safety in their environment.

- **Massachusetts General Hospital** in Boston created a multidisciplinary Physiological Monitoring Tiger Team with three workgroups that guided systemic improvements: one focused on clinical criteria for physiologic monitoring, one focused on monitoring practice, and one focused on alarm management.
- **Christiana Care Health System** in Newark, DE, points to the “crucial blend” of clinicians and IT and clinical engineering experts on a cardiac monitoring team that spearheaded equipment changes and standardization, one goal of which was to improve monitoring and response to alarm signals.

Tips for Team Building

- Select people who have a passion for improving alarm safety, not just professional credentials.
- Create a safe environment in which everyone supports a questioning attitude and is comfortable sharing issues and ideas.
- Consider bringing in a skilled facilitator to ensure that everyone has a voice.

Idea 3

Gather data and intelligence to identify challenges and opportunities—and be open to surprises.

At times, alarm management challenges are so obvious that immediate fixes might make sense. More often, however, it takes deeper investigation to identify the full scope of the challenges—such as the clinical environment, quantity and type of technology in use, staffing models and staff competencies—and develop systemic improvements. Indeed, short-term fixes without thorough planning or an eye toward longer-term solutions could introduce new failures.

Leading practitioners take the time to measure and analyze what's happening in their hospitals or units and cast a wider net to learn from others. (See List of Alarm Management Challenges on page 10 for a comprehensive list of identified challenges.) They also remain open to problems that might not be apparent. Leading practitioners also continue to use alarm data and analysis to gauge the effectiveness of changes in practices or technology designed to improve patient safety.

What quality improvement data and formal research methods yield the information that will frame improvement efforts? Consider these approaches from leading practitioners:

- Leverage data from incident investigations, such as retrospective chart reviews of patients who had adverse events or near misses.
- Collect and analyze data to document baseline alarm conditions and the care environment in a hospital unit or units. Baseline alarm conditions include default parameter settings, frequency of customization of default parameter settings, criticality of the alarm conditions, and number of alarms per bed.
- Meet with nurse managers and floor nurses for daily standups to discuss specific alarm management problems that occurred during the previous shift.
- Conduct action research, such as unit observations over a two-week period or longer, to document current practices.
- Examine whether alarm signals are sufficiently audible in the patient care environment—and be sure to do this assessment during peak times on units. Consider such factors as staffing levels, unit layout, background noise, and alarm signal frequency.
- Administer staff surveys to identify perceptions and concerns.
- Use Failure Modes and Effects Analysis (FMEA), a step-by-step approach for identifying possible failures or errors, studying their consequences, and eliminating deficiencies. (See, e.g., the Institute for Healthcare

Defining Terms

Action research in healthcare is a form of applied research—a process of inquiry, investigation, reflection, and continual improvement of clinical practices. Unlike formal research studies, action research is conducted by—or with the full and equal participation of—practitioners. The primary purpose is to develop a deep understanding of practices, interactions, and healthcare environments, using both qualitative and quantitative data, and to take action to improve conditions and results. Action research is a progressive problem-solving cycle of studying and planning, taking action or making change, collecting and analyzing evidence, and reflecting—and repeating that process, according to the Center for Collaborative Action Research at Pepperdine University.

Formal research, also known as scientific, experimental, or quantitative research, is a more rigorous research methodology, typically conducted by researchers whose goals are to be objective and to contribute to knowledge about a topic. Formal researchers identify a problem; conduct a literature review; develop a research question (or questions); formulate a hypothesis (or hypotheses); conduct controlled experiments, randomized trials, or research to collect data; analyze and interpret the data; and use the evidence to justify a claim (or claims). Formal research can be used to “establish or confirm facts, reaffirm the results of previous work, solve new or existing problems, support theorems, or develop new theories,” according to Wikipedia. Formal researchers typically aim to publish their findings in peer-reviewed publications.

Action researchers and formal researchers can use some of the same sorts of data, such as observations, interviews, surveys, and quantitative data, in their research. Action researchers sometimes publish or share their findings as well.

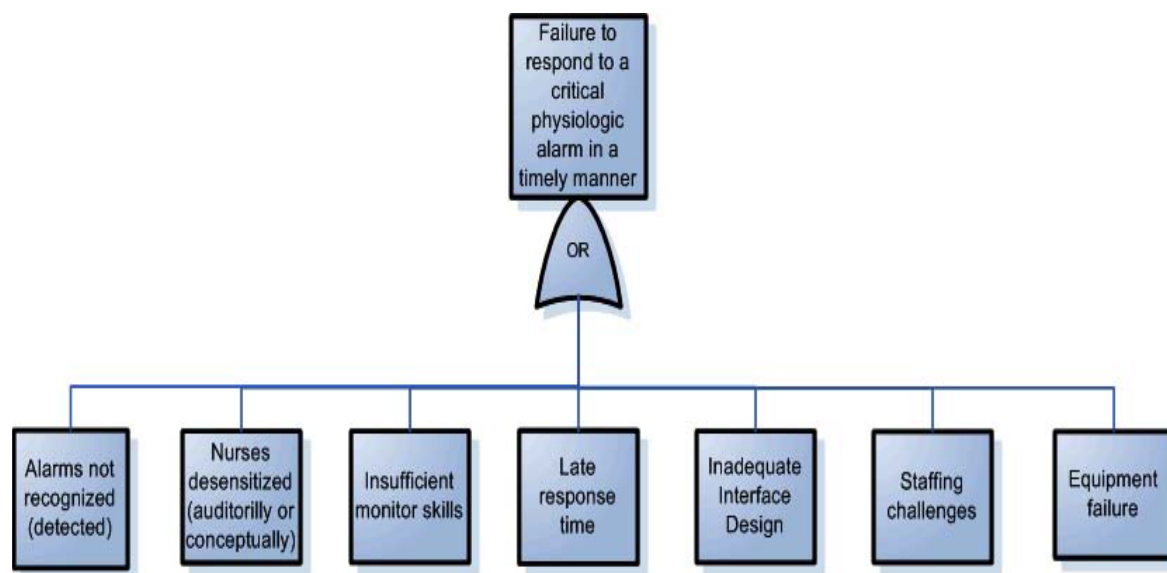


Figure 2. Fault Tree Analysis for a Missed Alarm Signal at Johns Hopkins Hospital

Source: Maria Cvach, RN, MSN, CCRN, and Andrew Currie, MS, The Johns Hopkins Hospital. "Using Data to Drive Alarm System Improvement Efforts." AAMI Foundation seminar presentation, Dec. 17, 2012. Used with permission of the Johns Hopkins Hospital Alarm Management Committee.

Improvement's free Failure Modes and Effects Analysis Tool, available at <http://www.ihl.org/resources/Pages/Tools/FailureModesandEffectsAnalysisTool.aspx>.)

- Conduct a Fault Tree Analysis to discover root causes of potential failures, such as failure to respond to a critical physiologic alarm condition in a timely manner. (See, e.g., Fault Tree Analyser, a free tool for Fault Tree Analysis, available at www.fault-tree-analysis-software.com.)
- Review the literature on alarm challenges and solutions. (See, e.g., the AAMI Foundation's Alarms Best Practices Library at <http://www.aami.org/htsi/alarms/library.html>.)
- Visit or consult with other healthcare systems to glean lessons learned about alarm systems, technologies, policies, protocols, and vendors.
- Visit or consult with your vendor partners to gather best practices from clinical specialists and better understand the technology and functionality around alarm settings and options.
- Conduct a formal research study, with collection of baseline and post-intervention data, and data from comparison units, to measure and analyze changes.

To learn more, see "How Do You Get the Data You Need" on the following page.

Exemplary Practices: Gathering Intelligence



- Just weeks after two sentinel events, **Beth Israel Deaconess Medical Center** had identified alarm-related vulnerabilities and moved quickly to address them. To improve alarm signal audibility, volume settings on alarmed devices were adjusted and remote speakers were installed on large units. To establish accurate timelines for incident investigations, clocks were synchronized on all devices. The medical center built on these corrective actions with a longer-term strategy, including an FMEA, shown in Figure 1, to improve alarm management and cardiac monitoring systems over time. The directors of nursing informatics, patient safety, and inpatient quality, and the supervisor of clinical engineering, were among those on the team that spearheaded these improvements.
- When nurses on a medical cardiology unit at the **University of Pittsburgh Medical Center (UPMC) Presbyterian Hospital** cited excessive alarm noise as a barrier to consistent quality nursing, the unit director and a team of nurses responded immediately with a

10-day pilot investigation. They directly observed the unit, shadowed nurses, and tracked the number and types of alarm conditions and signals and nurses' responses to them. The team also recorded and analyzed data from the unit and main central monitoring station. The findings confirmed nurses' concerns—and also added specificity to them: most alarm conditions were either “false positive” or “true positive,” but with no significant health consequences.

- **Johns Hopkins Hospital** spent two years extracting, analyzing, and interpreting alarm system data and determining key metrics to analyze. The hospital decided to track the average number of patient alarm conditions per monitored bed per day—a metric still used today. Figure 2 shows the top level of a Fault Tree Analysis for a missed alarm signal.
- **Children's National Medical Center** in Washington, DC, and **Dartmouth-Hitchcock Medical Center** conducted formal research studies to collect and analyze data before and after alarm-related improvements were implemented.



How Do You Get the Data You Need?

- Determine if alarm-related data is stored in primary or secondary systems, who has access to it, and how to retrieve it.
- Work hand-in-hand with your healthcare technology vendors. Ask vendors for all data collected in the alarm system logs—including data not necessarily shared as part of the user–device interface.
- Collect data from automated systems and from middleware (secondary notification systems), or both, using tools provided by medical device manufacturers and IT providers.
- Manually record alarm-related information (e.g., number of alarm signals, duration of the alarm signals, most common types of alarm conditions, patient alarm conditions vs. technical alarm conditions, clinician response time to alarms) during unit observations and rounding.
- Identify who will analyze data and how data will be presented (e.g., dashboards, charts, reports).
- Identify who is responsible for handling and silencing alarms.
- Start with a simple baseline and build from there (e.g., number of alerts per day, top three alerts, whether they are actionable).
- Use data to compare the number and type of alarm conditions at your hospital with those of other hospitals, and to compare before and after you make changes to alarm-related practices.
- Collaborate with the healthcare technology management professionals in your facility—and reach out to healthcare technology vendors, bioinformatics professionals and/or academic researchers if you need help with data collection or analysis.

Idea 4

Prioritize the patient safety vulnerabilities and risks to target with alarm management improvements.

The data and information from intelligence-gathering efforts can be used to zero in on the patient safety vulnerabilities to address. How should you go about this?

Consider these approaches from leading practitioners:

- Leverage clinical expertise through a multidisciplinary team to prepare an alarm inventory risk analysis and gap analysis, considering:
 - The priority/risk level of alarm conditions for particular medical devices, such as ventilators, physiologic and telemetry monitors, and infusion pumps (e.g., life-sustaining or life-critical devices; high-, medium- or low-priority alarm conditions; actionable vs. non-actionable alarm conditions)
 - The level of oversight/response needed for alarm conditions, based on the priority/risk level
 - The level of oversight/response typically available for alarm conditions
 - The gap between the needed and current levels of oversight/response

Suggested Priorities For Alarm Conditions

A = High: could result in death if unattended

B = Medium: could lead to unintended consequences if unattended

C = Low: little risk if unattended

Source: Shashi Avadhani, CBET, CCE, MBA, Resident Regional Manager, Crothall Clinical Equipment Solutions. "Initial Steps to Meet the Goal of Reducing Alarm Fatigue." In "How to Identify the Most Important Alarm Signals to Manage." Presentation at the AAMI Foundation Seminar Series on Alarm System Management Resources, Oct. 30, 2013.

