



## EDITORIAL

## CLINICAL ALARM EFFECTIVENESS AND ALARM FATIGUE

William A. Hyman<sup>1</sup>

The alarms on clinical devices have the intended purpose of calling the caregiver's attention to patient or device situations that require the caregiver to intervene. This intervention may be with respect to the patient's condition, or to correct some aspect of the operation of the medical device. An example of a patient issue is low heart rate while an example of an equipment issue is a leads-off alarm. Alarm situations may be urgent in that the patient's well being would be compromised if there were not a quick response. In other situations there may be little or no urgency, although the situation still requires attention. An unfortunate aspect of most clinical alarms is that the sounds that they make do not usually distinguish urgent situations from the less urgent. In some cases a device makes the same sound for all alarms regardless of the reason for the alarm. This is further complicated when multiple devices are in use and the various alarm sounds are all similar, or inconsistent with respect to urgency. Multiple devices on a single patient can also generate multiple alarms for the same clinical circumstances. Thus the bedside nurse is routinely confronted with numerous alarm sounds that have no clear meaning other than there is a call for their attention. In addition alarms of one kind or another may occur at a high rate, so that one or more alarms sounding is an almost constant situation. Also, it is commonly observed that there are many "false alarms" in which no intervention is actually required, other than to reset the alarm. Observations in the United States have shown that false alarms that do not actually indicate an adverse patient situation are in fact the overwhelming majority of all alarms, with numbers cited of 85% and more. That is, most alarms are false alarms.

If nursing were a leisurely occupation this might be a tolerable situation in which the nurse would respond quickly to all alarms and then determine if a quick intervention, or any intervention, was actually necessary. However in many clinical settings nurses are too busy to do this, in part because there may be too few nurses. Therefore a consistent rapid response to every alarm is not actually possible, especially given the large number of alarms. One consequence of there being many alarms, most of which are false alarms, is that "alarm fatigue" occurs in which nurses stop responding because of their own experience that most of the time no response is actually necessary. Beyond actively ignoring alarms, nurses also can reach a level of alarm fatigue in which they do not consciously even hear the alarm, even though the noise being made could be heard if they focused on it or it were called to their attention. Simply making alarms louder is not acceptable because of the adverse effects of noise on patients as well as caregivers. However The

<sup>1</sup> Professor Emeritus Department of Biomedical Engineering Texas A&M University College Station, Texas E-mail: w-hyman@tamu.edu

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Joint Commission (TJC), a private hospital accrediting organization, has in the past issued a National Patient Safety Goal related to assuring that alarms can be heard where they need to be heard, and there has been discussion of the TJC again addressing alarm issues. While an alarm being capable of being heard is certainly important, alarm fatigue suggests that the alarm being capable of being heard is not the primary issue.

The worst outcome of alarm fatigue is a clinical situation in which the alarm does indicate that there is a need for immediate attention, but intervention does not occur because the nurse does not respond even though it is at least theoretically possible that they could have heard it, and could have responded, in a timely manner. Even this assumes that the nurse was not otherwise doing something important that could not be reasonably interrupted. In these situations it is tempting, and perhaps traditional, to simply blame the nurse for not responding to an alarm that they could have heard and responded to. However blaming nurses is not an effective analysis because it ignores the reality of the work environment and the predictable human response to too many alarms, most of which are false alarms. Most importantly, blaming the nurse for not responding, and telling nurses to pay attention and respond more quickly in the future, cannot really be expected to have a long term positive effect. In this regard there is an important difference between what a hypothetical nurse could have possibly done, and what real nurses in the real environment of use can actually be expected to consistently do. This difference between theoretical performance and real performance is the subject of "human factors" which studies how real people perform and applies that knowledge to the design of medical devices, and to the design of the systems in which people work.

What then can be done about alarm fatigue? Unfortunately there is no single or easy solution. One immediate approach is to assess whether there are enough nurses to deal with the conditions of their patients and the number of alarms that occur. Adding nurses is of course adding expense, even assuming that there were enough nurses available so that more could be hired. Non-nursing, and perhaps less costly, personnel could also be added as alarm monitors so that more people were available to serve as a human interface between the device generating the alarm and the nurse that must ultimately respond to an urgent clinical situation. Alarm monitoring can also be moved away from the bedside to be a more centralized activity. Once centralized, additional people and technologies can then be added to assess the significance of the alarms, and to provide communication from the central station directly to the bedside nurse.

While relatively simple in concept, such systems must be carefully planned and designed so that all alarms are properly captured, and proper assessments are made either by human operators or automated systems. The communication link to the bedside nurse is the next critical step in designing a system that actually works. One communication approach is for the bedside nurse to be called on a dedicated portable telephone and advised as to which patient needs their attention. While this might address the issue of the nurse being unaware of the alarm, it does not directly address there being too many alarms, or too few nurses to respond to them all. At what rate can a nurse's telephone ring before the telephone becomes a further annoyance leading to "telephone fatigue"? Also, there is a hidden assumption that the nurse is actually available to answer the phone in a timely manner, and to provide the service needed. In other words, it is assumed that the nurse is not actually too busy to do so. One added approach here is to have human or automatic escalation of the telephone notification so that if the primary nurse does not answer, or indicates that they are not available, someone else or all nearby nurses can be notified. Escalation can also be used to only have the central system act only if the bedside alarm is not responded to by the local nurse in a predetermined time. Here the central system would serve as a back-up to the bedside nurse rather than providing the primary response. However appropriate and necessary response times have not been well

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defined or in a standardized manner, in part because frequent failures to respond quickly have not been adequately studied or even acknowledged.

