

ATTITUDES AND PRACTICES RELATED TO CLINICAL ALARMS

By Marjorie Funk, RN, PhD, J. Tobey Clark, MSEE, CCE, Thomas J. Bauld, PhD, CCE, Jennifer C. Ott, MSBME, CCE, and Paul Coss, RN

Background The number of devices with alarms has multiplied in recent years, causing alarm fatigue in bedside clinicians. Alarm fatigue is now recognized as a critical safety issue.

Objective To determine if attitudes and practices related to clinical alarms have changed since 2005.

Methods The Healthcare Technology Foundation's Clinical Alarms Committee developed an online survey for hospital personnel that addressed attitudes and practices related to clinical alarms. They administered it in 2005-2006 and in 2011 and compared the results.

Results Respondents were asked about their level of agreement with 19 statements about alarms. Many of the statements revealed no significant differences between the 2 survey years, although some differences were apparent. Respondents to the 2011 survey were significantly more likely to agree with statements about alarm sounds differentiating the priority of alarm and the helpfulness of central alarm management. Respondents in 2011 were significantly less likely to feel that nuisance alarms occur frequently and disrupt patient care. Respondents also ranked the importance of 9 different alarm issues. In both years, they ranked frequent false alarms as the most important. In response to a new question in the 2011 survey, 18% of respondents reported patients' experiencing adverse events related to alarms at their institutions.

Conclusions Since 2005-2006 when the first survey was conducted, not much has changed. False alarms continue to contribute to a noisy hospital environment, and sentinel events related to alarm fatigue persist. Alarm hazards are a significant patient safety issue. (*American Journal of Critical Care*. 2014;23:e9-e18)

Alarm fatigue occurs when nurses become overwhelmed by the sheer number of alarms.

In recent years, the number of devices with alarms has multiplied exponentially in the vast majority of hospital units. Monitors, ventilators, infusion pumps, and many other devices beep endlessly, demanding our attention. Alarm fatigue occurs when nurses become overwhelmed by the sheer number of alarms. Alarm fatigue can result in desensitization to the alarms, which can lead to missed alarms or a delayed response to alarms.¹ Such desensitization to alarms occurs largely because the devices have “cried wolf” too often. Studies have shown that 72% to 99% of alarms are false (no valid triggering event) or nonactionable (correctly sound, but for an event that has no clinical relevance).²⁻⁷

Nurses may not respond to alarms because they know that most of them are false or nonactionable. Because alarms are so prevalent, alarm sounds often become “white noise” that nurses no longer “hear.” In addition to ignoring alarms, nurses may also reduce audible alarm levels, unsafely widen alarm limits, and inappropriately silence or deactivate alarms.

Alarm fatigue has led to sentinel events and deaths of patients.

The Food and Drug Administration (FDA) reported 566 deaths related to monitor alarms from 2005 to 2008.⁸ Owing to the probable underreporting of these cases, it is likely that the number of deaths is far higher. Recognizing the gravity of problems related to alarm safety, the Association for the

Advancement of Medical Instrumentation, the FDA, the Joint Commission, the American College of Clinical Engineering, and the ECRI Institute convened the Clinical Alarms Summit in October 2011. More than 300 nurses; physicians; clinical and biomedical engineers; acoustical experts; safety experts from health

care, nuclear power, and aviation industries; and staff from regulatory bodies brought different perspectives to deal with the challenging issue of alarm system safety. Since then, the ECRI Institute, an independent nonprofit organization that addresses patient safety, named alarm hazards No. 1 of the top 10 technology hazards for 2012, 2013, and 2014.^{1,9,10}

The Joint Commission has been addressing clinical alarm safety for more than a decade. It released a National Patient Safety Goal (NPSG) to improve the effectiveness of clinical alarm systems in 2003, a Sentinel Event Alert on medical device alarm safety in hospitals in April 2013, and a new NPSG on alarm management in June 2013.¹¹ The new goal will be implemented in 2 phases. Phase I begins January 1, 2014, when hospitals will be required to establish alarm safety as an organizational priority and identify the most important alarms to manage on the basis of their own internal situations. Phase II begins January 1, 2016, when hospitals will be expected to develop and implement specific components of policies and procedures and to educate staff in the organization about alarm system management.

The Healthcare Technology Foundation (HTF; <http://www.thehtf.org>), an organization promoting the development, application, and support of safe and effective health care technologies, initiated a clinical alarms improvement program in 2004. This program focused on surveys, publications, and forums at professional meetings. In 2005-2006, the HTF performed a national survey of health care personnel to determine perceptions of clinical alarm issues.¹² In 2011, the HTF repeated this survey of health care personnel. The purpose of the analysis reported here is to determine if attitudes and practices related to clinical alarms have changed over time by comparing the results of the 2005-2006 and 2011 HTF surveys.