- Look for outliers in the data (e.g., units, patient populations, individual patients, time of day, spikes during shift changes).
- Prioritize the alarm-related risks and types of alarmed devices on which to focus.
- Target interventions based on whether an alarm condition exists, and the type of alarm condition—a patient alarm condition or a technical alarm condition.

- Consider customizing default alarm parameters for particular care units and patient populations.
- Identify “low-hanging fruit”—relatively easy improvements that can be implemented quickly, such as increasing the volume of audible alarm signals.
- Develop dashboards or other visual displays of information that support data monitoring, analysis, interpretation, and understanding.

Exemplary Practices:

Prioritizing Patient Safety Vulnerabilities and Risks



- From a literature review and its own data from an FMEA, **Dartmouth-Hitchcock Medical Center** identified two major contributing factors to failure-to-rescue events: unrecognized patient deterioration and unpredictable patient risk factors. In response, the medical center enacted stopgap measures to safeguard patients, including double checks of opioid administration, smart patient-controlled analgesia (PCA) pumps, and rapid response teams. Longer term, the medical center implemented surveillance monitoring—monitoring of all patients in a hospital—first with a high-risk population and then system-wide. (Universal surveillance monitoring differs from targeted telemetry or arrhythmia monitoring only for patients with known risks or conditions.)
- Before moving to longer-term solutions, **Beth Israel Deaconess Medical Center** suppressed clinically insignificant alarm conditions for typically benign premature ventricular contractions and assigned a nurse or patient care assistant to every shift who was primarily responsible for listening for and responding to alarm signals, particularly for low-priority alarm conditions.
- **Johns Hopkins Hospital** targets interventions based on whether an alarm condition exists, and the type of alarm condition—a patient alarm condition or a technical alarm condition. Figure 3 shows an example of a detailed weekly alarm report from a cardiac surgery unit, which identifies predominant patient alarm conditions—systolic, diastolic, and mean arterial blood pressure, and SPO2 low. These are referred to in the figure as “Bad Actors” since many of these alarm signals indicate non-actionable patient conditions. Technical (equipment-related) conditions (Leads fail) are also shown.

Top Tip

PVC alarm conditions duplicate other monitored alarm conditions. Many hospitals turn off this default, while others set it to visual alerts only. Hospitals or hospital units need to determine which alarms are actionable. Any alarm condition that does not prompt a response is a candidate to be reconsidered or reconfigured to be either a non-audible, visual alert (if this feature is available on the equipment) or turned off. This is highly dependent on the manufacturer and model of the equipment. Talk with your vendor about the PVC alarm and determine what works best for you.

The unit uses this data to evaluate high-volume alarm conditions and determines if the unit's default monitor settings should be adjusted to minimize non-actionable alarms. Using the data shown in Figure 3, the unit determined that adjusting the default blood pressure high and low alarm parameter limits very slightly yields big results in reduction of alarm burden without compromising patient safety. For example, the systolic blood pressure high alarm parameter limit was changed from 150 to 170 mmHg. Additionally, encouraging nurses to customize alarm parameter limits based on a patient's baseline conditions helps to make audible alarms more meaningful to nurses. The hospital also has developed a Hospital Alarm Burden and Management Toolkit, which is included in Appendix A.

Detailed Weekly Alarm Management Report

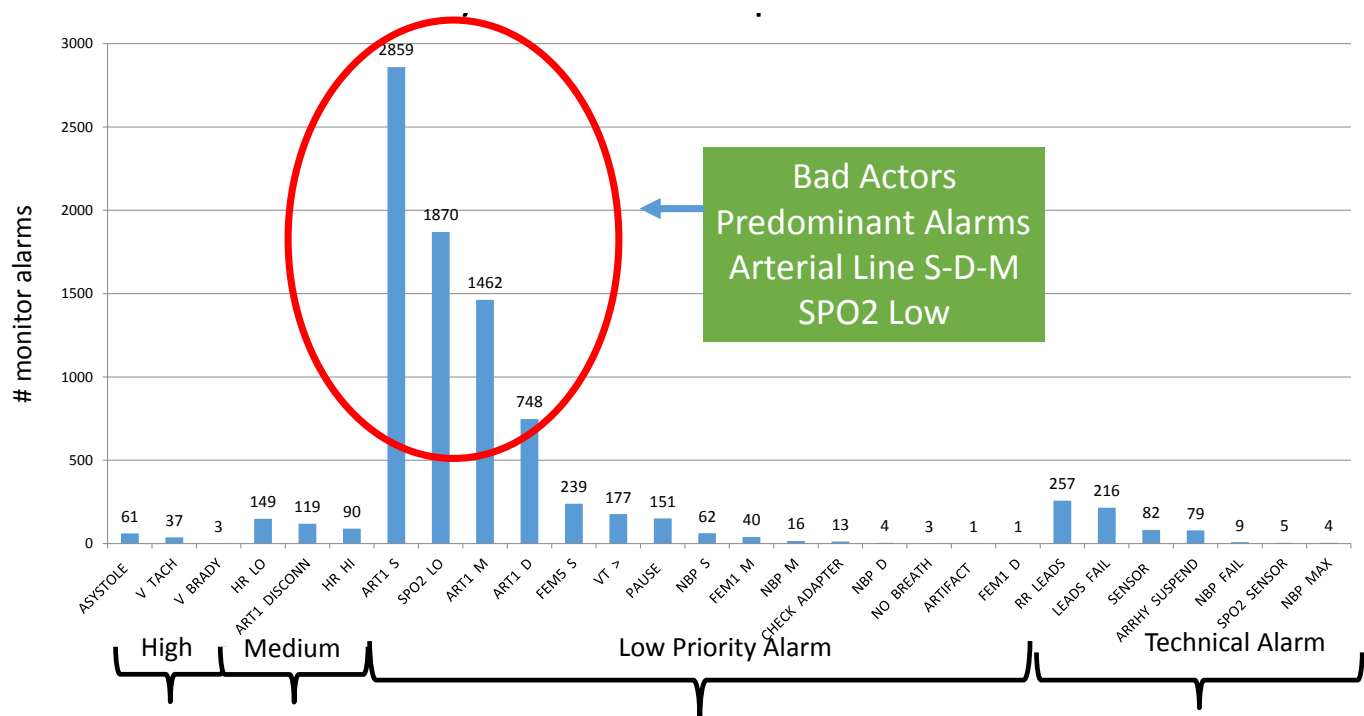


Figure 3. Detailed Weekly Alarm Management Report, with Predominant Low-Priority Alarm Signals Identified

Source: Maria Cvach, RN, MSN, CCRN. The Johns Hopkins Hospital Alarm Burden and Management Toolkit.



How to Manage Alarm Signals At the Bedside from the Clinician's Perspective

Consider these key questions from a seminar in the AAMI Foundation's *Safety Innovation Series* on alarm management:

Key questions

- Can your non-actionable alarm signals be visual only?
- Can alarm signal volume be adjusted?
- Can a delay of alarm signals be programmed, since approximately 90 percent of alarm signals self-correct?
- What alarm parameters are on—and why? For example, do you need continuous monitoring of respiratory rate?
- If you leave a default alarm setting on, will you treat the condition producing the alarm signal in 80% of patients (e.g., ventricular bigeminy, a slightly abnormal heart rate that is usually of no concern in the absence of other cardiovascular disease)?

Key Points

- Adjusting alarms to an actionable level for each patient is an important safety intervention.
- Ask physicians, nurse practitioners, and physicians' assistants: "When do you want to be notified?" Call them to the monitor only when something needs to be done.
- Nurse-to-nurse handoffs are an important time to discuss the frequency and types of alarm conditions, parameters monitored, and alarm system settings.

Idea 5

Set and share goals, objectives, and activities to address patient safety vulnerabilities and risks.

Alarm management task forces and committees can accomplish a great deal on their own to set the stage for improvements. To implement system-wide changes, however, leading practitioners formalize their goals, objectives, and activities and share them with institutional leaders to gain approval and funding. How do they go about this? Consider these approaches:

- Use Failure Modes and Effects Analysis (FMEA) to identify policies and procedures to address potential failure modes.
- Develop recommendations, with realistic and measurable goals, to address the highest-priority risks.
- Identify the departments that have the greatest need, interest, or influence to get on board with the plan.
- Use collected data and analysis, synthesized into compelling reports with visual displays of quantitative information, to present the case for improvement to leadership and to drive change. (For ideas, See Idea 1 on issuing a call to action and committing to solving problems, and Idea 2 on teaming to spearhead actions and build consensus.)
- Develop a business case for funding improvement strategies or solutions—and align it with the institutional mission or goals.
- Gain buy-in from senior leadership to ensure that plans and actions will be sustainable.
- Balance requests for funding with potential cost benefits for patient care (e.g., reduced patient stays, readmissions, and adverse events).

Exemplary Practices: Setting and Sharing Goals



- At the **Children's National Medical Center**, the monitoring committee set a goal of improving the safety and effectiveness of physiologic monitoring throughout the medical center, while providing structure and oversight to all monitoring-related issues. The committee's three objectives focused on reviewing and recommending best practices, recommending and implementing strategies to decrease staff monitor fatigue, and achieving improvements in monitoring throughout the organization. The committee backed up the goal and objectives with a number of specific activities.
- **Kaiser Permanente** identified four goals to improve alarm management: a new adult telemetry standard, alarm customization, alarm hygiene, and reduction of repeated pager notifications. The health system secured approval for its phased work plan from key stakeholders, including alarm work groups, regional critical care peer groups, regional physician chairs, chief nursing officers, and an executive sponsor.
- The multidisciplinary task force at **Christiana Care Health System** recognized that its proposal to implement a flexible telemetry monitoring system, with dedicated monitor technicians, would be a radical departure from established practices. The task force involved the health system's top management—including the CEO, CFO, chair of medicine, and department chiefs—to secure approval and funding. The business case aligned recommendations for improvement to the health system's goal of becoming a cardiac center of excellence.



Idea 6

Develop and pilot potential solutions.

Armed with data, insights, and institutional approval, leading practitioners typically are fired up about the potential to improve patient safety. At the same time, most begin conservatively, with pilot projects that become models for wider-scale implementations. How can you learn from this approach? Consider this advice from leading practitioners:

- Use “sandbox” thinking—design, development, and testing of an innovation or idea within a constrained and controlled environment—to conduct rapid-cycle mini-experiments with a continuous improvement mindset.
- Give consideration to evidence-based indications for appropriate initiation, maintenance, and discontinuation of medical equipment that produces alarm signals.
- Assess and test new equipment and alarm management alternatives.
- Make modest changes, going unit by unit.
- Recognize that a one-size-fits-all approach won’t work—even within the same hospital—given differences in the environment of care, patient populations and needs, and staff readiness on different hospital units.
- Facilitate and guide the change process, working with motivated clinical managers and vendors, if appropriate.
- Monitor changes closely, listen to front-line concerns, and respond quickly to any issues by making adjustments.

