The Multifaceted Solution for Alarm Fatigue

Author 124
Track 10: The Machine That Goes '*Ping*!'

ABSTRACT

Technological innovations have transformed hospitals in an environment where a plethora of devices make sounds. Research has demonstrated that up to 99% of these alarms require no clinical intervention. The excessive amount of irrelevant alarms has led to alarm fatigue, which occurs when clinicians are overwhelmed by the number of alarms and as a result become desensitized to them. This has already resulted in several patient deaths. Strategies focused on reducing irrelevant alarms, such as individualizing alarm settings, have proved significant reductions in the amount of alarms, but to overcome the problem all stakeholders must work together and a wider perspective to alarm (system) issues is needed. Solutions must be designed with a focus on the user and its needs and capabilities. Standardizing and redesigning current alarms into meaningful sounds could make a real difference. However, integrated and intelligent notification systems like Ascom Myco seem the most promising long-term solution for eliminating alarm fatigue and will create a more efficient, less-stressful and safer healthcare environment.

Keywords

Alarm fatigue, patient safety, false alarms, human factors, alarm management, sound design, intelligent notification systems

INTRODUCTION

We are all familiar with the pings, beeps and rings that form the soundtrack of many hospitals. These auditory alerts, in this paper referred to as 'alarms' for convenience, are intended to alert medical staff to urgent situations and are considered to be critically important for patient safety. However, the excessive number of clinical alarms has led to alarm fatigue, which occurs when clinicians are overwhelmed by the number of alarm signals of which many are false or clinically irrelevant, and consequently become desensitized to them. This may lead to delayed response or missed important alarms and is therefore a significant threat to patient safety [1].

This paper reviews different strategies and solutions proposed by healthcare organizations and companies to address alarm fatigue. This does not only include ways to reduce the number of irrelevant alarms, but also root causes like sound design and communication systems and how the issue must be managed. After discussing their strengths and limitations, the most promising solution will be highlighted.

ALARM FATIGUE: A THREAT TO PATIENT SAFETY

The emergence of alarm fatigue is not very surprising, as clinicians are exposed to hundreds of alarms per day. A 12-day analysis at the John Hopkins Hospital in the United States registered a total of 58,764 alarms, an average of 350 alarms per patient per day [1]. Studies have shown that most of these alarms require no clinical intervention: between 72% and 99% of them are false or non-actionable [2][3]. False alarms occur when no valid triggering event occurs, caused by for example patient motion, poor sensor placement or intermittent cables [4]. Non-actionable alarms do reflect the actual physiologic status of the patient, but require no clinical intervention. These are nuisance alarms, for example heart-rate sounds.

Firstly, this excessive amount of (irrelevant) alarms has led to a 'cry-wolf' situation, which means that the urgency to respond to signals diminishes when an alarm has been found to be false repeatedly before [5][6]. As a result clinicians will only respond to an alarm the percentage they deem it reliable. If an alarm is perceived to be 10% reliable, clinicians will only respond to it 10% of the time. Whether this happens consciously or unconsciously, this desensitization may lead to a clinician ignoring or even not hearing the sound when finally a significant event occurs. The true event gets lost in a cacophony of sounds. Secondly, in response to the constant noise, clinicians might take inappropriate actions like turning down the volume of alarm signals, extending alarm limits outside a safe and appropriate range for the patient or even deactivate alarms. This has already resulted in several patient deaths [3]. Lastly, the noise creates a stressful hospital environment for both staff and patients that may prevent them from recovering.

Alarm fatigue has been increasingly recognized as a critical safety issue by healthcare organizations and regulators. The ECRI Institute, an independent nonprofit organization that researches approaches to improving patient care, has listed alarm fatigue as the number one hazard of the "Top 10 Health Technology Hazards" for the fourth consecutive year in 2015 [7][8]. The Joint Commission, a nonprofit group that accredits nearly 21.000 healthcare programs and organizations in the United States, issued a Sentinel Event Alert on 'Medical Device Alarm Safety In Hospitals' in 2013 to address the issue of alarm safety in general, followed by a 2014 National Patient Safety Goal on clinical alarm safety [3]. The Association for the Advancement of Medical Instrumentation (AAMI) convened a summit in 2011 in collaboration with many other organizations to address this complex problem collaboratively, which highlights the widespread problem of alarm fatigue [1].