Methods

In 2005, the HTF Clinical Alarms Committee developed an online survey for hospital personnel that addressed clinical alarms.¹² We administered it by

About the Authors

Marjorie Funk is a member of the board of directors of the Healthcare Technology Foundation and is a professor at the Yale University School of Nursing in West Haven, Connecticut. **J. Tobey Clark** is president of the Healthcare Technology Foundation and director of instrumentation and technical services at the University of Vermont in Burlington. **Thomas J. Bauld** is a member of the board of directors of the Healthcare Technology Foundation and a biomedical engineer for the Department of Veterans Affairs, National Center for Patient Safety in Ann Arbor, Michigan. **Jennifer C. Ott** is secretary of the Healthcare Technology Foundation and a project manager and equipment planner for Northstar Management Company in St Louis, Missouri. **Paul Coss** is a member of the advisory board for Healthcare Technology Foundation and is a principal at Coss Associates in Lexington, Massachusetts.

Corresponding author: Marjorie Funk, RN, PhD, Yale University School of Nursing, PO Box 27399, West Haven, CT 06516-7399 (e-mail: marjorie.funk@yale.edu).

using SurveyMonkey from August 15, 2005, to January 15, 2006, and then again from August 8, 2011, to September 10, 2011. The initial section elicited information on work-related demographics of respondents and their workplace. The next section provided a number of general statements about clinical alarms and prompted respondents to rate their level of agreement with the statement, using options of *strongly agree*, *agree*, *neutral*, *disagree*, and *strongly disagree*. The last section contained a list of 9 issues that potentially inhibit effective management of clinical alarms. We asked respondents to rank the issues on a scale of 1 (most important) to 9 (least important). The survey also contained spaces for respondents to provide comments. The 2011 survey repeated most of the questions from the 2005-2006 survey¹² so that we could track changes. In addition, we added 4 new questions to explore issues that arose from the initial survey:

1. Has your institution experienced adverse patient events in the last 2 years related to clinical alarm problems?
2. Does your institution use "monitor watchers" in a central viewing area to observe and communicate alarm conditions to caregivers?
3. Has your institution developed alarm improvement initiatives over the past few years?
4. Has your health care institution instituted new technological solutions to improve clinical alarm safety?

We also expanded the job classifications and departmental choices on the basis of the first survey.

A number of health care organizations (Table 1), including the American Association of Critical-Care Nurses, supported the study by making members, subscribers, and other stakeholders aware of the survey. A link to the survey was posted on the HTF website and on the websites of these other organizations. We made paper copies available for people who were unable to use the electronic version. The survey elicited no personally identifiable information or the identity of the respondent's institution. The study was considered exempt by the human investigations committee at Yale University.

We downloaded the data from SurveyMonkey to Microsoft Office Excel 2007 and then to SAS 9.1 for analysis. We used χ^2 analysis, with odds ratios and 95% confidence intervals as appropriate, to determine differences between the 2005-2006 and 2011 surveys for nominal level responses. For opinions about alarms, where the responses were on a 5-point Likert scale from strongly agree to strongly disagree, we used χ^2 analysis to compare percentages responding to each level and Mann Whitney U

Table 1
Supporting organizations

American Association for Respiratory Care
American Association of Critical-Care Nurses
American College of Clinical Engineering
Association for the Advancement of Medical Instrumentation
ECRI Institute
Food and Drug Administration/Medical Product Safety network
Medical Equipment and Technology Association
US Department of Veterans Affairs
24x7 Magazine

with median interquartile ranges to compare median values.

Results

We received 1327 responses to the 2005-2006 survey and 4278 responses to the 2011 survey. Demographic characteristics of the entire sample are displayed in Table 2. Overall, a vast majority of respondents worked in acute care hospitals and about half worked in intensive care units (ICUs). About 80% of respondents were registered nurses or respiratory therapists. Almost three-quarters had more than 11 years of experience.

A comparison of these characteristics between 2005-2006 and 2011 is shown in Table 3. Compared with the 2005-2006 survey, the 2011 survey revealed that a significantly higher proportion of respondents worked in acute care hospitals and ICUs. Respondents to the 2011 survey were significantly more experienced, with a higher proportion having worked more than 11 years. On the other hand, the 2005-2006 survey had a significantly higher proportion of nurses responding (51.81% of total respondents in 2005-2006 vs 33.06% of total respondents in 2011), although the total number of nurse respondents was greater in the 2011 survey (688 in 2005-2006 vs 1414 in 2011). This smaller proportion of nurses responding to the 2011 survey is most likely due to the large numbers of respiratory therapists ($n = 2116$, 60.75%) who were encouraged to participate by the American Association for Respiratory Care in 2011.