Exemplary Practices: Piloting Solutions



- **Dartmouth-Hitchcock Medical Center** piloted the rollout of its surveillance monitoring system on a unit that met its requirements to conduct a robust research study: a patient population prone to respiratory deterioration, a strong leadership team, and staff who were motivated to participate. The nurse manager on that unit played a central role in supporting the staff and, with colleagues on the implementation team, working with nurses to optimize the system and changes in practices. Within 24 hours, for example, nurses made clear that short (30-second) notification delays in alarm signals would reduce their alarm burden, a change that was made quickly. Nurses also were empowered to pull the plug on the project—and, in a survey six weeks into the project, 100 percent gave it a thumbs-up.

“Any intelligent fool can make things bigger and more complex... It takes a touch of genius—and a lot of courage—to move in the opposite direction.”

— *Albert Einstein*

- **UPMC Presbyterian Hospital** launched pilot projects aimed at decreasing alarm signal ring time, improving staff response to cardiac monitor alarm signals, and decreasing alarm noise on two units—a medical cardiology unit and a progressive care unit with a high volume of monitoring equipment. The top priorities of the pilots were to increase staff accountability, help staff differentiate between actionable and non-actionable alarm conditions, and manage low-priority alarm conditions that do not require immediate response, but cannot be ignored, such as telemetry pack battery warnings.
- **Kaiser Permanente** carefully selected beta sites that were willing to test alarm management improvements aligned with its four goals. Kaiser also produced resources and tools, such as a quick reference pocket guide and an online library, to support clinicians in implementing the changes with fidelity.
- **Christiana Care Health System** tested its technology infrastructure before implementing a pilot of its “mission critical” flexible telemetry monitoring system, and made further tweaks after the system went live, to eliminate “dead spots” in wireless coverage.
- **Johns Hopkins Hospital** piloted modest changes to default alarm settings, differentiating between visual and auditory alarm signals and adjusting parameter limits. Changes were made incrementally and monitored on each unit.

Immediate and Longer-Term Alarm Management Actions

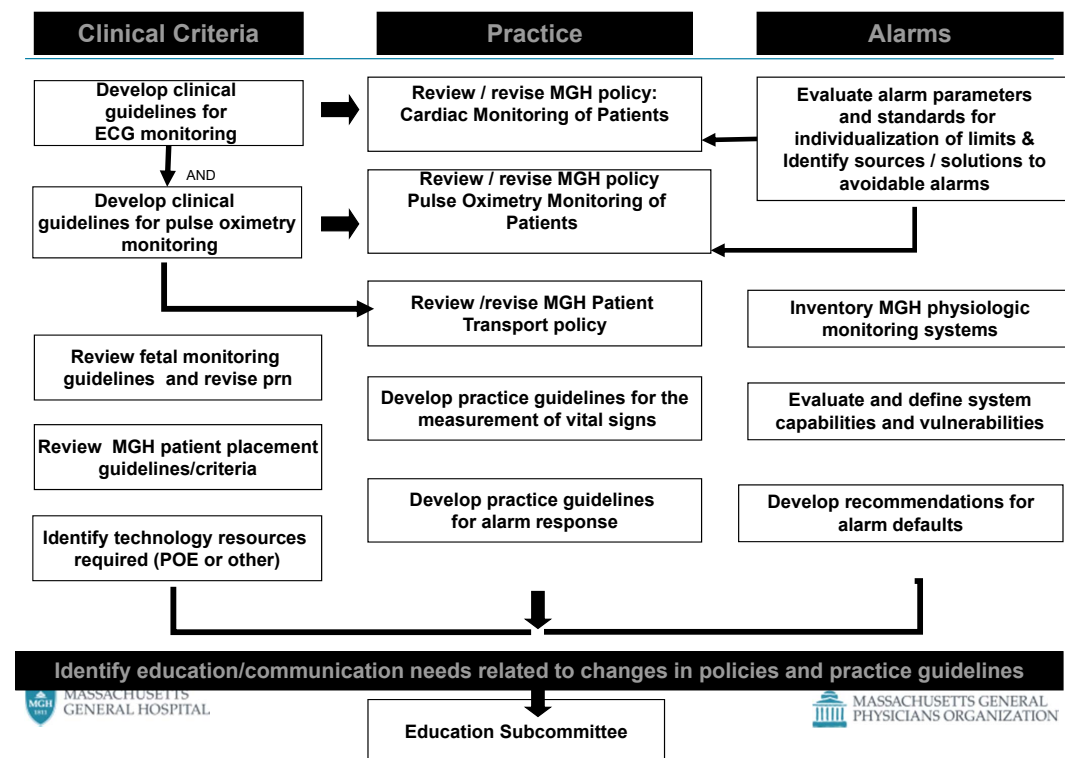


Figure 4. Massachusetts General Hospital Physiological Monitoring Tiger Team Workgroups and Deliverables

Source: Bryan, R., & Volpe, P. "Clinical Alarm Management: Our Journey." Massachusetts General Hospital. Presentation at the AAMI Foundation National Coalition for Alarm Management Safety, April 24–25, 2014.

Efforts to improve clinical alarm management at Massachusetts General Hospital began with the development of a clinical alarms task force. In 2010, the hospital strengthened the campaign across the institution, which resulted in these actions:

- Standardized alarm volume defaults, at bedside and centrally, and set absolute minimums
- Enhanced alarm signal audibility by installing additional distributed speaker systems
- Installed additional distributed speaker systems
- Implemented a review and approval process for variation requests from institutional standards
- Developed the multidisciplinary Physiologic Monitoring Tiger Team
- Implemented mandatory RN education and training

Physiologic Monitoring Tiger Team workgroups had specific tasks and deliverables to address clinical criteria for physiologic monitoring, monitoring practice, and alarm management, as shown in Figure 4. The groups worked together and identified education and communication needs related to changes in policies and practice guidelines. An education subcommittee used this information to promote technical competency and create a branding campaign, "Every Alarm Warrants Attention," to support a culture of alarm system awareness and response.

Idea 7

Evaluate the effectiveness of improvements and make adjustments as needed.

Just as data and analysis inform alarm management priorities and plans, they can help you make adjustments before a wider scale-up. How can you learn from pilot projects, make the next round of alarm management changes go more smoothly, and avoid unnecessary expenditures?

Consider these approaches from leading practitioners:

- Compare recorded baseline data with changes to key metrics to measure the impact of new practices and technology.
- Compare the impact of interventions to the status quo on other units.
- Gather feedback from pilot participants.
- Communicate findings and share insights with pilot participants, executive sponsors, and other key stakeholders.
- Consider whether adjustments are necessary.

Exemplary Practices: Evaluating and Improving

- **Johns Hopkins Hospital** compared pre- and post-change data from different units, which convinced the hospital that multiple solutions would be needed to address the risk profiles of different patient populations and units.
- Similarly, **Dartmouth-Hitchcock Medical Center** reviewed its data and realized it needed to optimize its universal surveillance monitoring system by adjusting parameters on monitored variables for different patient populations.
- **UPMC Presbyterian Hospital** examined data on nursing confidence before and after alarm management changes were implemented, and realized that it needed to provide nurses with more training to improve their competencies. Similarly, a key takeaway from early improvement efforts at **Dartmouth-Hitchcock Medical Center** was the need to “double down” on training.

“Alarm [signal] enunciation should not be stress-inducing. In fact, if alarm [signal] enunciation induces a startle or stress response, then the most likely reaction will either be an immediate ‘turn it off!’ or some other automated response, rather than more thoughtful deliberation about the situation. Rather, the goal of an alarm [signal] should be to inform and then move the recipient to an appropriate action.”

— Matthew B. Weinger, M.D., Norman Ty Smith chair in patient safety and medical simulation and professor of anesthesiology, biomedical informatics, and medical education at Vanderbilt University School of Medicine

Idea 8

Develop policies and procedures.

With literature and best practices on alarm management accumulating, you might be tempted to use them to jumpstart improvements by crafting policies and procedures at the outset of your efforts.

Leading practitioners advise against this. Instead, they recommend first going through the process of data collection and analysis to understand the real challenges at your institution, prioritize the risks, try small-scale pilots, and learn from them. Only then will you have enough knowledge and experience to know what sorts of changes to policies and procedures make sense. When the time is right, how can you develop effective policies and procedures? Consider this advice from leading practitioners:

- Consider having an overarching alarm management policy with device-specific alarm management procedures incorporated into the device protocol.
- Negotiate changes to alarm settings, parameters, and notifications; alarm response times; and/or alarm-related clinical practices with key stakeholders.
- Keep in mind that policies and procedures should take into account different alarm management solutions on different units. Consider standardization across common areas (e.g., telemetry units, ICUs) to minimize disparity and reduce risk of errors due to differences in practices.
- Consider adopting or adapting existing policies and procedures from other institutions.
- Put teeth in policies and procedures by tasking responsibility for monitoring them to one or more stakeholders, such as healthcare technology management professionals, clinical managers, and nurse educators.
- Think about whether new policies or procedures are really necessary—or if poor compliance with existing policies and procedures is the true issue that needs to be addressed with education and training, for example.

Exemplary Practices: Policies and Procedures



- **Christiana Care Health System** developed a system-wide alarm policy and a set of protocols that defined an alarm management strategy for alarmed medical equipment, including flex monitors, standard cardiac monitors, pulse oximeters, and infusion pumps. The clinical engineering department serves as a clearinghouse that keeps the policy in effect. Biomedical technology professionals set up alarmed medical devices with the healthcare system's alarm settings, rather than keeping the manufacturer default settings, and make sure these settings are maintained after servicing. They step in if a clinician wants to deviate from agreed-upon standards, and they coordinate and document decisions and changes to the standards.
- The Alarm Management Committee at **Johns Hopkins Hospital** revised default monitor alarm settings unit by unit, in all monitored units, to actionable levels. The committee also standardized practices throughout the hospital and developed the hospital's clinical alarm policy and cardiac and physiological monitor policy.
- **Beth Israel Deaconess Medical Center** adopted existing guidelines for putting patients on monitors.
- An evaluation by **Children's National Medical Center** revealed that fewer than 50% of physicians and licensed independent providers complied with the hospital's existing alarm management policy, which required them to order or set cardiopulmonary monitor alarm parameters every 24 hours.

See Sample Default Parameter Settings for Alarm Management on page 34 to find out how some institutions are customizing settings on alarm systems for specialized units and particular adult and pediatric patient populations.

Tips for Developing Alarm Management Policies and Procedures

- There should be an institution standard for alarm management.
- Alarm parameters should be set for actionable levels and to decrease false alarms—monitor this as part of your unit performance improvement (PI).
- Nurses must be educated to the policy so there is consistency as to how the alarms are set.
- At least once per shift, the staff should analyze alarm parameters and alarm levels to determine if they are appropriately set.
- Allow staff input to the policy.
- Work with staff to audit compliance to the policy.

Source: Nancy Blake, PhD, RN, CCRN, NEA-BC, FAAN, Director of Clinical Care Services, Children's Hospital Los Angeles. "How to Manage Alarms at the Bedside: The Administrator's Perspective." Presentation at AAMI Foundation Alarm Management seminar, Dec. 3, 2013.