REDUCING IRRELEVANT ALARMS

Customizing Alarm Settings

So far, most initiatives for eliminating alarm fatigue have focused on reducing the number of false and non-actionable alarms by tweaking the settings on devices [9]. With the current mechanism alarms are generated when a pre-established threshold limit is exceeded. Many nuisance (i.e. non-actionable) alarms result from the fact that these thresholds are often set too tight. This is because devices are purposefully designed by manufacturers for high sensitivity in order to not miss a clinically significant event [6], but this results in many insignificant alarms. Moreover, these default settings are based on normal healthy population and may therefore not match the patients [10]. For example, the baseline SpO2 of a patient with severe COPD would be significantly different than a patient with healthy lungs [11]. Adjusting the default alarm settings to match the patient population of each hospital unit and further customizing alarm parameters to individual patient‘s needs have proved to reduce the amount of alarms. In one study, heart rate alarms were reduced by more than 50% with a simple adjustment of the limit from 120 to 130 bpm [12].

Reduce False Alarms

One contributor of false alarms are artifacts (i.e. electrical interference/a distortion) in the waveform, caused by problems with the contact between sensor and skin, due to patient motion or the sensor’s adhesive drying out, or poor lead wire preparation. According to participants in the AAMI Summit, nurses should prepare the skin properly before electrode placement and change the electrodes daily to ensure good signal quality [1]. Cvach conducted a quality improvement project that demonstrated a 46% reduction in the number of alarms per bed per day with daily electrode replacement [13].

Adding Delays

Non-actionable alarms often have a short duration and will usually correct themselves when the patient’s condition returns to a normal range within a few seconds [4]. Adding a delay in the interval of time between when a threshold is exceeded and when the alarm sounds has shown an even higher reduction in alarms. Welch reported one study where lowering the SpO2 alarm limits to 80% and adding a 15-second delay resulted in a reduction of alarms of more than 80% [14].

Smart Alarms

Another proposed solution to alarm fatigue are smart alarms, which consider information from other parameters before sounding, such as checking blood pressure before alarming for asystole [2]. In this way machines act more like a nurse since they make decisions similar to those that clinicians now have to make. Such systems are very promising and are starting to emerge, but so far they have been restrained by regulatory requirements.

AN HOLISTIC APPROACH

The abovementioned approaches derive from thinking about the problem as a matter of reducing the number of alarms. But the problem is not that simple, as Barbara Drew, professor of critical care nursing, says: ‘’It is important to identify all possible perspectives in defining alarm (system) issues, so that the solution is not driven by simply reducing the nuisance of alarm signals. It is more than a nuisance issue’’ [1]. So according to Drew merely relying on technical change is not the right solution, the challenge also depends on operational, organizational and cultural changes [6]. Hospitals need to develop policies and protocols for things like how to set alarm limits and when it is appropriate to customize alarms for individual patients [16]. Clinicians should be educated and trained on how to use monitoring devices.

This already shows that alarm management is a complex issue that needs to be addressed with a commitment from many different stakeholders [17]. AAMI President Mary Logan states: ‘’Bringing industry, regulators, outside experts, patient safety officers, healthcare technology management professionals and clinicians together in the same room helps everyone gain a better understanding of the complexity of technology issues. We are more and more convinced that these tough technology challenges are system issues that cannot be solved well by any single stakeholder group in the system’’ [1].

User-Centered Design

Elaborating on this, it is important to recognize that alarm fatigue is primarily a system failure that results from technology driving healthcare process instead of processes driving technology [1]. This means human needs and experiences are often neglected in the design and development of devices and alarm systems. Patient monitoring is dependent on clinicians, so an alarm system is foremost a human system that should support clinicians in their activities. Therefore healthcare organizations propose paying comprehensive attention to the ‘human factors’ in design, by designers often referred to as user-centered design, where user’s needs, characteristics and capabilities are central.