Respondents were asked about their level of agreement with 19 statements about alarms (Table 4). Many of the statements revealed no significant differences between the 2 survey years, although some differences were apparent. Respondents to the 2011 survey were significantly more likely to agree with statements about alarm sounds differentiating the priority of alarm and the helpfulness of central

Table 2
Demographic characteristics of combined
2005-2006 and 2011 samples

Characteristic	Number	Percentage ^a
Facility type		
Acute care hospital	5040	96.26
Ambulatory care facility or surgery center	132	2.52
Subacute care facility	5	0.10
Assisted living/rehabilitation facility	4	0.08
Nursing home	3	0.06
Other	52	0.99
Hospital department		
Intensive care unit	1966	49.13
General care area	474	11.84
Support services	321	8.02
Clinical engineering	214	5.35
Progressive care	196	4.90
Operating room/anesthesia	161	4.02
Emergency department	121	3.02
Nursery	116	2.90
Risk/safety management	56	1.40
Other	377	9.42
Job title		
Respiratory therapist	2302	42.21
Registered nurse	2063	37.83
Clinical manager	353	6.47
Biomedical equipment technician	235	4.31
Clinical engineer	163	2.99
Administrator/nonclinical manager	120	2.20
Nurse's aide or orderly	48	0.88
Physician	36	0.66
Licensed practical nurse	29	0.53
Monitor technician	27	0.50
Paramedical (eg, radiology, laboratory, pharmacy)	15	0.28
Transporter	1	0.02
Other	62	1.14
Years of experience		
0-3	344	6.23
3-6	499	9.04
6-11	575	10.42
>11	4100	74.30

^a Percentages are based on the total number of respondents for whom information on that characteristic was available.

alarm management. Respondents in 2011 were significantly less likely to feel that nuisance alarms occur frequently and disrupt patient care. The situation in 2011 also seemed better regarding the perceived complexity of setting alarm parameters. On the other hand, respondents to the 2005-2006 survey were significantly more likely to agree that that sounds and displays should be distinct based on the parameter or source, policies and procedures regarding alarm management were effectively used, and that there is a requirement to document that alarms are set and appropriate for each patient.

Respondents also ranked the importance of 9 different alarm issues (Table 5). In both 2005-2006 and 2011, they ranked "Frequent false alarms, which

lead to reduced attention or response to alarms when they occur" as the most important. The 3 least important issues ("Difficulty in setting alarms properly," "Noise competition from nonclinical alarms and pages," and "Lack of training on alarm systems") were similar across the 2 surveys. Differences occurred in the middle of the rankings. For example, respondents ranked "Overreliance on alarms to call attention to patient problems" as second in importance in 2005-2006, but it dropped to fifth in 2011. The second most important issue in 2011 was "Difficulty in identifying the source of an alarm."

Four new questions were included in the 2011 survey (see Figure). Almost 1 in 5 respondents (18%) reported experiencing adverse patient events related to alarms in their institutions in the past 2 years. Nearly half of the respondents (47%) stated that monitor watchers/technicians are used in their institutions. Clinical alarm improvement initiatives were developed in 21% of institutions. Only 19% of respondents reported that their institutions instituted technological solutions to improve alarm safety. Technological solutions implemented included integration of monitor and ventilator alarms within the nurse call system, the use of wireless alarm notification devices such as phones and pagers, installation of remote displays, implementation of alarm consolidation systems, and upgrading or purchasing of new equipment.

Discussion

The hazards associated with clinical alarms have been known for many years; one of the first reports of a sentinel event related to alarms appeared in 1974.¹³ More recently, both the professional and lay literature have called attention to alarms hazards, with a key issue being alarm fatigue. The rationale for the Joint Commission's new NPSG¹¹ is strong evidence that alarm management is a critical safety issue.

The substantial increase in the number of responses from the first to the second survey was most likely due to effective publication of the survey by using partner society relationships. We also suspect that because of the increased media coverage and ranking on hazard listings, alarm issues are garnering more attention.

Has the situation related to clinical alarms hazards improved since the 2005-2006 survey? It appears not. A key finding in our data is the limited change in the results from the 2005-2006 survey to the 2011 survey. The 2011 results also reveal that only a small percentage of hospitals report alarm improvement initiatives and nearly 20% of the respondents had

adverse events related to alarms. The relatively high proportion of respondents reporting adverse events may be due to an increased awareness of alarm safety.