Leadership Goals for Alarm Management

- Enhance patient care and patient safety.
- Decrease nuisance alarms and alarm fatigue.
- Ensure staff accountability and responsiveness to alarm signals and ensure they know their responsibility.
- Improve productivity and work flow.
- Increase patient and staff satisfaction.
- Optimize technology.
- Align with/meet The Joint Commission National Patient Safety Goal on alarm management.
- Make the organization an environment of healing, where there is a decrease in the noise.

Source: Lisa Pahl, Senior Consulting Manager and Practice Lead for Alarm Fatigue/Alarm Management, Philips Healthcare. In Nancy Blake, PhD, RN, CCRN, NEA-BC, FAAN, Director of Clinical Care Services, Children's Hospital Los Angeles. "How to Manage Alarms at the Bedside: The Administrator's Perspective." Presentation at AAMI Foundation Alarm Management seminar, Dec. 3, 2013.

Idea 9

Educate to build and maintain staff competencies.

Changes to alarm management tend to be some of the most ambitious shifts in practice that any hospital can make. Without attending to staff education, these changes are hard to implement with fidelity and to sustain. How should you develop and deliver staff education and training? Consider these approaches from leading practitioners:

- Educate and train staff at all levels before, during, and after launching pilots and wider-scale implementations.
- Share the training implementation plan and process with senior management.
- Make sure that staff know why changes are occurring, and how changes will benefit them and their patients, not just what they are supposed to do differently or how to operate new technology.
- Circle back to policies and procedures to design training.
- Use and share collected data and patient case studies with clinicians to illustrate the need for changed practices and the impact of piloted changes.
- Build clinicians' critical thinking competencies so that they can use alarm-related information to improve patient care.
- Ensure that clinicians understand the science behind which aspect of each vital sign is being monitored, and how the particular technology your hospital uses meas-

ures that function. This knowledge is critical to successfully customizing a parameter to a particular patient's functions.

- Blend formal and informal learning experiences.
- Use multiple learning modalities and venues, such as face-to-face training in classrooms or on units; training during clinical rounds; simulations; and online, self-paced training.
- Relieve clinicians of patient care responsibilities during training, so they can focus on learning without interruptions and distractions.
- Consider phased or leveled approaches to training to develop basic to advanced competencies.
- Deliver training over time, in multiple doses, not as a one-time event.
- Supplement training with job-embedded coaching or mentoring.
- Use daily standups with nurse managers and floor nurses to discuss specific alarm management problems that occurred during the previous shift.
- View training as an opportunity to create a cadre of people who can become advocates for improvements.
- Assess clinical competencies after training and regularly thereafter to refresh and update alarm management skills.
- Assess the effectiveness of training programs regularly—and adjust or double down on training, if necessary.
- Share and celebrate staff successes during and after training.
- Cultivate “champions” on patient care units.

“Research has demonstrated that education alone does not change practice. One more effective strategy is that of a “champion.” This works especially well in a healthcare environment that is 24/7. I always say it needs to work at 2 a.m. on a Saturday.”

—Sue Sendelbach, PhD, RN, CCNS,
FAHA, FAAN, Director of Nursing
Research, Abbott Northwestern
Hospital, MN

Exemplary Practices: Building Staff Competencies



- Before a pilot project and research study began at **Dartmouth-Hitchcock Medical Center**, project leaders developed a comprehensive training program for all nurses on the pilot unit, including a motivational discussion to explain the patient safety issues and the plan to minimize them, vendor training on new surveillance monitoring technology, and explanation of new alarm thresholds. For the first two weeks of the pilot, project leaders led daily clinical rounds to help nurses become comfortable with the clinical and equipment aspects of the system. When nurses had trouble using pagers, the project team brought the vendor back for additional training. The nurse manager also used every opportunity to teach nurses during patient care, mentor them to troubleshoot problems to improve patient outcomes, share experiences and results, and celebrate successes. Today, the training

program for what is now universal surveillance monitoring for all patients includes a background slide presentation and hands-on pager and system training.

- **UPMC Presbyterian Hospital** conducted “alarm competency classes” with a curriculum focused on how alarm signals can be customized by nursing staff on pilot units. Project leaders also held Nursing Grand Rounds on how to address alarm fatigue and improve alarm recognition and awareness. Based on their experiences on the pilot units, the hospital created an evaluation tool, “Eight Critical Elements to Monitor Alarm Competency,” based on commonalities across units and departments, as shown in the sidebar below. Nurses and medical technicians throughout UPMC are now required to take an annual competency review on each of the critical elements, which includes a written exam and, for the clinical team responsible for managing patients, a hands-on observation exam. Coaching is provided to anyone who does not pass the review.
www.aami.org/NCAMS/Alarm_Competency_White_Paper.pdf

UPMC’s Eight Critical Elements to Monitor Alarm Competency

UPMC requires hospital staff to demonstrate how to:

1. Admit a patient in the cardiac monitoring system
2. Discharge a patient from the cardiac monitoring system
3. Review alarm settings
4. Customize alarm settings and document these settings in the electronic health record
5. Properly place leads on a monitored patient
6. Correctly load ECG paper in the machines
7. Appropriately put patient monitors in stand-by mode versus alarm signal suspend mode
8. Set monitors to correctly identify a pacemaker implanted in a patient (i.e., the “pacer” function must be turned on in the monitor if a patient has a pacemaker so the algorithm can detect the pacer spikes and not misread them as an event that requires an alarm signal).

- **Beth Israel Deaconess Medical Center** developed a new specialty—telemetry technician—and an in-house, three-level telemetry education program. Every year, all clinical nurses have to take a telemetry competency assessment to make sure their skills are up to date.
- **Boston Medical Center**, which in recent years has standardized default alarm settings and made other changes to manage crisis alarm conditions and reduce alarm burden, also ensures staff competency through a telemetry exam. Staff members can build competencies through simulation and by using a portable training cart. Training affects all users—physicians as well as nurses. The medical center leverages quality tools to define issues, uncover risks and gaps, and tailor training to address them. And it uses “in-the-moment” training to support staff as they manage changes.

Whalen, D.A., Covelle, P.M., Piepenbrink, J.C., Villanova, K.L., Cuneo, C.L., & Awtry, E.H. Novel Approach to Cardiac Alarm Management on Telemetry Units. *J Cardiovasc Nurs*. 2014 Sep-Oct;29(5):E13-22. doi: 10.1097/JCN.0000000000000114.

- **VA Boston Healthcare System** considers training tools, clinical competency, the learning environment, vendor involvement, and clinical engineering involvement as training factors in its education program. VA Boston provides ongoing training in skin preparation, proper electrode placement, troubleshooting, and critical thinking. The healthcare system also offers a monthly education series on topics such as arrhythmia-specific alarms and management, and an annual medical equipment day focused on alarm chaining and latching. Every two years, clinicians take the American Heart Association’s Advanced Cardiovascular Life Support course. Finally, VA Boston plans to implement computer-based training (CBT) and revised competency assessments, and will working with vendors to integrate their educational materials into its CBT education and tracking system.

Idea 10

Scale up and sustain by creating ownership at the unit level and with continuous improvement.

Alarm-related patient safety doesn't just happen. You have to work at it—and continue working at it.

Leading practitioners began engaging in initiatives to improve alarm management long before the Joint Commission 2014 National Patient Safety Goal was announced. Whether they convened a task force to respond to a patient safety incident or because they had a sense that they could change the trajectory of some burgeoning alarm-related challenge, most never envisioned that they would be working on alarm management issues for years.

Yet that is what it takes to scale up and sustain improvements system-wide—and leading practitioners are more committed than ever. That's because they have hard data verifying that alarm management initiatives yield measurable results, such as improved patient safety and environment of care, reduced alarm burden, and a shared sense of responsibility for alarm management.

How can you embed alarm management into business as usual into your hospital or healthcare system? Take these cues from leading practitioners:

- Preserve and draw upon the collective wisdom of the alarm management team (or teams) by making it a permanent part of the institutional management team.
- Meet regularly to discuss alarm-related progress and issues.
- Communicate to all levels of your organization, not just with the alarm management team or units in which you are working.
- Involve front-line staff in all aspects of alarm management.
- Continue monitoring, measuring, and sustaining alarm management improvements—and attend to the degree to which improvements are used, a key indicator of success.
- Stay current on emerging research, best practices, and technology.
- Develop a culture of action research and continuous improvement.
- Revise your plans frequently to address new issues and to reflect changes in the environments of care in your hospital or healthcare system, along with insights from research and best practices, and new technology options.
- Explore innovative ways to use alarm-related systems and capabilities to improve patient safety.
- Continue educating and training to refresh the alarm-related competencies of new and existing staff and to prevent progress from backsliding.
- Develop educational resources, campaigns, or both, to remind staff members to follow protocols and best practices.
- Network with colleagues and professionals in your organization and beyond who are committed to improving alarm management to stay abreast of alarm management needs and innovations.

“Safety is “a dynamic non-event.”

—Karl Weick, *Rensis Likert Distinguished University Professor Emeritus of Organizational Behavior and Psychology, University of Michigan*

Exemplary Practices: Scaling Up and Sustaining



- **Beth Israel Deaconess Medical Center's** telemetry task force now guides decisions around alarm system management standards, guidelines, and equipment upgrades. It works with vendors to tailor alarm systems on medical equipment, and focuses on which patients should be connected to cardiac telemetry monitors. And the task force continues to look for improvements to further reduce alarm signal noise. The medical center uses “plan, do, check, act” cycles of continuous improvement.
- **UPMC Presbyterian Hospital** set up two task forces—a Monitor Task Force Group and a Patient Safety Group—to continue to improve upon alarm safety, review any incidents, and identify improved outcomes. In addition, UPMC created a Monitoring Alarm Communications Committee to address alarm-related issues across the entire UPMC system, which operates more than 20 academic, community, and specialty hospitals.

The focus of **Johns Hopkins Hospital's** alarm-related work has shifted away from rescue alarm conditions toward developing better predictive systems that can catch declining patient states before they become emergencies. www.aami.org/NCAMS/Johns_Hopkins_White_Paper.pdf

- **Dartmouth-Hitchcock Medical Center** continues to look for innovative ways to use universal surveillance monitoring for all patients, such as optimizing its system for different patient populations to improve on the threshold rates of alarming. Similarly, **Christiana Care Health System's** multidisciplinary task force continues to seek innovative ways to use its flexible telemetry monitoring system, such as identifying early warning indicators of patient deterioration. www.aami.org/NCAMS/020613_Slides_Dartmouth_Hitchcock.pdf
www.aami.org/NCAMS/Dartmouth_Hitchcock.pdf

Consider Institutional Policies and Practices of High-Reliability Organizations

“By definition, a high-reliability organization is an organization that, despite operating in a high-stress, high-risk environment, continually manages its environment mindfully, adopting a constant state of vigilance resulting in the fewest number of errors. Many healthcare organizations have adopted, or are in the process of adopting, high-reliability behaviors and business strategies, resulting in fewer medical errors for their patients.

