Case Study

Reducing Interruption Fatigue through Improved Alarm Support

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At a clinical alarms summit convened in 2011, hospitals and industry were challenged to join forces in reaching, by 2017, the goal of no patients being harmed by adverse alarm events.[1] Although substantial advances have been made in meeting this challenge, clinicians have reached a roadblock when it comes to managing clinical alarms. This impasse necessitates the need to shift focus to a broader process perspective that includes clinical workflow. According to a substantial body of knowledge,[2–12] clinical alarms require modification and management. However, the secondary alarm notification stopgaps put in place by hospitals have frequently exacerbated the problem, causing duplication of alarms, including nonactionable and nuisance alarms. The challenge in communicating only essential alarm and alert information to the proper person or care-team is a challenge that recent advances in clinical technology could work to resolve.

Aim

This article describes a case study in which one hospital implemented a workflow improvement plan. The goal was to measure the effects of using a secondary alarm notification with a unified alarm management technology platform, a smart mobile device, and a monitor technician, in order to determine whether it could help resolve issues surrounding "clinical interruption fatigue."

Background

During the previous several decades, technology has expanded the ability to assess telemetry-monitored patients. In a centralized telemetry configuration, a widely used practice to enhance patient safety is for numerous patients to be monitored by a core group of technicians.[2] However, for the point person determining the value of each alarm, responsibility and subsequent risk have exponentially intensified, as they work to perform simple (e.g., basic rhythm analysis) to more complex (e.g., myocardial ischemic events) functions.[3] This type of advanced measurement recognition requires the system to have a greater discrimination of what it is monitoring, subsequently resulting in an overall higher sensitivity as a result of capturing every event. The tradeoff when choosing to capture all alarms (high sensitivity so a major event is not missed) means that the system cannot be as specific regarding which alarms are annunciated and which are not, resulting in countless false alarms. Despite the documented evidence of high sensitivity/low specificity, leading to a term clinicians refer to as "alarm fatigue," alarms remain the gold standard of clinical practice.[1] The sole purpose of a clinical alarm is to provide notification of an urgent medical situation, which is a deviation from normal physiological measurement limits set for a particular patient. However, due to the vast amount of false and nonactionable alarms, as

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well as the ensuing clinical attention required to respond to these distractions, the larger problem faced by clinicians is actually "interruption fatigue." Other clinical processes are being interrupted, distracting nurses' attention elsewhere.

Clinical alarm and event overload is not a new issue for clinicians. Concern has been raised regarding system-related issues restricting clinical workflow, with the claim being that interruptions due to alarms, alerts, distractions, and noise have the potential to compromise patient safety.[4,5] A substantial portion of all clinical interruptions come from false and nonactionable alarms, causing an unwarranted lapse in workflow.[6–9,11] Here are the main premises upon which hospitals today are addressing the problem: 1) quality and effectiveness of patient care can be improved by using a dedicated monitor watcher[7,13]; 2) nurses who are proactive and set individualized patient alarm parameter limits help to decrease the amount of nonactionable alarms[3,7]; 3) the importance of a thorough skin prep, consistent lead placement, and changing electrodes daily are essential[1,3,7]; and 4) timely patient interventions only exist if monitored abnormalities discovered are promptly communicated to the direct caregiver.[10] Addressing each of these steps, a study by Graham and Cvach[11] demonstrated that critical monitor alarms were reduced 43% from baseline data. Many other hospitals have found similar results when implementing a well-thought-out customized approach at their institutions.

Another study has described actual interruptions to clinical practice as being of greater concern to patient safety than alarms themselves,[12] prompting nurse leaders to look at the larger picture. Current technologies exist to facilitate the delivery of patient safety through care group communication (patient-centric communication of alarms, alerts, and text messaging). However, many value-demonstrated technologies related to alarms and communication are underused.[14] The following case study seeks to illustrate a use model of how technology, in conjunction with a monitor technician, can help resolve workflow gaps and further reduce interruption fatigue.

Case in Point: Background and Setting

As part of a large integrated delivery network (IDN) on the east coast of the United States, one hospital leadership team made the decision to move beyond its current alarm and event response model to maximize 21st century technology. The four units they selected for participation in this quasiexperimental study were an intensive care unit, progressive care unit, and two telemetry units (52 patient beds total). A typical centralized "war room" telemetry monitoring setting was used. Situated in the war room, the monitor technician acted as a point person to evaluate and escalate important alarms. The duration of the study was one week in December 2014. Of note, a baseline of alarm data were collected during a one-week period a month before the study, and these data reflected almost an identical number of alarms.