The primary demographic change between the 2 surveys was the participation of respiratory therapists in greater numbers in 2011. A significantly higher percentage of respondents to the 2011 survey (57.56%) were from ICUs, compared with only 31.11% in 2006. In general, ICUs are more affected by the proliferation of alarms because of the density of alarm-generating equipment.

Results of the 2011 survey reveal a significant improvement in the items related to the frequency of nuisance alarms and nuisance alarms disrupting patient care. Possible reasons for this improvement include devices being better able to filter noise and analyze signals, improved preparation of patients for monitoring or therapy, or increased use of monitor watchers to respond to alarms. On the other hand, the responses to the item addressing the impact of nuisance alarms and the possibility that they might lead staff to turn off alarms inappropriately did not change from the first to second survey.

The perceived effectiveness of alarm management policies and procedures decreased in the 2011 survey. The perception of the reduced effectiveness of policies and procedures may be related to an increase in the proportion of patients having devices with alarms. It may also be associated with the competing demands of other safety initiatives, such as initiatives related to the prevention of falls, hospital-acquired infections, and pressure ulcers. It is likely that the emphasis by hospitals on alarm safety, as reflected in the development of effective policies and procedures, may improve with the adoption of the Joint Commission's NPSG on alarm management.¹¹ The surveys also indicated that institutional requirements to document alarm settings and appropriateness for each patient decreased. This decrease may be due to a perception at institutions that nurses spend more time documenting patient care than providing patient care.

In terms of the survey questions ranking the importance of different alarm issues, frequent false alarms was ranked first in importance in both surveys. This issue clearly must be addressed. Hospitals need to use an interdisciplinary approach to develop solutions to false alarms in their institutions. Researchers should carry out rigorously designed multisite clinical trials with the focus on patients' outcomes, rather than just on the reduction in the number of alarms. We need to be assured that patients are not harmed by decreases in the number of alarms. Statistical power may be lacking for outcomes such as mortality and sentinel events. We need large multisite

Table 3
Comparison of demographic characteristics by survey year

Characteristic	Percentage		P	Odds ratio (95% CI)
	2005-2006	2011		
Facility type			<.001	2.18 (1.63-2.92)
Acute care hospital (n = 5040)	93.82	97.07		
Other (n = 196)	6.18	2.93		
Hospital department			<.001	3.00 (2.61-3.46)
Intensive care unit (n = 1966)	31.11	57.56		
Other (n = 2036)	68.89	42.44		
Job title			<.001	2.18 (1.92-2.47)
Registered nurse (n = 2017)	51.81	33.06		
Other (n = 3349)	48.19	66.94		
Years of experience			<.001	1.72 (1.50-1.97)
≤11 (n = 1418)	34.17	23.16		
>11 (n = 4100)	65.83	76.84		

studies and/or appropriate surrogates for these relatively rarely occurring outcomes. It will also be important to measure changes in outcomes over time.

In the meantime, bedside clinicians can implement common-sense strategies, such as improving the preparation of patients' skin before applying monitor electrodes and changing electrodes and telemetry unit batteries daily. They can customize alarm thresholds to the individual patient to avoid nonactionable alarms and consider establishing unit-specific default thresholds. They should also make informed decisions regarding when to initiate and terminate monitoring to avoid unnecessary monitoring with the accompanying false alarms.^{14,15} In non-ICU settings, requiring an order to continue monitoring after a certain period of time is one way to address unnecessary monitoring.

A decrease in false alarms should result in a marked reduction in alarm burden with a higher proportion of clinically meaningful alarms. With fewer alarms, nurses' response time to these clinically meaningful alarms should be shorter. The future impact will most likely be more efficient use of nurses' time, a quieter environment, and fewer sentinel events related to monitor alarms.

The statements "Difficulty in identifying the source of an alarm" and "Difficulty in hearing alarms when they occur" both moved up in the rankings of importance in 2011. This increase in perceived importance may be related to the increase in the number of monitored patients, the lack of standardized alarm annunciation, and the use of more and more devices with alarms. The increasing levels of background noise in hospitals may also play a role.