High-reliability organizations are built upon a foundation with a just culture as the supporting framework. That framework is comprised of a number of components, with incident reporting playing an integral role. According to experts, achieving high reliability will be challenging without a thorough understanding of a health system's strengths and weaknesses. To better understand the areas of potential weakness, every unsafe condition, near miss or harm event needs to be reported and analyzed in order to find the place where, as James Reason advises, the holes in the Swiss cheese are soon likely to line up, and cause greater harm.”¹

5 Traits of High-Reliability Organizations^{2,3,4}

1. Sensitivity to operations
2. Reluctance to oversimplify the reasons for problems
3. Preoccupation with failure
4. Deference to expertise
5. Resilience

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TEXAS CHILDREN'S HOSPITAL

Bringing Multiple Alarm Management Challenges into Focus

A multi-year initiative at Texas Children's Hospital to improve alarm management illustrates the value of sticking with efforts to understand and address multi-faceted challenges.

A multidisciplinary alarm management team celebrated success in 2011, when its hospital-wide strategies to manage code red alarm signals and staff emergencies associated with physiological monitors resulted in a 66% reduction in the quantity of secondary alarm notifications to nurses. Those strategies included:

Alarm thresholds

- Defining and standardizing alarm limits by patient age and hospital unit
- Developing a nursing policy on who can change alarm limits and when

Secondary notifications and escalations

- Reviewing alarm gateway and middleware to route alarm signals from the bedside to the nurse device
 - This eliminated the escalation path for unanswered alarm signals/code red/staff emergency.
 - This reduced redundant messaging by 52 messages per event.

Delays

- Delaying alarm signals to reduce the number of alarms to caregivers
 - Example: Increased a 10-second alarm signal delay to 20 seconds in acute care areas

More Work Needed to Be Done

Those strategies, however, did not help "Nurse Nancy," who was assigned on one shift to three patients on a progressive care (step-down) unit, with physiological alarm parameters shown in Table 1.

In one 12-hour shift, the physiological monitors for these three patients generated 336 alarm signals. On average, Nurse Nancy spent 14% of her shift that day in "alarm flood," defined as more than 10 alarms in 10 minutes—more than she could respond to. She experienced seven alarm floods, totaling 2.25 hours of her shift, with more than 50% of secondary alarm notifications indicating "warning" or "crisis" alarm conditions. With only 70 minutes of "alarm silence" during her shift, Nurse Nancy could not prioritize how to deliver care during alarm floods.

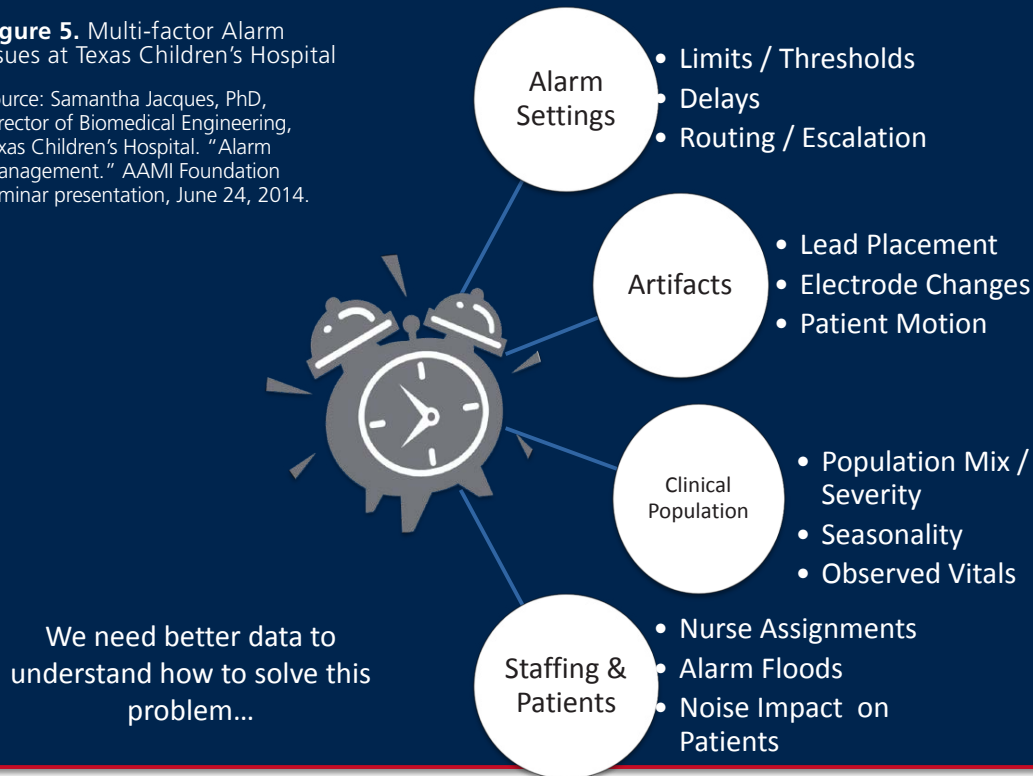
	Oxygen Saturation (SpO2)	Heart Rate (beats per minute)	Respiratory Rate (breaths per minute)
An 11-month-old patient, post-heart surgery	93–100%	80–120	25–40
A two-year-old renal patient, post-pheresis	93–100%	70–110	20–30
An eight-year-old cystic fibrosis patient, post-lung transplant	93–100%	55–85	12–18

Table 1. Patients and Alarm Parameters in a High-Risk Environment

Source: Samantha Jacques, PhD, Director of Biomedical Engineering, Texas Children's Hospital. "Alarm Management." AAMI Foundation seminar presentation, June 24, 2014.

Figure 5. Multi-factor Alarm Issues at Texas Children's Hospital

Source: Samantha Jacques, PhD, Director of Biomedical Engineering, Texas Children's Hospital. "Alarm Management." AAMI Foundation seminar presentation, June 24, 2014.



To better understand the challenges for Nurse Nancy and her colleagues, the Texas Children's alarm management team worked with Medical Informatics to analyze unit-, nurse-, and patient-level data:

- At the unit level, the team identified the top 15 types of alarms conditions, with low oxygen saturation (SpO2) representing 44% of all alarm conditions, 25.5% of which were artifacts of patient motion or electrode placement issues. The team also identified "bad actors," such as LEAD FAIL on respiratory rate alarm conditions. Instituting a four-second delay on these alarm conditions reduced alarm signals by 64%.
- At the nurse level, the team analyzed the alarm load distribution for nurses during their shifts, finding a median of 175 alarm signals per nurse on a 12-hour shift. They considered more than 150 alarms for a 12-hour shift as high.
- At the patient level, the team examined individual patient data, including the observed distribution of vital signs, alarm conditions and alarm duration vis à vis the mix of the patient population and severity of their

conditions. This data supported changes to SpO2 thresholds for some patients, from the standard 93% to 90%, and alarm signal delays of up to 10 seconds to reduce alarm burden.

This unit-, nurse-, and patient-level data also led to a leadership dashboard with trending and shift alarm analytics. The dashboard provides unit charge nurses with situational awareness on patients with high volumes of alarm conditions, which enables them to better assign nurses for improved patient management.

Now, the alarm management team is working on care team tools for managing alarm thresholds for individual patients and deploying intelligent alarm systems that analyze multiple alarm signals. The team also is turning its attention to alarm systems beyond those in physiological monitors, such as ventilators.

Figure 5 shows the multi-factor alarm issues recognized at Texas Children's Hospital.

Sample Default Parameter Settings

Adjusting default parameter settings to reflect different clinical settings and patient populations can be part of a thoughtful, comprehensive alarm management initiative. This section provides a compilation of sample settings for adult and pediatric care units reported in a small-sample survey of hospitals and healthcare systems.

To better understand how healthcare organizations are responding to alarm management challenges, the AAMI Foundation National Coalition for Alarm Management Safety conducted a survey of hospitals and healthcare systems in the coalition. This small-sample survey is informative, but not necessarily representative of all facilities.

All survey respondents indicated that changing default parameter settings on medical devices with alarm systems is part of their alarm improvement strategy. The parameters covered in this section are:

- Heart rate (beats per minute [BPM])
- Blood pressure (systolic, diastolic, and mean) – millimeters of mercury (mmHg)
- Oxygen saturation (SpO₂)
- Respiratory rate (breaths/minute)
- End-tidal carbon dioxide (in some facilities or units) (mmHg)

Sample default parameter settings are provided for adult and pediatric care units.

“Remember: The defaults are your starting point—you start there and adjust for the individual patient.”

— JoAnne Phillips, MSN, RN, CCRN, CCNS, CPPS, clinical informatics professional development specialist, the University of Pennsylvania Health System

The sample default alarm parameters in this section vary by organization, unit type, and patient population, and on which manufacturer’s monitor they were established. They are **by no means prescriptive**. They are intended to be a helpful resource for healthcare delivery organizations, so that every organization does not have to start its alarm management work from scratch.

It is important to note that these sample settings do not reflect best practice or standard of care, and may not have been optimized to minimize non-actionable alarm signals. They are snapshots in time and show how some hospitals are evolving in setting their alarm default parameters.

This information does not constitute legal, regulatory, operational, or procedural advice, nor does it constitute a standard of care. It is essential that each healthcare delivery organization assess the material in the context of its own organizational needs, culture, technology, and priorities.

For Adults

The default parameter settings for adults are aggregated for the 17 hospitals and healthcare systems that responded to the survey:

- Medical intensive care unit (ICU)
- Surgical ICU
- Medical–Surgical ICU (combined unit)
- Cardiac Surgical ICU
- Neurological ICU
- Coronary care
- Emergency department
- Progressive step-down unit
- Medical–surgical telemetry

Unit type was identified by survey respondents and not defined. Not all survey respondents provided information for all of these types of units or for all default parameter settings.