The need for a user-centered focus has already been acknowledged by other industries outside of healthcare, for example in the aviation and nuclear power industry [18]. After the Three-Mile Island accident in 1979 there has been a growing interest in human errors in nuclear plant control rooms and there have been many researches on how to improve the man-machine interface systems and design [19]. The healthcare industry could learn from these examples how a primary focus on the user can improve safety.

SOUND DESIGN

Another facet that clearly shows user experience is not considered is the design of the alarms sounds themselves, yet a different layer to the problem of alarm

fatigue. Evidence suggests that the current ISO standard on medical equipment alarms (IEC 60601-1-8) that was meant to help make alarms discernable from other sounds, does not work as intended in the hospital environment [20]. The current sounds are too loud, uninformative, difficult to discriminate from other sounds and do not distinguish urgent situations from less urgent situations [21]. Moreover, there is no standardization of sounds between the various devices from many different manufacturers. This means that multiple devices on a single patient may produce the same sound or multiple alarms are generated for the same clinical circumstances. The standard includes 17 different melodic alarms, but previous research shows that humans are only capable of discriminating five to seven different categorical sounds [5]. Also, other research indicates that alarms with similar rhythms and repetition or similar duration and amplitude, such as the IEC 60601-1-8 alarms, are more likely to be confused [23]. So it is very hard for clinicians to learn, remember and differentiate the overlapping melodic alarms and thus to determine where a sound is coming from and what it means.

This calls for the need of a redesign of the IEC standard sounds. Two key factors to be considered are the learnability and types of sound and urgency of sounds [23]. Wilcox argued that ‘’humans are much better at learning, differentiating, identifying, classifying, remembering and understanding natural sounds’’ than sounds without inherent meaning (i.e. sounds including only simple acoustic parameters such as frequency), so according to him it would be good to design natural alarm sounds [20]. One suggestion is the use of auditory metaphors, also referred to as earcons (i.e. auditory equivalents of icons), which sound like the condition they represent, for example the rhythmic sound of a heartbeat. A limitation of this is that some conditions may not have such an intuitively obvious auditory icon. In any case, the first thing to do is to create a vision of what would make alarm signals meaningful and then design sounds that conform to that vision [24], which also requires urgency mapping. Subsequently, the sounds should be tested in real life situations if they are perceived as intended.

SECONDARY NOTIFICATION SYSTEMS

Monitor Watchers

In the current situation clinicians rely on auditory alerts which are typically directly presented, forcing them to assess the urgency of and respond to every alert. This means they are faced with a barrage of (unnecessary) work interruptions and competing priorities which can be very frustrating, but is most of all distracting and impedes them to deliver care effectively and efficiently [25]. Many hospitals try to solve this by using central monitoring, whereby monitor watchers identify alarms in a central viewing area and then notify nurses on the floor. In this way clinicians do not have to filter the alerts anymore. A limitation of this is that the communication with nurses is often one-way with the use of pagers, so the monitor watcher has no confirmation that the message was received and acted upon. So who makes sure alarms are responded to when the patient’s nurse is already busy? [26].

Intelligent Notification Systems

A modern alternative to human monitoring is using wireless notification devices like smartphones or tablets that allow closed-loop communications. Here, middleware becomes the intermediary between clinical systems and mobile devices, centrally controlling the distribution and display of alarm notifications [25]. According to Cvach, such a system has many advantages, since it can be configured to optimize alarm management on many levels, by incorporating algorithms and automatic delays in sending only alerts to nurses when necessary [26]. This also allows for the use of other sensory stimuli apart from auditory senses.

Ascom Myco

One such product is Ascom Myco (figure 1), a purpose-built smartphone developed by the company Ascom that is specifically designed to reduce alarm fatigue and improve workflows [27]. It combines the capabilities of a smartphone with intelligent alert filtering. Nurses will only get notified when a relevant event occurs and when the alarm is triggered by their assigned patients. The top display of the smartphone allows them to read notifications at a glance, including content-rich information like bed location, status and severity of the event. A real-time image of patient monitors can provide the nurse with more context related to the alarm so they will better understand the situation and respond to it accordingly.

