

A Framework for Reducing Alarm Fatigue on Pediatric Inpatient Units

AUTHORS

Amogh Karnik, MSc, BSE,^{1,2} Christopher P. Bonafide, MD, MSCE^{2,3,4,5}

¹*The Commonwealth Medical College, Scranton Pennsylvania;*

²*Division of General Pediatrics, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania;*

³*Center for Pediatric Clinical Effectiveness, The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania;*

⁴*Perelman School of Medicine at the University of Pennsylvania, Philadelphia, Pennsylvania;*

⁵*Leonard Davis Institute of Health Economics, University of Pennsylvania, Philadelphia, Pennsylvania*

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alarm fatigue, clinical alarms, false alarms, physiologic monitoring.

ABBREVIATION

ECG: electrocardiographic

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Address correspondence to Christopher P. Bonafide, MD, MSCE, The Children's Hospital of Philadelphia, 34th St and Civic Center Blvd, Suite 12NW80, Philadelphia, PA 19104. bonafide@email.chop.edu, 267-426-2901.

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On my (AK) first day on the patient floors as a medical student, I couldn't help but notice the buzzing, beeping, cacophony of alarms that ostensibly indicated impending danger for just about every patient on the unit. I looked around, waiting for someone (a nurse, a doctor, anyone) to react. Yet thus far in my brief career, I've come to learn that most of the alarms I hear do not indicate emergencies, and in fact most do not warrant any clinical intervention at all. As a result, the buzzing and beeping fades into the background now.

CONTEXT

Physiologic monitor alarms are intentionally designed to alert clinicians immediately to any deviation from the norm, regardless of the quality of the signal or cause of the deviation.¹ In theory, this design ensures that doctors and nurses will always be informed of physiologic changes to respond to important deterioration events quickly.

However, we know that monitors generate frequent alarms (39–352 alarms per patient, per day)^{2–9} and that a high proportion are false, defined as not being actionable (>90% of pediatric ICU^{2,3} and >70% of adult intensive care alarms).^{6,7} The task of separating the true, actionable alarms from the false or nonactionable alarms falls to the clinicians responsible for responding to alarms, who in most settings are nurses.

However, we rely on nurses for myriad other important responsibilities that we really care about, from administering antibiotics to a septic child, to discharging a kid with asthma so the mother can pick up the child's inhaler before the pharmacy closes. Thus, nurses are forced to make difficult decisions on a nearly continuous basis about whether to respond to alarms from different patients or to continue with the tasks at hand, assuming that the alarms do not require their immediate attention.

For example, consider a nurse in the midst of suctioning a patient while gowned and gloved who hears an alarm go off for her other patient across the hall. At this point, the nurse has to decide which task is more important: either continuing to suction this patient or stop suctioning, remove her gown and gloves, and check to see whether her other patient is having a life-threatening event. If that patient has produced many false alarms before, the nurse may rely on her previous experiences to assume that this alarm has a low probability of requiring her immediate attention, finish the suctioning, and then respond to the alarm several minutes later. This tendency can have consequences because nurses may become

accustomed to responding slowly or even ignoring alarms altogether, given that it is so uncommon for alarms to require intervention. This effect is known as “alarm fatigue.”

Alarm fatigue is not a new problem, but recently it has received a great deal of attention in hospitals throughout the United States. In 2013, the Joint Commission issued a Sentinel Event Alert that named frequent exposure to nonactionable alarms “the most common contributing factor to alarm-related sentinel events.”¹⁰ Soon after, they released a National Patient Safety Goal to their >3300 accredited hospitals, requiring implementation of measures to improve alarm management by 2016.¹¹

NONACTIONABLE ALARM TYPES

Nonactionable clinical alarms fall into 2 main categories. First, they can be “invalid,” meaning they do not reflect the actual physiologic status of the patient. An example is a pulse oximetry alarm in a happily wheezing baby with bronchiolitis who is kicking his legs around, causing motion artifact. The second type of nonactionable alarm is the nuisance alarm, which does reflect the actual physiologic status of the patient but does not require clinical intervention.¹² An example is a desaturation to 89% with a good quality waveform that self-resolves within 5 seconds. If a patient repeatedly triggers these types of alarms, nurses can easily become desensitized and routinely choose to complete other tasks before addressing alarms or ignore alarms altogether.

PROPOSED FRAMEWORK FOR REDUCING ALARM FATIGUE

That said, what can be done to minimize the potential for alarm fatigue in

pediatric settings, and how can this complex problem be addressed on our inpatient units? Here, we propose a series of categories of interventions that together form a framework for alarm fatigue reduction on pediatric inpatient units. The framework, conceptualized as a sequential series of intervention steps, includes the following: (1) monitoring only the patients at significant risk of life-threatening events (2) reducing invalid (artifact) alarms, (3) reducing nuisance (valid but nonactionable) alarms, and (4) improving alarm notification for the remaining actionable alarms.

Monitor Only the Patients at Significant Risk of Life-Threatening Events

According to American Heart Association guidelines, pediatric continuous electrocardiographic (ECG) monitoring, aimed primarily at detecting arrhythmias, is indicated for only a small fraction of patients who we care for on pediatric hospitalist-led teams outside the ICU.¹ For patients without known heart disease, they note that monitoring may be beneficial but is not essential in children with chest pain, blunt chest trauma, acute neurologic events, severe asthma exacerbation, Kawasaki disease, those administered drugs with potential for QT prolongation, those being evaluated for syncope (which we would extend to apparent life threatening events), and infants with prenatal exposure to cocaine (putting them at risk for coronary vasospasm).