Central systems can also serve as alarm integrators that can assess all of the alarm information coming from a patient and, at least in principle, issue a single alarm for that patient at that time. An integrator could also in principle use multiple types of information to determine whether an alarm was actually necessary. Of course the integrator has to be able to receive and process the multiple outputs from devices that may have been provided by different manufacturers. Capturing and using such diverse output is still not a simple matter because of the lack of easily used and commonly applied standardization for device communications. Creating and proving the clinical correctness of assessment algorithms is also challenging.

A related technological refinement that could lead to fewer monitoring alarms from an individual medical device is to design them to be better able to distinguish important clinical or device events from unimportant artifacts. Using multiple clinical parameters, as mentioned above for some alarm integrators, has been suggested. Here the challenge falls to the manufacturer to design a more sophisticated internal multi-parameter signal processing system. However manufacturers may be reluctant to do this because it increases their responsibility to design a system that detects what must be detected while not creating false alarms. If such a system were to not alarm when it should have or needed to alarm, then an adverse patient outcome could be blamed on the design of the device rather than the alleged lack of response by the nurse. At least in the United States who is blamed has important economic consequences because of our system of seeking compensation in the courts for what is perceived to be a death or injury that should not have occurred. Similarly, manufacturers are reluctant to use different sounds to distinguish important alarms from less important alarms because it requires them to make the judgment on what is important and what is not. If instead all alarms make the same sound then the clinical staff has to make those judgments.

Another approach to reducing the large number of false alarms in order to reduce the overall number of alarms, and to give more importance to the alarms that do occur, is to slightly increase the time between a possible clinical event and when an alarm sounds. For example this might eliminate an alarm caused by a patient moving, or coughing, which is wrongly interpreted by a monitor as a significant cardiovascular event. Instead of sounding the alarm immediately the alarm could be made to not sound if the measured clinical variable returned to the patient's normal in a short period of time. A similar effect can be obtained by a small increase in an upper alarm limit or a small decrease in a lower alarm limit (heart rate for example) so that the acceptable range of the patient's values is wider, yet still clinically appropriate. However standard methods for implementing appropriate delays or adjusting limits have not yet been developed and the research showing the safety and effectiveness of these approaches is limited. Simply reducing the number of alarms is in general not acceptable if this results in a lack of response to a situation for which there should have been a response. Therefore, while time delays and wider limit ranges can probably be effective in reducing unnecessary alarms if carefully done, there can be resistance to such measures because of the concern that important events will be missed. Perhaps equally, or even more, controversial is the idea that fewer less critical patients should be monitored at all, thus reducing the total number of false alarms. The potential risk of doing this can perhaps be balanced against the observation that important events are already being missed because of alarm fatigue. In addition there must be careful controls and supervision in the process of selecting patients, and setting delays and sensitivity adjustments, so that effective patient monitoring is not lost.

Adjusting alarm settings other than delays and limits to reduce the number of alarms has also been used to eliminate alarm annoyance without necessarily applying sound clinical judgment. Simply turning the alarm volume down to an inaudible or barely audible level has been known to occur so that the nurse simply  
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doesn't have to listen to it anymore. This is inappropriate alarm avoidance rather than alarm fatigue. Some devices also allow the alarm to be turned off, or at least the sound to be turned off. This also invites use of this capability to fully silence an alarm that should not be silenced. In addition it can lead to the predictable error of turning an alarm off temporarily, and then forgetting to turn it back on, yet still expecting the device to alarm when necessary. This reliance on alarms is another aspect of the alarm challenge. Nurses believing that an alarm will alert them to important clinical conditions may become less vigilant, instead of alarms serving to improve vigilance.

Another alarm issue is the appropriateness of the monitoring for the condition of the patient. For example having a patient with a respiratory problem on a heart rate monitor may not result in a low heart rate alarm until hypoxia from loss of respiration has already resulted in brain damage. This can also be an example of false reliance in which the sense that the patient is being monitored makes the nurse less attentive.

Despite the many years of concern about alarms and their effective use, including alarm fatigue, alarm management remains a significant challenge in the clinical setting. While new technologies may offer some improvements, these technologies are not yet all readily available, nor are they easily integrated. In the meantime a starting point is to properly understand the current local situation. Are there too many alarms, many of which are false? Is response time being delayed? Are alarms being ignored? Is there enough staff to properly deal with the alarms that do occur, without ignoring them? If it is identified that there is a local alarm problem, then the situation must be further addressed. At a minimum the lack of current adequate alarm response must be recognized and brought to the attention of the appropriate supervisory personnel—before there is an adverse event for which the nurse gets blamed. In addition, which devices are generating most of the alarms, and why, should be addressed. In this regard simple and safe adjustments may be possible that reduce unnecessary alarms, or more personnel may be required. Implementing more complex solutions such as alarm centralization and integration must be approached with care.

Unfortunately it is common to over promise results and under estimate implementation challenges. In this regard bedside nurses must be involved in identifying problems, and the solutions that will actually work and be effectively used. Attempts to implement new systems, whether by technology or work methods, are likely to not be effective if the new systems suddenly appear without adequate nursing contributions to their selection. In this regard I like to ask the following questions before implementing claimed improvements. (1) What exactly is the problem that is to be solved? (2) How exactly will the proposed solution solve that problem? and (3) How and what will we measure to determine if the solution has been successful?