Myco is designed with a strong focus on the users, as Claes Ödman, General Manager Wireless Solutions, says: ‘’By collaborating with healthcare facilities, ‘shadowing’ nurses during entire shifts and applying user-centric design methods, we have developed Ascom Myco with the whole healthcare team in mind’’. Several proof of concepts were already approved and this year Ascom has successfully completed MobileIron tests for Android capability [28].

Figure 1. Ascom Myco: a smartphone designed to reduce alarm fatigue and improve workflows.

DISCUSSION

Despite great attention has been paid to finding strategies for eliminating alarm fatigue, there is not yet consensus on the optimal approach. From the suggested strategies and solutions in this paper, the easiest and most direct ways to reduce alarm fatigue would be to individualize alarm settings for each patient condition and proper handling of electrode placement. However, although quality improvement initiatives have demonstrated significant reductions in the amount of false and non-actionable alarms, still very little has changed in hospitals [15]. Also, these outcomes actually have not proved anything meaningful with regard to reducing alarm fatigue. Solutions must be tested in real life situations whereby randomized controlled trials (RCT's), that give the highest level of evidence, are needed. The focus should be on patient outcomes rather than on reducing the amount of alarms [1][3][5].

As previously discussed, I believe it is important to view the issue from a wider perspective and to address root causes (e.g. sound design) rather than solely focusing on reducing irrelevant alarms. Standardizing and adding meaning to existing sounds seem valuable ways to create a more natural and less stressful environment for both clinicians and patients and may therefore help to eliminate alarm fatigue. Unfortunately the relationship between meaning and sound variables is not yet fully understanded, so there is still a lot of research needed for creating the perfect sounds [20].

What is strong about products like Ascom Myco is that it addresses the bigger picture, by integrating different information flows that are currently fragmented in the hospital, such as the medical devices that all signal on their own, into one intelligent solution. Furthermore, bringing the information to the clinicians instead of clinicians having to go to the information creates a far more logical flow of information. Clinicians can be more efficient in their decision-making and respond faster to demands, which improves their workflow significantly. Ascom Myco has the potential to solve multiple alarm system issues at once and makes the other discussed solutions rather unnecessary. For example, in such integrated systems, auditory signals would only fulfill just one function, i.e. indicating that a message was received and directing the user to the visual display, and therefore do not have to be meaningful in itself. Based on previous information, I think such a product-service system is the most promising long-term solution for eliminating alarm fatigue.

A new notification system would, just like redesigned sounds, require considerable organizational and cultural changes in the hospital. Therefore it is important to involve all stakeholders throughout the entire process. After a concept has been approved, which is already the case for Ascom Myco, the next step would be to make a plan for implementing such a new system successfully in the hospital, which might ask for research in itself. Until new systems are implemented or when hospitals are reluctant of such radical changes, strategies like adjusting settings could also make a real difference when applied correctly. A last important remark is that it should not be forgotten that none of these interventions can be successful without proper staff education and training.

CONCLUSION

The proliferation of alarms that were meant to improve patient safety have, ironically, led to a significant safety concern in hospitals: alarm fatigue. Interventions to address this problem have proved significant reductions in the amount of false and non-actionable alarms. However, solely focusing on reducing the number of alarms is not enough. Alarm fatigue is a systematic problem that needs to be dealt with using a group approach, including healthcare industry, regulators, technology management professionals, designers and clinicians. Solutions must be designed with a primary focus on the users and their needs and capabilities in the healthcare environment. Integrated and intelligent notification systems like Ascom Myco that address the bigger picture in alarm system issues, seem the most promising long-term solution. Such a product-service system creates a less-stressful hospital environment and more efficient workflow which allows clinicians to spend more time with their patients. This solution requires considerable organizational and cultural changes, so the next step would be to make a plan for implementing the system successfully in the hospital, requiring proper staff education and the involvement from all stakeholders.

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