For the purpose of this evaluation, only patient monitor alarms were examined. Although all alarms may affect clinical workflow, the team decided to concentrate on one workflow at a time. The rationale for this design was for hospital leadership to be empowered with information regarding the effect on individual workflows.

The team collaborated with industry and implemented principles (Table 1) to guide its workflow throughout the four designated units, with the prospect of implementing the design on a system-wide basis.

All primary alarm notifications from the patient physiological monitor remained untouched within the scope of this project. However, the clinical staff did in fact implement their own alarm modification both unit-wide (global alarm default settings stipulated for entire care unit) and patient customized (customized for an individual patient, based upon clinical circumstantial need) on all study units. Another best practice that was implemented was daily electrode change and thorough skin prep.

The focus of this clinical workflow evaluation was to determine the value added, if any, of using a secondary alarm notification with a unified alarm management technology platform, monitor tech, and mobile device. A unified alarm management platform assimilates alarms, alerts, and text messages; therefore, that communication context is

Principles for an Effective Alarm System
Integrate, aggregate, and store disparate data from medical devices/various clinical information systems and provide easy access for clinicians, with the goal of improving patient safety.
The system must make sense and be easy for clinicians to use.
Synthesize alarm/alert/messaging contextual information on the mobile device; that is, make it patient centric, prioritized in acuity, and available in a single application. This should help 1) facilitate standardization and continuity of patient care and 2) prevent errors of data misinterpretation and interruption from navigating between applications.
Information integrity: prevent patient identification issues by insisting that platforms have blocked electronic cut-and-paste option (as per AHIMA Body of Knowledge[16]).
Care team collaboration: easy access to pertinent team members specific to the patient event, without needing to search a large directory. Ensure that hospital text-messaging strategy is aligned with patient care team and clinical workflow objectives.
The system needs to have an FDA 510k clearance to enable medical device alarms to be integrated along with all other alert/messaging interruptions.
The system needs to be able to take advantage of all types of contextual data in order to present intelligent alarms to clinicians and affect an efficient event response.
The system must be able to simultaneously process alarms from multiple data sources and apply advanced rules to those alarms, bringing mobile information directly to the caregiver.
Situational awareness: If one nurse is busy (e.g., responding to a patient code) and another of her/his patients sounds a red alarm, the notification will go to the next available or assigned nurse instead of interrupting the primary care nurse.

Table 1. Attributes to consider for mobile alarm and event response communication in the hospital setting

provided to the patient care team for particular situations and/or events. The clinician is able to move past receiving individual alarms, alerts, and messages—and conceptually having to put the various pieces of information together—to being able to navigate consolidated information via one application on his/her smart phone. This type of context adds relevance to clinical communication at a time when outside the four walls of the hospital, complex mobile technology is commonly used in our everyday lives.

The alarms being sent to the secondary device consisted of all red (life-threatening) alarms, and in-op (leads-off) alarms. The integrity of these alarms continues to originate at the bedside, maintaining both auditory and visual notification. Yellow (limit) alarms are not escalated to a secondary device. A nationwide best practice expectation is that limit alarms, a component of the nuisance and nonactionable alarms, will be addressed in the first tier of alarm modification, through customization, skin prep, and electrode replacement. The goal is to take our best practices to the next level, using alarm middleware technology as a safety net and smart mobile devices as our methodology.

Methods

Alarms that are life threatening in nature were included in the evaluation: asystole, ventricular tachycardia, ventricular fibrillation, extreme tachycardia, extreme bradycardia, apnea, and oxygen desaturation. If the central monitor alarm is active for more than 15 seconds for a programmed alarm, the middleware technology used will send the alarm to a dedicated phone in the monitoring war room. The monitor tech then will either forward or stop the alarm from going to the primary nurse. In essence, the monitor tech serves as the first point of escalation. If the technician determines that the alarm was false in nature, the escalation path will cease. If the alarm is true, the communication of this alarm will follow the preconfigured escalation path. The technological middleware then continues the escalation path per design based on nurse response and predetermined escalation times, which can take up to another 30 seconds.[15]

Results

The results of the total alarms triggered during the seven-day period are shown in Table 2. Of the 2,533 alarms that were triggered, 1,923 (76%) were dispatched to the monitor tech. This means that the patient either self-corrected or the monitor tech manually intervened at the central station. This 15-second delay translated to a 25% reduction in interruptions to the monitor tech (level 1 stopgap).