About the Survey Respondents

The 17 hospitals and healthcare systems that responded to the survey about default parameter settings for adults are designated by letters and described as follows, with large facilities defined as those with 400+ beds and medium facilities defined as those with 150 to 399 beds:

- A. Large Academic, Midwest
- B. Large Academic, Northeast
- C. Large Academic, Northeast
- D. Medium Academic, Midwest
- E. Large Academic, Northwest
- F. Large Academic, Southwest
- G. Large Academic, Southeast
- H. Large Academic, Southeast
- I. Medium Academic, Midwest
- J. Large Academic, Northeast
- K. Large Academic, Southwest
- L. Medium Academic, Southwest
- M. Large Academic, Northeast
- N. Large Academic, Northeast
- O. Large Children’s Academic, Southeast
- P. Large Children’s Academic, Southwest
- Q. Large Academic, Midwest

Understanding the Default Parameter Settings For Adults

Changing default parameter settings must be considered in the context of whether “smart” or intelligent software interfaces and alarm delays exist on medical equipment with alarm systems. If a hospital in the survey reported it was using this type of technology, the type of technology is marked by the hospital identifier in the default tables as:

* Incorporating short delays before alarm sounds

Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)

^ Using a software interface to incorporate multiple parameters into a single indicator

Medical ICU

Default Parameter Settings

	Heart Rate		Respiratory Rate		Oxygen Saturation	End-tidal Carbon Dioxide	
Facility	Low	High	Low	High	Low	Low	High
A	45	—	—	—	87	—	—
B	50	120	8	35	92	10	40
C *	60	120	8	30	90	30	50
D *	50	130	—	—	88	—	—
E *#^	—	130	—	—	—	30	50
F ^	—	120	10	24	90	—	—
G #	50	150	—	35	87	30	50
H *	50	140	8	30	88	—	—
I *#	—	—	—	30	90	—	—
K #	—	130	6	40	89	—	—
L *#^	45	140	8	25	< 80	—	—
Q	30	160	—	—	88	—	—

Table 2. Heart Rate, Respiratory Rate, Oxygen Saturation, and End-tidal Carbon Dioxide: Default Parameter Settings by Facility, Medical ICU

	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
Facility	Low	High	Low	High	Low	High
B	90	160	50	90	55	120
C *	90	160	50	90	60	90
D *	80	180	40	100	50	140
E *#^	90	160	50	90	60	110
F ^	90	—	—	—	—	—
G #	—	180	—	—	60	—
H *	90	180	40	110	65	120
K #	90	160	40	100	60	—
L *#^	40% change	40% change	40% change	40% change	40% change	40% change

Table 3. Blood Pressure: Default Parameter Settings by Facility, Medical ICU

Legend	
*	Incorporating short delays before alarm sounds
#	Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)
^	Using a software interface to incorporate multiple parameters into a single indicator

Surgical ICU

Default Parameter Settings

Facility	Heart Rate		Respiratory Rate		Oxygen Saturation
	Low	High	Low	High	Low
A	45	—	—	—	87
B	50	120	8	35	92
C *	60	120	8	30	90
D *	50	130	—	—	—
E *#^	—	130	—	—	—
F ^	—	120	—	—	—
H *	50	120	5	50	88
K #	—	130	6	40	89
L *#^	45	140	8	25	< 80%

Table 4. Heart Rate, Respiratory Rate, and Oxygen Saturation: Default Parameter Settings by Facility, Surgical ICU

Facility	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
	Low	High	Low	High	Low	High
B	90	160	50	90	55	120
C *	90	160	50	90	60	90
E *#^	90	160	50	90	60	—
H *	90	180	0	350	55	120
K #	90	160	40	100	60	—
L *#^	40% change	40% change	40% change	40% change	40% change	—

Table 5. Blood Pressure: Default Parameter Settings by Facility, Surgical ICU

Legend	
*	Incorporating short delays before alarm sounds
#	Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)
^	Using a software interface to incorporate multiple parameters into a single indicator

Medical–Surgical ICU (Combined)

Default Parameter Settings

	Heart Rate		Respiratory Rate		Oxygen Saturation	End-tidal Carbon Dioxide	
Facility	Low	High	Low	High	Low	Low	High
A	—	—	—	—	87	—	—
B	50	120	8	35	92	10	40
D *	50	130	—	—	88	—	—
E *#^	—	130	—	—	—	30	50
F ^	50	120	10	24	90	—	—
J	45	150	5	50	85	—	—
K #	—	130	6	40	89	—	—
L *#^	45	140	8	25	< 80	—	—
M #^	50	140	—	—	80	—	—

Table 6. Heart Rate, Respiratory Rate, Oxygen Saturation, and End-tidal Carbon Dioxide: Default Parameter Settings by Facility, Medical–Surgical ICU

	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
Facility	Low	High	Low	High	Low	High
B	90	160	50	90	55	120
D *	—	—	40	100	50	140
E *#^	90	160	50	90	60	110
F ^	90	140	—	—	—	—
J	80	180	—	—	50	180
K #	90	160	40	100	60	—
L *#^	40% change	40% change	40% change	40% change	40% change	40% change

Table 7. Blood Pressure, Default Parameter Settings by Facility, Medical–Surgical ICU

Legend	
*	Incorporating short delays before alarm sounds
#	Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)
^	Using a software interface to incorporate multiple parameters into a single indicator

Coronary Care

Default Parameter Settings

Facility	Heart Rate		Respiratory Rate		Oxygen Saturation	End-tidal Carbon Dioxide	
	Low	High	Low	High	Low	Low	High
A	—	—	—	—	87	—	—
B	50	120	8	35	92	10	40
C *	60	120	8	30	90	—	—
E *#^	—	130	—	—	—	30	50
F ^	50	120	—	—	—	—	—
H *	50	120	8	30	88	—	—
I *#	50	140	8	30	90	—	—
K #	—	130	—	—	89	—	—
N	45	130	—	—	—	—	—

Table 8. Heart Rate, Respiratory Rate, Oxygen Saturation, and End-tidal Carbon Dioxide: Default Parameter Settings by Facility, Coronary Care

Facility	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
	Low	High	Low	High	Low	High
B	90	160	50	90	55	120
C *	90	160	50	90	60	90
E *#^	90	160	50	90	—	—
H *	85	180	40	110	55	120
I *#	90	160	50	90	60	110
K #	90	160	40	100	60	—

Table 9. Blood Pressure: Default Parameter Settings by Facility, Coronary Care

Cardiac ICU

Default Parameter Settings

Facility	Heart Rate		Respiratory Rate		Oxygen Saturation	End-tidal Carbon Dioxide	
	Low	High	Low	High	Low	Low	High
A	45	—	—	—	87	—	—
B	50	120	—	—	—	—	—
C *	60	120	8	30	90	—	—
E *#^	—	130	—	—	—	30	50
H *	50	130	5	30	88	—	—
I *#	50	120	8	30	88	30	50
K #	—	130	6	40	89	—	—
Q	30	160	—	—	88	—	—

Table 10. Heart Rate, Respiratory Rate, Oxygen Saturation, and End-tidal Carbon Dioxide: Default Parameter Settings by Facility, Cardiac ICU

Facility	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
	Low	High	Low	High	Low	High
B	90	160	50	90	55	120
C *	90	160	50	90	60	90
E *#^	90	160	50	90	—	—
G #	—	—	—	—	60	110
H *	80	170	30	130	55	120
I *#	90	160	50	90	70	110
K #	90	160	40	100	60	—

Table 11. Blood Pressure: Default Parameter Settings by Facility, Cardiac ICU

Legend	
*	Incorporating short delays before alarm sounds
#	Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)
^	Using a software interface to incorporate multiple parameters into a single indicator

Neurological ICU

Default Parameter Settings

Facility	Heart Rate		Respiratory Rate		Oxygen Saturation	End-tidal Carbon Dioxide	
	Low	High	Low	High	Low	Low	High
A	45	—	—	—	87	—	—
C *	60	120	8	30	90	—	—
D*	50	130	—	—	88	—	—
E *#^	—	130	—	—	88	30	50
H *	50	120	5	30	89	—	—
K #	—	130	6	40	89	—	—
Q	30	160	—	—	88	—	—

Table 12. Heart Rate, Respiratory Rate, Oxygen Saturation, and End-tidal Carbon Dioxide: Default Parameter Settings by Facility, Neurological ICU

Facility	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
	Low	High	Low	High	Low	High
C *	90	160	50	90	60	90
D*	—	—	40	100	50	140
E *#^	90	160	50	90	—	—
H *	90	180	40	110	55	120
K #	90	160	40	100	60	—

Table 13. Blood Pressure, Default Parameter Settings by Facility, Neurological ICU

Emergency Department

Default Parameter Settings

Facility	Heart Rate		Respiratory Rate		Oxygen Saturation	End-tidal Carbon Dioxide	
	Low	High	Low	High	Low	Low	High
A	45	—	—	—	87	—	—
B	50	130	8	30	90	10	40
C *	60	120	3	30	90	30	50
D*	50	130	—	—	88	—	—
F ^	50	120	10	24	90	—	—
H *	40	150	5	30	88	—	—
I *#	50	140	10	30	—	30	50
K #	—	130	6	40	89	—	—

Table 14. Heart Rate, Respiratory Rate, Oxygen Saturation, and End-tidal Carbon Dioxide: Default Parameter Settings by Facility, Emergency Department

Facility	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
	Low	High	Low	High	Low	High
B	90	200	50	90	60	110
C *	—	—	50	90	60	90
D*	—	—	40	100	50	140
F ^	90	140	—	—	—	—
H *	90	210	30	120	49	140
I *#	90	160	50	90	70	110
K #	—	—	40	100	20	220

Table 15. Blood Pressure, Default Parameter Settings by Facility, Emergency Department

Legend	
*	Incorporating short delays before alarm sounds
#	Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)
^	Using a software interface to incorporate multiple parameters into a single indicator

Progressive Step-Down Default Parameter Settings

	Heart Rate		Respiratory Rate		Oxygen Saturation
Facility	Low	High	Low	High	Low
A	45	—	—	—	87
B	40	130	8	30	88
C *	60	120	8	30	90
D *	50	130	—	—	88
E #^	50	120	—	—	88
F ^	50	120	—	—	90
H *	50	140	8	30	88
K #	—	130	6	40	89
M #^	50	140	—	—	—
Q	—	—	—	—	88

Table 16. Heart Rate, Respiratory Rate, and Oxygen Saturation: Default Parameter Settings by Facility, Progressive Step-down

	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
Facility	Low	High	Low	High	Low	High
B	90	160	50	90	60	110
C *	—	—	50	90	60	90
D *	—	—	40	100	50	140
H *	90	180	40	110	60	120
K #	—	—	40	100	20	220

Table 17. Blood Pressure, Default Parameter Settings by Facility, Progressive Step-down

Medical–Surgery Telemetry Default Parameter Settings

	Heart Rate		Respiratory Rate		Oxygen Saturation
Facility	Low	High	Low	High	Low
A	45	—	—	—	87
B	40	130	—	—	90
C *	60	120	8	30	90
D *	50	130	—	—	88
E #^	50	120	—	—	88
F ^	50	120	—	—	90
H *	50	140	8	30	88
K #	45	130	6	40	89

Table 18. Heart Rate, Respiratory Rate, and Oxygen Saturation: Default Parameter Settings by Facility, Medical–Surgery Telemetry

	Systolic Blood Pressure		Diastolic Blood Pressure		Mean Blood Pressure	
Facility	Low	High	Low	High	Low	High
B	90	160	50	90	60	110
C *	—	—	50	90	60	90
D *	—	—	40	100	50	140
H *	90	180	40	110	55	120
K #	—	—	40	100	50	100

Table 19. Blood Pressure, Default Parameter Settings by Facility, Medical–Surgery Telemetry

Legend	
*	Incorporating short delays before alarm sounds
#	Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)
^	Using a software interface to incorporate multiple parameters into a single indicator

For Pediatrics

Of the 17 hospitals and healthcare systems that responded to the survey about default parameter settings, six of them provided settings for pediatrics for the following units:

- Neonatal ICU
- Pediatric ICU
- Cardiac surgical ICU
- Cardiac neonatal ICU
- Emergency department

Understanding the Pediatric Settings

- Not all survey respondents provided information for all of these types of units or for all default parameter settings.
- Pediatrics often delineates parameter profiles by age range, as evidenced by the variety of organization-defined age ranges in this section.
- Descriptions of each organization are included with their default parameter settings.
 - H. Large Academic, Southeast
 - I. Medium Academic, Midwest
 - K. Large Academic, Southwest
 - L. Medium Academic, Southwest
 - O. Large Children's Academic, Southwest
 - P. Large Children's Academic, Southwest

Pediatric Facility H

Large Academic Facility, Southeast

Neonatal ICU					
Parameter		Default Settings by Age Range and Condition			
		Gestational Age < 36 Weeks	Gestational Age ≥ 36 Weeks (Acutely ill)	Postconceptual Age (PCA) 36 Weeks (Growing, not acutely ill)	Cardiac Abnormality
Heart Rate	Low	99	99	79	99
	High	221	221	221	221
Blood Pressure	Noninvasive systolic low	20	30	30	30
	Noninvasive systolic high	120	150	150	150
	Arterial systolic low	30	40	40	40
	Arterial systolic high	100	100	100	100
	Noninvasive diastolic low	10	20	20	20
	Noninvasive diastolic high	80	120	120	120
	Arterial diastolic low	10	20	20	20
	Arterial diastolic high	60	60	60	60
	Noninvasive mean low	20	30	30	30
	Noninvasive mean high	100	130	100	130
	Arterial mean low	30	40	40	40
	Arterial mean high	60	70	70	70
Oxygen Saturation	Low	87	92	92	72
	High	96	101	101	88
Respiratory Rate*	Low	1	1	1	1
	High	121	121	121	121

Table 20. Neonatal ICU, Default Parameter Settings by Age Range and Condition, Pediatric Facility H

* This hospital, after much discussion with leadership and staff, determined that respiratory rate was not a useful parameter for monitoring neonates, because it produces numerous non-actionable alarm conditions. Therefore, since the monitor system does not allow this parameter to be turned off, the hospital sets the defaults as widely as possible to avoid triggering an alarm signal.