Table 4
Opinions about alarms

Item	Percentage		P for χ^2	Median score ^a (interquartile range)		P for Mann Whitney U
	2005-2006	2011		2005-2006	2011	
Alarm sounds and/or visual displays should differentiate the priority of alarm (n = 5350)			<.001	1 (1-2)	1 (1-2)	<.001
Strongly agree	66.53	73.14				
Agree	27.78	22.65				
Neutral	3.46	1.96				
Disagree	1.73	1.45				
Strongly disagree	0.49	0.80				
Alarm sounds and/or visual displays should be distinct based on the parameter (eg, heart rate) or source (device type) (n = 5339)			.001	1 (1-2)	1 (1-2)	.001
Strongly agree	62.12	57.85				
Agree	32.26	32.93				
Neutral	3.72	6.34				
Disagree	1.49	2.15				
Strongly disagree	0.41	0.73				
Nuisance alarms occur frequently (n = 5336)			<.001	2 (1-2)	2 (1-2)	<.001
Strongly agree	39.03	30.84				
Agree	41.91	44.69				
Neutral	12.13	15.16				
Disagree	6.35	8.32				
Strongly disagree	0.58	0.68				
Nuisance alarms disrupt patient care (n = 5316)			<.001	2 (1-2)	2 (1-3)	<.001
Strongly agree	38.04	28.75				
Agree	39.46	42.62				
Neutral	13.85	16.75				
Disagree	7.56	11.03				
Strongly disagree	1.09	0.85				
Nuisance alarms reduce trust in alarms and cause caregivers to inappropriately turn alarms off at times other than setup or procedural events (n = 5346)			.14	2 (1-2)	2 (1-2)	.08
Strongly agree	42.13	38.37				
Agree	35.70	39.05				
Neutral	9.32	10.04				
Disagree	11.13	10.62				
Strongly disagree	1.73	1.91				
Properly setting alarm parameters and alerts is overly complex in existing devices (n = 5213)			<.001	3 (2-4)	4 (3-4)	<.001
Strongly agree	6.81	4.51				
Agree	21.01	15.99				
Neutral	23.17	22.62				
Disagree	42.69	48.69				
Strongly disagree	6.31	8.18				
Newer monitoring systems (eg, < 3 years old) have solved most of the previous problems we experienced with clinical alarms (n = 5193)			<.001	3 (2-4)	3 (2-3)	.10
Strongly agree	3.57	3.39				
Agree	27.14	25.80				
Neutral	39.25	45.86				
Disagree	24.15	21.64				
Strongly disagree	5.89	3.31				
The alarms used on my floor/area of the hospital are adequate to alert staff of potential or actual changes in a patient's condition (n = 5186)			.31	2 (2-4)	2 (2-3)	.45
Strongly agree	18.87	17.24				
Agree	53.39	54.95				
Neutral	14.90	14.38				
Disagree	10.43	11.61				
Strongly disagree	2.40	1.81				

Continued

Table 4
Continued

Item	Percentage		P for χ^2	Median score ^a (interquartile range)		P for Mann Whitney U
	2005-2006	2011		2005-2006	2011	
There have been frequent instances where alarms could not be heard and were missed (n = 5149)			.10	4 (2-4)	4 (2-4)	.33
Strongly agree	5.74	5.43				
Agree	23.65	23.71				
Neutral	17.22	17.15				
Disagree	46.43	44.19				
Strongly disagree	6.96	9.53				
Clinical staff is sensitive to alarms and responds quickly (n = 5084)			.15	2 (2-3)	2 (2-3)	.11
Strongly agree	13.58	13.14				
Agree	49.35	52.86				
Neutral	18.28	18.09				
Disagree	16.54	13.88				
Strongly disagree	2.26	2.03				
The medical devices used on my unit/floor all have distinct outputs (ie, sounds, repetition rates, visual displays) that allow users to identify the source of the alarm (n = 5080)			.89	2 (2-3)	2 (2-3)	.86
Strongly agree	16.05	15.28				
Agree	53.34	55.05				
Neutral	13.36	13.11				
Disagree	15.18	14.51				
Strongly disagree	2.08	2.04				
When a number of devices are used with a patient, it can be confusing to determine which device is in an alarm condition (n = 5069)			.22	2 (2-4)	2 (2-4)	.32
Strongly agree	10.32	9.17				
Agree	41.02	41.29				
Neutral	14.14	14.35				
Disagree	32.52	32.00				
Strongly disagree	1.99	3.19				
Environmental background noise has interfered with alarm recognition (n = 5,070)			.61	3 (2-4)	3 (2-4)	.30
Strongly agree	7.73	7.32				
Agree	35.45	35.09				
Neutral	16.59	15.51				
Disagree	37.01	38.05				
Strongly disagree	3.21	4.03				
Central alarm management staff responsible for receiving alarm messages and alerting appropriate staff is helpful (n = 5034)			<.001	3 (2-3)	2 (2-3)	<.001
Strongly agree	12.15	15.14				
Agree	37.15	37.53				
Neutral	33.74	36.07				
Disagree	13.11	8.95				
Strongly disagree	3.85	2.31				
Alarm integration and communication systems via pagers, cell phones, and other wireless devices are useful for improving alarms management and response (n = 4932)			.09	2 (2-3)	2 (2-3)	.11
Strongly agree	14.40	17.30				
Agree	40.40	38.33				
Neutral	29.84	30.88				
Disagree	12.65	10.94				
Strongly disagree	2.71	2.56				