Of the 1,923 alarms that reached the monitor tech, only 610 were forwarded to the appropriate nurse. Of note, the types of alarms that will be deflected from the escalation path are predetermined by the decision-making body of the hospital and/or unit. The monitor tech is responsible for carrying out the agreed escalation path. Leveraging the monitor tech and the desk phone in the war room translated to a 68% reduction in alarms sent to the nurse (level 2 stopgap). Overall, 76% less alarms were dispatched to nurses on their mobile devices.

Discussion

In this case example, industry and the hospital collaborated to reduce the number of patient monitoring nonactionable alarms that reached nurses' mobile devices by 76%. As a result, duplicate alarm notifications for nonactionable alarms, as well as clinical interruption fatigue, were reduced. Further, at the monitor tech level, the combination of using middleware alarm/event response technology with mobile phone technology provided a safety net to ensure that red alarms were not missed by the monitor tech. Given the stressful reality of this environment, which at times requires instantaneous decision making, the margin for error is small. If the monitor tech is overwhelmed at a given time, the middleware escalation path and preconfigured rules ensure that alarms will be sent to the mobile caregiver.

The middleware alarm communication strategy functions as a safety net if the monitor tech misses the initial alarm at the central station, providing additional pertinent clinical context around the patient alarm to be dispatched to the mobile caregivers' device(s). In addition, the technology facilitates collaboration among the patient care team; precipitating autoescalation of an alarm to the next available nurse without disturbing the primary caregiver when he/she is busy or unavailable.

Limitations

This study had three essential limitations. First, because it was a case study at one hospital network, the data may not be extrapolated to other settings. This study was intended to be an initial step for clinicians to realize that alarm fatigue is a subset of a bigger issue: clinical interruption. Second, the study hospital used monitor techs, which may not be the case at other hospitals. Therefore, reproducing the study at institutions that do not employ monitor watchers will not be possible. Last, this case study measured the effects of physiological monitors alone. This was an intentional first step in delineating and measuring individual

Alarm Type	Total Triggered Alarms	Total Triggered Alarms Delivered to Monitor Tech	Total Triggered Alarms Delivered from Monitor Tech to Nurse
Asystole	256	174	82
Ventricular tachycardia	174	144	30
Ventricular fibrillation	36	12	24
Extreme tachycardia	160	123	37
Extreme bradycardia	241	151	90
Apnea	336	336	0
Oxygen desaturation	1,130	983	347
Total	2,533	1,923	610

Table 2. Alarm data for a seven-day period across four units at a large integrated delivery network

workflows. Nurse leaders at the facility in question have expressed interest in exploring future studies to examine more complex workflows that integrate other clinical technology (e.g., ventilators, intravenous pumps, nurse call, bed exit alarms/alerts).

Suggestions for Future Practice

One suggestion for future practice is to take the current evaluation to the next technological tier, by including all other devices with clinical alarming (e.g., ventilators, nurse call, bed-alerts) and clinical interruptions. The data involved could be tracked via an advanced middleware platform, using a smart phone and the keen eye of a monitor tech. Of note, however, smart phone technology alone means little unless it is integrated into the same platform as the alarm and communication.

Conclusion

Of the total alarms generated, only 24% were deemed actionable and forwarded to the nurse. The 76% reduction in the number of alarms sent to nurses' mobile devices reduced workflow interruptions considerably. Without a secondary notification system, or with a first-generation alarm solution, all of these alarms (which were stopped at the first point of escalation by the monitor tech) would have been audible, thereby adding to the clamor and, more importantly, duplicating the interruption. Monitoring war rooms, which often are focused solely on patient monitors, can benefit from the increased reliability of alarm middleware; this same middleware platform should be maximized to include all other devices (e.g., events, nurse call, bed alerts, other alarms).

The current state of patient care and clinical workflow are extremely demanding in today's hospital environment. As technology advancements in clinical decision support have been established, the subsequent consequences often burden the clinician with additional response times or interruptions, in part because the nurse must physically go to the technology itself to acknowledge the event triggered. The question should be posed: If the clinicians are mobile, shouldn't the technology be as well? Advanced middleware accomplishes this task, bringing technology to the clinician on the run, allowing care team communication and collaboration. ■

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