Similar to ECG monitoring, 1 of the 5 recommendations on the Pediatric Hospital Medicine Choosing Wisely list is “Don’t use continuous pulse oximetry routinely in children with acute respiratory illness unless they are on supplemental oxygen.”¹³ On the basis of the American

Heart Association and Choosing Wisely recommendations, a first step that we can take now is to develop consensus guidelines at our institutions for initiating continuous ECG and pulse oximetry monitoring. One potential implementation strategy is to include the appropriate indications in a drop-down menu when monitoring is ordered in an electronic health record as a means of providing clinical decision support and reinforcing appropriate use.¹⁴

A second area in which we can improve care and reduce unnecessary monitoring is to develop standards on how best to discontinue monitoring in patients who no longer need it. One effective way to do this that is analogous to the way we order many medications is to include a duration in the monitoring order based on the patient’s initial condition and severity of illness. For example, an initial order for monitoring could include a duration of 24 hours, with a prompt for nurses to reassess the need and contact the physician once the order expires if they believe that discontinuing monitoring would be unsafe.¹⁴

Reduce Invalid (Artifact) Alarms

Invalid alarms from artifact are usually caused by poor contact between the sensor and the skin, which may be due to the sensor’s adhesive drying out or the patient moving. Among patients in whom monitoring is necessary while they are awake and active, interventions that have been successful in reducing these alarms include meticulous skin preparation and changing electrodes every 24 hours.¹⁵

Reduce Nuisance (Valid but Nonactionable) Alarms

Nuisance alarms occur mainly when the alarm thresholds used to trigger

alarms are set to levels at which clinicians would not intervene or when the alarm thresholds are set at appropriate actionable thresholds but the amount of time the patient spends outside the threshold is brief and resolves spontaneously. First and foremost, alarms are designed to indicate emergencies and should summon staff to the bedside immediately. So the first step is to identify thresholds at which there is little ambiguity that a valid alarm beyond that threshold indicates an emergency: a condition for which an intervention is necessary.¹⁶ One reasonable starting point is to use published data from hospitalized children to choose age-based cut points for heart and respiratory rates¹⁷ (e.g., using the first and 99th percentiles for age, or even more extreme values) and an actionable threshold for pulse oximetry that represents an emergency (e.g., <80%).¹⁸

After thresholds are chosen, they can be adjusted further based on the patient's physiology to minimize non-actionable alarms. Because nurses are primarily responsible for responding to the alarms themselves, they often have excellent insight into whether a patient's parameters are effective based on their unique conditions and whether those parameters should be adjusted. Although policies may vary from institution to institution, it may be beneficial to expand the responsibilities of the nursing staff to allow nurses to change alarm parameters within a margin considered safe (e.g., $\pm 10\%$ from the originally ordered settings) without a physician order provided that physicians and the rest of the team caring for that patient are notified and the change is documented.

The next step is to consider instituting a delay in the interval of time between when a threshold is crossed and when the alarm fires. The aim of this intervention is to reduce frequent alarms for brief and self-limited breaches of the thresholds. One technology for implementing pulse oximetry alarm delays called SatSeconds (for Nellcor devices) takes into account both the depth of the desaturation and the duration, alarming immediately for major desaturations while delaying alarms for less significant drops.¹⁹

Improve Alarm Recognition and Notification for the Remaining Actionable Alarms

Once interventions have been implemented to improve the signal-to-noise ratio by reducing the noise (invalid and nuisance alarms), we can turn our attention to strengthening the signal (actionable alarms). Alarms cannot be useful if no one hears them or recognizes their acuity. As inpatient units expand to become more spacious and hospitals convert multipatient rooms into private rooms flanking long hallways, it gets harder and harder for staff to hear and recognize alarms. Two potential approaches to address this problem that can be considered include secondary notification systems and the employment of monitor watchers.

Secondary notification systems pass alarm information from the monitor system to the nurse's pager or wireless telephone system using a network interface.²⁰ These systems allow the hospital to configure which alarms pass through to the mobile device and which alarm at the bedside only. They also allow for automatic escalation of the alarm message to the charge nurse or another clinician if the primary

nurse does not acknowledge the alarm within a specified timeframe.¹⁹

An additional layer of support is to employ technicians who continuously view the waveforms and alarms of many patients from a central station. These "monitor watchers" have the potential to improve care but are expensive, and few studies have demonstrated tangible improvements in patient outcomes.^{21,22}

HOW TO GET STARTED

Above, we have outlined a wide range of interventions that can be implemented as part of a large-scale quality improvement initiative with the aim of reducing nonactionable alarms that contribute to alarm fatigue. Often the most difficult part of beginning to address a problem like this is getting started. As a first step, we suggest getting a sense of the issue at your institution. Data on the frequency and types of alarms firing on each unit will help immensely with this, and you may find that your biomedical engineering department is eager to provide this kind of data. If data are hard to come by, you could begin by conducting an audit of how many patients are on monitors, evaluating what their default settings are and whether they are at actionable levels, and interviewing nurses about the ways they are alerted about alarms and how they manage them. Once you understand the problem, it will be helpful to form a multidisciplinary team that includes other physicians, nurses, biomedical engineers, and staff experienced in quality improvement to prioritize interventions from the menu of items listed here based on the most salient issues at your institution.

In summary, alarm fatigue has the potential to harm our patients. Hospitalists

are uniquely positioned to directly address this complex problem with interventions that are relatively easy to implement and evaluate. We hope that the framework we have proposed is helpful in developing new alarm management strategies. We should collaborate across institutions to identify the most effective interventions and implementation strategies to reduce nonactionable alarms and minimize the potential for adverse patient outcomes from alarm fatigue.

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