Continued

Table 4
Continued

Item	Percentage		P for χ^2	Median score ^a (interquartile range)		P for Mann Whitney U
	2005-2006	2011		2005-2006	2011	
Smart alarms (eg, where multiple parameters, rate of change of parameters, and signal quality are automatically assessed in their entirety) would be effective to use for reducing false alarms (n=4934)			.29	2 (2-2)	2 (2-2)	.44
Strongly agree	21.17	22.05				
Agree	59.23	55.79				
Neutral	17.06	19.05				
Disagree	2.27	2.77				
Strongly disagree	0.26	0.34				
Smart alarms (eg, where multiple parameters, rate of change of parameters, and signal quality are automatically assessed in their entirety) would be effective to use for improving clinical response to important patient alarms (n=4923)			.08	2 (2-2)	2 (2-2)	.57
Strongly agree	21.40	23.10				
Agree	59.39	54.69				
Neutral	16.40	18.85				
Disagree	2.46	2.93				
Strongly disagree	0.35	0.42				
Clinical policies and procedures regarding alarm management are effectively used in my facility (n=4915)			<.001	2 (2-3)	2 (2-3)	<.001
Strongly agree	14.00	10.66				
Agree	54.53	44.57				
Neutral	19.77	26.96				
Disagree	12.16	14.98				
Strongly disagree	2.54	2.84				
There is a requirement in your institution to document that the alarms are set and are appropriate for each patient (n=4886)			.008	2 (1-2)	2 (1-3)	<.001
Strongly agree	33.94	29.70				
Agree	41.83	41.36				
Neutral	12.52	14.38				
Disagree	9.98	11.68				
Strongly disagree	1.72	2.88				

^a Scoring system: strongly agree = 1, agree = 2, neutral = 3, disagree = 4, strongly disagree = 5.

Answers to questions unique to the 2011 survey revealed that 671 of 3740 respondents (18%) knew of adverse events related to clinical alarm problems in their institutions in the previous 2 years. Because sentinel events related to alarms are most likely underreported, this statistic may be even more representative of the true extent of the problem than the 566 deaths related to monitor alarms from 2005 to 2008 reported by the FDA.⁸

Of marked concern given the prevalence of adverse events related to alarms is the small proportion of hospitals actively working on alarm improvement initiatives. One reason may be the complexity of the

issue and the need for a consistent, disciplined, and thorough interdisciplinary approach. Another reason for the lack of alarm improvement initiatives may be the presence of numerous competing priorities. These priorities are likely to change with the need to address the Joint Commission's 2014 NPSP on alarm management.¹¹ Sources of alarm hazards include sensor artifact, poor human factors design, complexity of ancillary alarm systems, inadequate facilities design, environmental noise, the lack of well communicated or poorly designed care management and alarm escalation processes, and limited staff education on alarms and equipment with alarms.

Table 5
Importance of alarm issues: entire sample
(2005-2006: n = 1327; 2011: n = 4276)

Question	2005-2006		2011		P
	Mean ^a	Ranking ^b	Mean ^a	Ranking ^b	
Difficulty in setting alarms properly	5.4624	7	5.1578	7	.01
Difficulty in hearing alarms when they occur	5.0596	6	4.7007	4	<.001
Difficulty in identifying the source of an alarm	4.7837	4	4.6145	2	.03
Difficulty in understanding the priority of an alarm	4.5085	3	4.6360	3	.10
Frequent false alarms, which lead to reduced attention or response to alarms when they occur	2.8776	1	4.2108	1	<.001
Inadequate staff to respond to alarms as they occur	5.0178	5	4.8719	6	.14
Overreliance on alarms to call attention to patient problems	4.4984	2	4.8615	5	<.001
Noise competition from nonclinical alarms and pages	6.0919	8	5.6616	9	<.001
Lack of training on alarm systems	6.1256	9	5.5500	8	<.001

^a Mean ranking for the item.
^b Ranking of the means.

Individual hospitals need to take a systematic, interdisciplinary approach to alarm safety issues. Focus on alarm events and frequency of alarms, current alarm management practices, staff knowledge, and hospital “culture” is a necessary step. A failure mode and effects analysis might be performed that would lead to strategies and actions suited to individual institutions to reduce alarm hazards.