* Incorporating short delays before alarm sounds

Pediatric Facility H

Large Academic Facility, Southeast

Pediatric General ICU and Post-anesthesia Care Unit (PACU)						
Parameter		Default Settings by Age Range				
		0–12 Months	1–3 Years	4–7 Years	8–14 Years	> 14 Years
Heart Rate	Low	100	80	60	60	60
	High	180	150	130	110	100
Blood Pressure	Systolic low	60	60	75	95	100
	Systolic high	105	105	110	125	130
	Diastolic low	30	30	40	45	50
	Diastolic high	65	65	75	80	85
	Mean low	30	30	40	45	50
	Mean high	105	105	110	125	130
Oxygen Saturation	Low	89	89	89	89	89
	High	105	105	105	105	105
Respiratory Rate	Low	25	20	18	14	12
	High	60	40	35	24	20

Table 22. Pediatric General ICU and Post-anesthesia Care Unit (PACU), Default Parameter Settings by Age Range, Pediatric Facility H

Pediatric Emergency Department						
Parameter		Default Settings by Age Range				
		0–12 Months	1–3 Years	4–7 Years	8–14 Years	> 14 Years
Heart Rate	Low	100	80	60	60	60
	High	180	150	135	100	100
Blood Pressure	Systolic low	60	60	70	95	100
	Systolic high	105	105	110	125	130
	Diastolic low	30	30	40	40	50
	Diastolic high	65	65	75	80	85
	Mean low	30	30	40	45	50
	Mean high	105	105	110	125	130
Oxygen Saturation	Low	91	91	91	91	91
	High	105	105	105	105	105
Respiratory Rate	Low	25	20	18	14	12
	High	60	40	35	24	20

Table 23. Pediatric Emergency Department, Default Parameter Settings by Age Range, Pediatric Facility H

Pediatric Facility I

Medium Academic Facility, Midwest

Neonatal ICU Age Range: ≤ 90 Days		
Parameter		Default Settings
Heart Rate	Low	90
	High	210
Blood Pressure	Systolic low	55
	Systolic high	90
	Diastolic low	20
	Diastolic high	60
	Mean low	30
	Mean high	60
Oxygen Saturation	Low	88
	High	93
Respiratory Rate	Low	20
	High	100
End-tidal Carbon Dioxide	Low	30
	High	60

Table 24. Neonatal ICU Default Parameter Settings, Pediatric Facility I

* Incorporating short delays before alarm sounds

Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)

Pediatric Facility K

Large Academic Facility, Southwest

Neonatal ICU				
Parameter		Default Settings by Age Range		
		Pre-term	31–34 Weeks	35 Weeks–Term
Heart Rate	Low	99	79	79
	High	201	201	201
Blood Pressure	Systolic low	70	—	—
	Systolic high	200	—	—
	Diastolic low	40	—	—
	Diastolic high	100	—	—
	Mean low	50	25	25
	Mean high	140	—	—
Oxygen Saturation	Low	90	90	92
	High	101	97	~101
Respiratory Rate	Low	6	10	10
	High	40	—	—

Table 25. Neonatal ICU, Default Parameter Settings by Age Range, Pediatric Facility K

Pediatric ICU						
Parameter		Default Settings by Age Range (in Years)				
		0–2	3–6	7–10	11–13	> 13
Heart Rate	Low	60	60	50	40	40
	High	200	180	180	150	150
Blood Pressure	Systolic low	50	50	50	50	70
	Systolic high	150	150	180	180	200
	Diastolic low	40	40	30	40	40
	Diastolic high	90	90	90	100	100
	Mean low	50	50	50	50	50
	Mean high	100	—	140	140	140
Oxygen Saturation	Low	90	90	90	90	90
	High	101	101	101	101	101
Respiratory Rate	Low	15	6	6	6	6
	High	60	45	45	45	40

Table 26. Pediatric ICU, Default Parameter Settings by Age Range, Pediatric Facility K

Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)

Pediatric Facility L

Medium Academic Facility, Southwest

Neonatal ICU Age Range: 1–30 Days		
Parameter	Default Settings	
Heart Rate	High	205
Blood Pressure	Systolic low	> 40% change from baseline
	Systolic high	> 40% change from baseline
	Diastolic low	> 40% change from baseline
	Diastolic high	> 40% change from baseline
	Mean low	> 40% change from baseline
	Mean high	> 40% change from baseline

Table 27. Neonatal ICU, Default Parameter Settings, Ages 1–30 Days, Pediatric Facility L

Pediatric ICU				
Parameter		Default Settings by Age Range		
		1–24 Months	3–5 Years	5–10 Years
Heart Rate	Low	50	50	50
	High	205	160	160
Blood Pressure	Systolic low	> 40% change from baseline	> 40% change from baseline	> 40% change from baseline
	Systolic high	> 40% change from baseline	> 40% change from baseline	> 40% change from baseline
	Diastolic low	> 40% change from baseline	> 40% change from baseline	> 40% change from baseline
	Diastolic high	> 40% change from baseline	> 40% change from baseline	> 40% change from baseline
	Mean low	> 40% change from baseline	> 40% change from baseline	> 40% change from baseline
	Mean high	> 40% change from baseline	> 40% change from baseline	> 40% change from baseline
	Mean high	> 40% change from baseline	> 40% change from baseline	> 40% change from baseline
Oxygen Saturation	Low	< 80	< 80	< 80
Respiratory Rate	Low	20	15	12
	High	80	50	30

Table 28. Pediatric ICU, Default Parameter Settings by Age Range, Pediatric Facility L

* Incorporating short delays before alarm sounds

Using monitors with “smart” alarms (Sat Seconds™, a feature of Nellcor™ pulse oximetry alarm management technology, is captured here when indicated)

^ Using a software interface to incorporate multiple parameters into a single indicator

Pediatric Facility O

Large Children's Academic Facility, Southwest

Pediatric ICU			
Parameter		Default Settings by Age Range	
		0–2 Years	3–10 Years
Heart Rate	Low	100	60
	High	200	180
Blood Pressure	Systolic low	34	70
	Systolic high	100	160
	Diastolic low	20	40
	Diastolic high	60	90
	Mean low	21	30
	Mean high	70	90
Oxygen Saturation	Low	88	93
	High	96	—
Respiratory Rate	Low	12	12
	High	60	60

Table 29. Pediatric ICU, Default Parameter Settings by Age Range, Pediatric Facility O

Cardiac Surgical ICU		
Parameter		Default Settings
Heart Rate	Low	90
	High	200
Blood Pressure	Systolic low	40
	Systolic high	100
	Diastolic low	20
	Diastolic high	60
	Mean low	30
	Mean high	70
Oxygen Saturation	Low	90
Respiratory Rate	Low	15
	High	100
End-tidal Carbon Dioxide	Low	60
	High	90

Table 31. Cardiac Surgical ICU, Default Parameter Settings, Pediatric Facility O

Emergency Department		
Parameter		Default Settings
Heart Rate	Low	60
	High	180
Blood Pressure	Systolic low	70
	Systolic high	160
	Diastolic low	40
	Diastolic high	90
	Mean low	30
	Mean high	90
Oxygen Saturation	Low	94
Respiratory Rate	Low	10
	High	60

Table 30. Emergency Department, Default Parameter Settings, Pediatric Facility O

Pediatric Facility P

Large Academic Children's Facility, Southwest

Neonatal ICU Age Range: 1–90 Days		
Parameter		Default Settings
Heart Rate	Low	100
	High	200
Blood Pressure	Systolic low	40
	Systolic high	90
	Diastolic low	20
	Diastolic high	60
	Mean low	24
	Mean high	70
Oxygen Saturation	Low	85
	High	95
Respiratory Rate	Low	20
	High	80
End-tidal Carbon Dioxide	Low	30
	High	50

Table 32. Neonatal ICU, Default Parameter Settings, Ages 1–90 Days, Pediatric Facility P

Pediatric ICU				
Parameter		Default Settings by Age Range		
		< 1 Year	1–18 Years	18+ Years
Heart Rate	Low	100	75	50
	High	200	160	120
Blood Pressure	Systolic low	40	70	90
	Systolic high	90	120	160
	Diastolic low	20	40	50
	Diastolic high	60	70	90
	Mean low	24	50	60
	Mean high	70	90	110
Oxygen Saturation	Low	90	90	90
	High	100	100	100
Respiratory Rate	Low	20	12	8
	High	80	40	30
End-tidal Carbon Dioxide	Low	30	30	30
	High	50	50	50

Table 33. Pediatric ICU, Default Parameter Settings by Age Range, Pediatric Facility P

Appendix A

The Johns Hopkins Hospital Alarm Burden and Management Toolkit

This toolkit shows how The Johns Hopkins Hospital, a member of the National Coalition for Alarm Management Safety, approaches management of physiologic monitors.

Maria Cvach DNP, RN, FAAN

The Johns Hopkins Hospital

1. Determine the manufacturer and model number of your unit's physiologic monitor.
2. Determine baseline monitor settings.
 - a. Arrhythmia baseline settings

Example:

```

      A R R H Y T H M I A   A L A R M   L E V E L S

R E T U R N
A S Y S T O L E
V F I B / V T A C
B R A D Y
                                C R I S I S
                                C R I S I S
                                W A R N I N G
  
```

- b. Threshold baseline settings

Example:

Parameters Departments	PULSE OX % * = 15 sec delay ** = 10 sec delay		HEART RATE BPM		BP SYSTOLIC mmHg		BP DIASTOLIC mmHg		BP MEAN mmHg		RESP RATE Breaths / min	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High

- c. Determine if monitor permits the use of delay features and signal averaging time.