The use of monitor watchers in a central viewing area to observe and communicate alarm conditions to caregivers was reported by 47% of respondents. Despite the proliferation of hospitals using monitor watchers, it is not known if they improve patients’ outcomes. In studies conducted more than 15 years ago, the presence of monitor watchers resulted in the improved detection of arrhythmias. However, the use of monitor watchers was not associated with lower rates of most adverse outcomes, although fewer episodes of sustained ventricular tachycardia occurred when someone was watching the monitor at all times.^{16,17} Research on the use of monitor watchers in current hospital environments needs to be conducted. Is the expense associated with employing monitor watchers a good investment? Does the use of monitor watchers result in improved alarm management and better outcomes for patients?

Several major institutions have implemented long-term comprehensive improvement projects that have demonstrated reductions in the numbers of both false alarms and total alarms, while simultaneously not missing any critically significant true alarms. For example, Johns Hopkins Hospital in Baltimore, Children’s National Medical Center in Washington, DC, Beth Israel Deaconess Medical

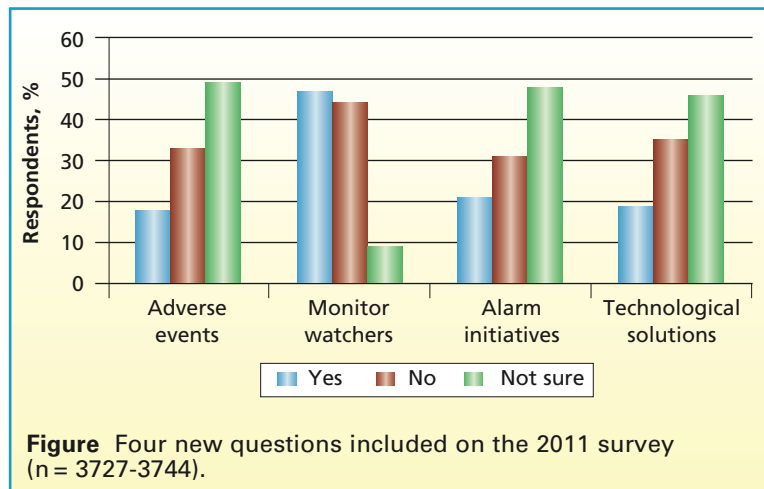


Figure 4 Four new questions included on the 2011 survey (n = 3727-3744).

Center in Boston, and Christiana Care Health System in Delaware embarked on long-term improvement projects that have produced measureable and sustainable results. Despite the reduction in alarms, they report that clinical care has been improved and true alarms have not been missed. Patient and staff satisfaction have both increased, as the noise and frequency of alarms have been reduced.¹⁸⁻²¹ Their work has generated strategies that other institutions can implement.

This study has both strengths and limitations. The national survey was broadly distributed to health care professionals working in clinical environments where alarms have proliferated in recent years. Although the 2011 survey had more than 3 times the number in the initial survey, it still represents only a tiny fraction of clinicians in the field.

Conclusions

Clinical alarm safety has been an ongoing challenge that has received considerable attention, but it appears that little measurable progress has been made. Since 2005-2006, when the first survey was conducted, not much has changed except at a few major health care institutions. False and nonactionable alarms continue to contribute to a noisy hospital environment, and sentinel events related to alarm fatigue persist. Perhaps hospitals will pay more attention to this significant patient safety issue with the implementation of the Joint Commission's NPSG on alarm management.¹¹ Our 2 surveys substantiated the fact that alarm hazards are a problem. We need to act now to attain the goal established by Mary Logan, president of the Association for the Advancement of Medical Instrumentation, at the 2011 Alarm Summit: by 2017, no patient will be harmed by adverse alarm events.²²

ACKNOWLEDGMENTS

The authors are grateful for the statistical consultation provided by Kristopher Fennie, PhD, Florida International University, Miami, Florida.

FINANCIAL DISCLOSURES

None reported.

eLetters

Now that you've read the article, create or contribute to an online discussion on this topic. Visit www.ajconline.org and click "Responses" in the second column of either the full-text or PDF view of the article.