Example:

```

M A S I M O   A V E R A G I N G
M A S I M O   A L A R M   D E L A Y
                                1 2   S E C S
                                1 0   S E C S
  
```

3. Determine if monitor permits the development of profiles.

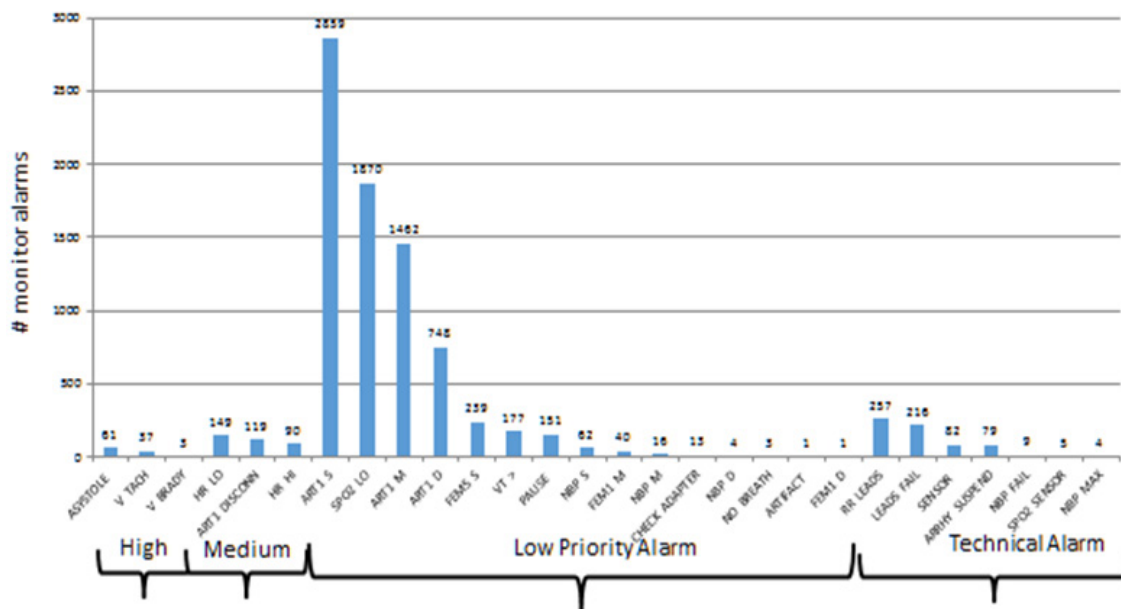
Example:

Neonatal Intensive Care Unit (GA < 36 <u>wk</u>)
Neonatal Intensive Care Unit (GA >36 <u>wk</u>)
Neonatal Intensive Care Unit (CARDIAC)
Neonatal Intensive Care (Growing, not acutely ill >= 36 weeks)

4. Obtain baseline survey information on perception of alarms and alarm management from unit staff.
 - a. Focus groups
 - b. Staff surveys
5. Obtain baseline monitor alarm data: Determine how monitor categorizes alarms (i.e., high-priority, medium-priority, low-priority, equipment-related).

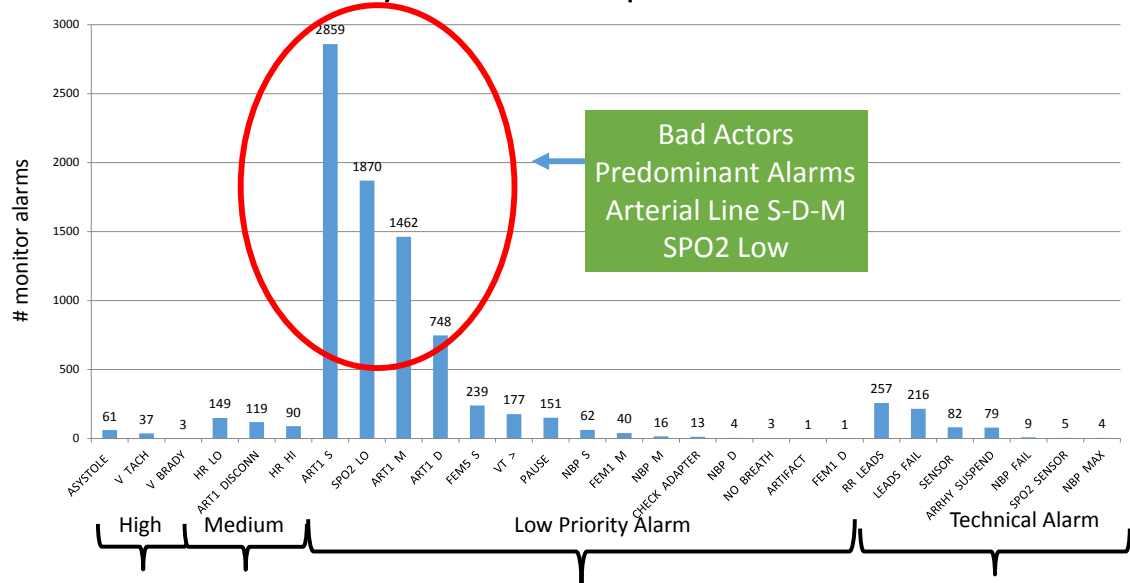
Example from one hospital unit:

Weekly Alarm Report, Cardiac Surgery ICU Data



6. Study data to determine the “bad actors” and where substantial improvement can be obtained because excessive quantities of alarms are occurring.
 Example from one hospital unit, which shows the predominant alarms for this unit are arterial line systolic, diastolic and mean as well as SPO2 low and SPO2 probe:
 Study the literature to determine the best alarm programming for the population served.
 - a. Determine evidenced-based settings for SPO2 high and low; signal averaging time; best delay for SPO2 to allow for alarm auto-correction.

Detailed Weekly Alarm Report



7. Talk to staff and leadership to determine the best approach to reduce alarm burden.
 - a. Some examples to reduce alarm burden include, but are not limited to: Readjust alarm thresholds; develop profiles for populations served; alter signal averaging time; use different delay features; examine different equipment; allow alarm customization by nursing staff.
8. Use a quality improvement (QI) rapid cycle change approach to make modest changes to monitor alarms based on evaluation of data and discussion with staff/leadership.
9. Reevaluate the effect of changes.
 - a. Examine post data.
 - b. Talk to staff about their perception about the changes.
10. Examine ways to assure alarm audibility and accountability when not at the bedside or central monitor.
 - a. Some examples of alarm notification systems: use of monitor features such as “view on alarm,” hallway waveform screens, monitor watchers, middleware technology to send alarms to devices following and escalation path.



AAMI Foundation

Goals of the National Coalition For Alarm Management Safety

The National Coalition for Alarm Management Safety has eight teams working on multiple goals:

Team 1 will develop a toolkit for the clinical community to assist in understanding and setting SPO2 default parameters.

Team 2 will develop compendium of accepted taxonomy required for alarm management to move the nation toward using same terminology for same issues.

- a. Investigate where terms have already been defined and vetted and create definitions for clinical terms where no standard terms exist (e.g., move away from use of the term “false alarm” to “non-actionable alarm” to denote an event where the monitor correctly issues the alarm based on the default settings, but the nurse determines there is no need for clinical intervention.
- b. Incorporate new terms into AAMI alarms standards.

Team 3 will develop educational materials and tests for competencies for healthcare teams on why and how to perform alarm management.

- a. Determine what gaps in knowledge need to be addressed in three main areas: 1) understanding the physiology behind the measure; 2) understanding what default parameters are; and 3) knowing when and how to customize alarm parameters for individual patient need).
- b. Determine which coalition members (hospitals and industry), and other non-coalition groups, have materials they are willing to share.

- c. Develop materials to fill the gaps not addressed—and develop simulation training materials where possible.
- d. Determine what competencies and tests should be evaluated and/or developed—and develop simulation testing where possible.

Team 4 will determine feasibility of creating a database with annotated waveforms from physiological measures that may be used by researchers to create new detection algorithms. If determined to be feasible, the team will:

- a. Begin a project to build database and populate.
- b. Create taxonomy to use for standardized annotation of various waveforms.

Team 4a. Team members from Purdue University’s Regenstrief Center for Healthcare Engineering will determine the feasibility of building a database for all hospitals to join and use to upload physiological parameters—both factory-setting manufacturer defaults and their own “enhancements” to those defaults. Hospitals could look to this database to see what others in the country are doing to update parameters.

Team 5 will evaluate why most non-actionable alarms seem to be triggered by the minority of patients.

- a. Determine which alarms for these patients are triggered most often and why.
- b. Determine easy strategies to use when a patient is triggering numerous non-actionable alarms.

Team 6 will develop educational materials demonstrating how to use monitor alarm data.

- a. Provide information on how to get the data out of the devices.
- b. Provide information on how to use the data to improve alarm management.
- c. Provide information on how to monitor to ensure no untoward patient outcomes result from alarm parameter changes.

Team 7 will develop educational materials to teach hospitals to become high-reliability, “systems-thinking” organizations.

Team 8 will evaluate the effectiveness of using “monitor watchers.”

- a. Collect available information and survey hospitals that use “monitor watchers” to determine the reasons the hospitals set up these types of programs and to collect any return on investment (ROI) information available.
- b. Publish lessons learned from this exploration.
- c. Propose competencies monitor watchers should have.
- d. Investigate the feasibility of setting up a simulation to determine the response time of monitor watchers in signaling to a nurse when an actionable alarm has occurred as compared to the response time of sophisticated middleware.

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The AAMI Foundation is grateful to these organizations and individuals for sharing their alarm management safety practices and experiences in the Safety Innovation Series of white papers and seminars cited in this compendium.

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Learn More from Leading Practitioners

Below, you will find links to the following:

- Papers and national seminars cited in the body of the compendium
- Additional papers and national seminars of interest not included in compendium
- Informal monthly seminars that take place between coalition members. These informal presentations are coded as CM for coalition meeting.

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"Managing Alarm Systems: Progress and Insights." (Dec. 3, 2012). AAMI Foundation seminar presentation.

www.aami.org/NCAMS/120312_Beth_Israel_Deaconess.wmv

Plan, Do, Check, Act: Using Action Research to Manage Alarm Systems, Signals, and Responses. AAMI Foundation Safety Innovations Series.

www.aami.org/NCAMS/Beth_Israel_2013.pdf

Boston Medical Center

Clinical Practice Changes Associated with Alarm Standardization: The Boston Medical Center Experience.

www.aami.org/NCAMS/Alarm_Standardization_White_Paper_2.pdf

(CM) "Pulse Oximetry Alarm Reduction Strategy at Boston Medical Center." (July 29, 2014). AAMI Foundation seminar presentation. <https://vimeo.com/136154888>

(CM) "Targeting Pulse Oximetry Alarms: Phase III." (April 28, 2015). AAMI Foundation seminar presentation. <https://vimeo.com/129032734>

Children's National Medical Center

Cardiopulmonary Monitors and Clinically Significant Events in Critically Ill Children: Children's National Medical Center. (April 25, 2013). AAMI Foundation Safety Innovations Series.

www.aami.org/NCAMS/Cardiopulmonary_Monitors_Children.pdf

"Cardiopulmonary Monitors and the Monitor Oversight Committee: Learning from the Children's National Medical Center Experience." (April 25, 2013). AAMI Foundation seminar presentation.

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Dartmouth-Hitchcock Medical Center

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For additional resources on alarm management, visit:

www.aami.org/foundation/alarms

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