REFERENCES

1. ECRI Institute. Top 10 health technology hazards for 2012. *Health Devices*. 2011;40(11):1-16.
2. Atzema C, Schull MJ, Borgundvaag B, Slaughter GRD, Lee CK. ALARMED: adverse events in low-risk patients with chest pain receiving continuous electrocardiographic monitoring in the emergency department—a pilot study. *Am J Emerg Med*. 2006;24:62-67.
3. Chambrin M-C, Ravaux P, Calvelo D, Jaborska A, Chopin C, Boniface B. Multicentric study of monitoring alarms in the adult intensive care unit (ICU): a descriptive analysis. *Intensive Care Med*. 1999;25:1360-1366.
4. Görges M, Markewitz BA, Westenskow DR. Improving alarm performance in the medical intensive care unit using delays and clinical context. *Anesth Analg*. 2009;108:1546-1552.
5. Lawless ST. Crying wolf: false alarms in a pediatric intensive care unit. *Crit Care Med*. 1994;22:981-985.
6. Siebig S, Kuhls S, Imhoff M, Gather U, Schölmerich J, Wrede CE. Intensive care unit alarms—how many do we need? *Crit Care Med*. 2010;38:451-456.
7. Tsien CL, Fackler JC. Poor prognosis for existing monitors in the intensive care unit. *Crit Care Med*. 1997;25:614-619.
8. Weil KM. Alarming monitor problems. *Nurs* 2009. 2009; 39(9):58.
9. ECRI Institute. Top 10 health technology hazards for 2013. *Health Devices*. 2012;41(11):1-23.
10. ECRI Institute. Top 10 health technology hazards for 2014. *Health Devices*. 2013;42(11):1-16.
11. The Joint Commission. New NPSG on clinical alarm safety: phased implementation in 2014 and 2016. http://www.jointcommission.org/issues/article.aspx?Article=GeNkFk%2FTmIWHMOPBVWgu73ZK9Oo6a%2BET8TmUU0idaFM%3D&goback=%2Egde_4284508_member_253356778. 2013. Accessed February 13, 2014.
12. Korniewicz DM, Clark T, David Y. A national online survey on the effectiveness of clinical alarms. *Am J Crit Care*. 2008; 17:36-41.
13. ECRI Institute. Hazard: Gaymar hypothermia machine. *Health Devices*. 1974;4:229-230.
14. Funk M, Winkler CG, May JL, et al. Unnecessary arrhythmia monitoring and underutilization of ischemia and QT interval monitoring in current clinical practice: baseline results of the Practical Use of the Latest Standards for Electrocardiography (PULSE) Trial. *J Electrocardiol*. 2010;43:542-547.
15. Feder S, Funk M. Over-monitoring and alarm fatigue: For whom do the bells toll? *Heart Lung*. 2013;42:395-396.
16. Stukshis I, Funk M, Johnson CR, Parkosewich JA. Accuracy of detection of clinically important dysrhythmias with and without a dedicated monitor watcher. *Am J Crit Care*. 1997; 6:312-317.
17. Funk M, Parkosewich JA, Johnson CR, Stukshis I. Effect of dedicated monitor watchers on patient outcomes. *Am J Crit Care*. 1997;6:318-323.
18. Association for the Advancement of Medical Instrumentation (AAMI) Foundation/Healthcare Technology Safety Institute (HTSI). Using Data to Drive Alarm System Improvement Efforts, The Johns Hopkins Hospital Experience. http://www.aami.org/htsi/SI_Series/Johns_Hopkins_White_Paper.pdf. 2012. Accessed February 13, 2014.
19. Association for the Advancement of Medical Instrumentation (AAMI) Foundation/Healthcare Technology Safety Institute (HTSI). Cardiopulmonary Monitors and Clinically Significant Events in Critically Ill Children, Children's National Medical Center. https://www.aami.org/htsi/SI_Series/Cardiopulmonary_Monitors_Childrens.pdf. 2013. Accessed February 13, 2014.
20. Association for the Advancement of Medical Instrumentation (AAMI) Foundation/Healthcare Technology Safety Institute (HTSI). Plan, Do, Check, Act: Using Action Research to Manage Alarm Systems, Signals, and Responses, The Beth Israel Deaconess Medical Center. http://www.aami.org/htsi/SI_Series/Beth_israel_2013.pdf. 2012. Accessed February 13, 2014.
21. Association for the Advancement of Medical Instrumentation (AAMI) Foundation/Healthcare Technology Safety Institute (HTSI). Recommendations for Alarm Signal Standardization and More Innovation, The Christiana Care Health System Experience. http://www.aami.org/htsi/si_series/christiana_care_alarm_signal.pdf. 2012. Accessed February 13, 2014.
22. Association for the Advancement of Medical Instrumentation (AAMI). Clinical Alarms: 2011 Summit; Page 3. http://www.aami.org/hottopics/alarms/AAMI/2011_Alarms_Summit_publication.pdf. 2011. Accessed February 13, 2014.

To purchase electronic or print reprints, contact the American Association of Critical-Care Nurses, 101 Columbia, Aliso Viejo, CA 92656. Phone, (800) 899-1712 or (949) 362-2050 (ext 532); fax, (949) 362-2049; e-mail, reprints@aacn.org.