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Anesthesia Alarm Fatigue Policy Recommendations: The Path of Development

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By

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Abstract

Healthcare workers are inundated with alarms every minute, yet 80-95% of these alarms do not result in provider intervention. False alarms cause a "cry-wolf" phenomenon among providers resulting in cognitive stress and workflow interruptions. A cross-sectional design was used to examine the perceptions of alarm fatigue and alarm management of Certified Registered Nurse Anesthetists (CRNAs), Student Registered Nurse Anesthetists (SRNAs) and

Anesthesiologists. This Likert-scale questionnaire was sent to approximately 150 anesthesia providers at NorthShore University HealthSystem (NSUHS) through an online survey. Data analysis revealed anesthesia trainees and providers with less total years in practice and less clinical experience exhibit statistically significant (*p*=0.011), higher levels (10.60%) of alarm fatigue and associated provider distress. A *p* value of 0.007 indicated students appreciate significantly higher levels (11.76%) of alarm fatigue than their CRNA colleagues. In conjunction with survey responses, a survey development table based on evidence and current endorsements in the literature was used to guide proposed policy recommendations for the anesthesia department at NSUHS. Future work involves adoption and implementation of the policy and evaluation to determine if it improved provider workflow, their alarm fatigue experience or patient safety.

Key Words: Anesthesia, alarm fatigue, alarm management, alarm policy

Introduction

Alarm fatigue occurs when providers are inundated with frequent alarms resulting in desensitization, or diminished responsiveness. Auditory alarms occur at a rate of 1.2 times per minute in the operating room (OR), and 80% of them are false alarms or non-actionable.[3] Root causes of unnecessary alarms include but are not limited to inadequate electrodes or sensors, lack of tailoring alarm thresholds to unique patient parameters, inappropriate culture and competency of staff, and unfavorable device defaults and functions.[7] Alarm fatigue can result in delayed or inadequate responses, decreased cognitive function, increased provider stress, and diminished patient safety.[8] In 2006, the American College of Clinical Engineering surveyed healthcare professionals and found nuisance alarms disrupt patient care (77%) and reduce provider trust in

alarms, causing clinicians to disable alarms (78%) by muting or setting unsuitable thresholds, which can lead to serious, even fatal consequences.[9]

Patient safety is one of the most highly measured indicators of quality healthcare. From 2009 to 2012, The Joint Commission received 98 alarm-related patient incidents of which 80 resulted in deaths and 13 resulted in permanent functional deficits.[1] Due to these tragedies, The Joint Commission made alarm fatigue and alarm management a National Patient Safety Goal in 2014.[2] Consequently, the audible alarms that were intended to alert providers of potential harm are under much higher scrutiny.

Clinical alarms relied on by anesthesia providers are unique because patients are often anesthetized, mechanically ventilated, and surgically manipulated, producing a wide variation in physiological parameters. The majority of physiological monitor alarms dealt with in anesthesia sound when a predetermined threshold is violated consistently for a certain amount of time. It is vital that anesthesia providers set tight enough thresholds, so they are alerted to the patient's condition, but wide enough to account for normal variations throughout the surgical case.[3] The incongruity between end-users and monitoring equipment also fuels alarm fatigue. A lack of knowledge of monitor function leads to frustration and distraction from alarms that continue after new thresholds are set or alarms are silenced.[12]

According to the American Society of Anesthesiologists, every operating facility should have an alarm management policy specifically for anesthesia equipment and monitors.[13] The implementation of alarm management policies on telemetry units greatly reduced false alarm occurrences.[9] However, no anesthesia-specific strategies have been identified. Several themes appeared in alarm management policies from the literature and surrounding hospitals. The first theme on alarm management related to alarm system operation.[2] Alarm customization involves

manipulating thresholds to be patient specific to reduce nuisance alarms. Other motifs were understanding end-users' identification of and interaction with clinical alarms and standardizing physiological monitor use.[9] Lastly, the most popular topic was understanding providers' perceptions of alarm fatigue by providers in order to cultivate change which sparked the origination of this study.[2] Though regulatory agencies and anesthesia professional groups recommend the establishment of anesthesia specific alarm management policies, few policies or guidelines exist.

To date, there is very little research into anesthesia providers' unique experience with clinical alarms and harm alarm fatigue may cause. Based upon a review of currently available research, there was no validated survey questionnaire to assess anesthesia providers' perception of alarm fatigue and practices related to clinical alarms. This online survey had two objectives:

1. To assess anesthesia providers' perceptions of their alarm fatigue experiences and interactions with alarms and monitors.
2. To explore associations between sociodemographic factors and the various perceptions of alarm fatigue experience among anesthesia providers.

Ultimately, alarm management policy recommendations were made using responses and an evidence-based survey development table for the anesthesia department at NSUHS.

Methods

• *Study Design.* This study used a cross-sectional online survey administered to anesthesia providers to evaluate alarm practices, perceived barriers to their use, and their experience with alarm fatigue.
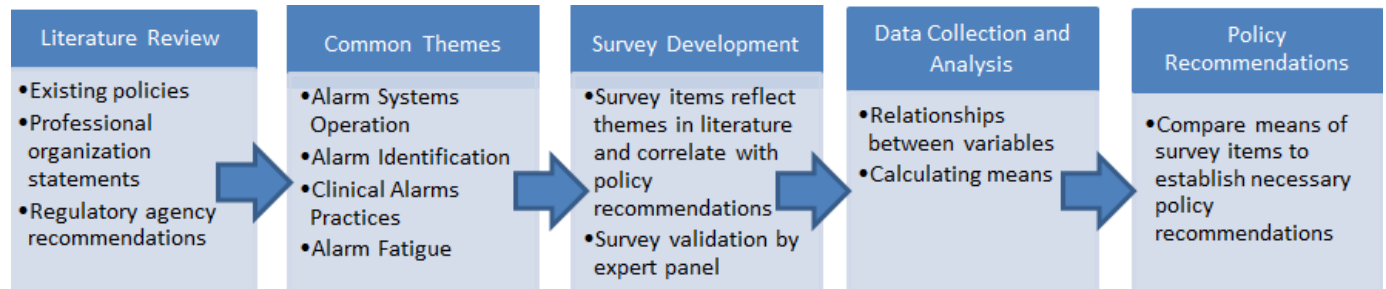
•Sample. The sample population included CRNAs, SRNAs, and anesthesiologists practicing at NSUHS. The inclusion criteria consisted of actively practicing anesthesia providers with current state licensure that consented to participate in the survey. Exclusion criteria involved anyone under the age of 18 and anesthesia providers outside of NSUHS. Out of the 150 emails sent, we received 35 responses, or a 23.3% response rate.

•Setting. Participants included anesthesia providers at NSUHS; a hospital system with four hospitals in the northern suburbs of Chicago. NSUHS consists of a level 1 trauma center with 18 ORs, a community hospital with 8 ORs, a community hospital with 12 ORs and a team for open heart surgery, and an orthopedic specialty hospital with 12 ORs. Participants completed the survey on an electronic device of their choice.

•Instruments. The anonymous online survey was distributed using Qualtrics online research platform and asked the anesthesia providers to respond to 20 statements related to alarm management practices and alarm fatigue using a Likert scale. Demographic questions were used to determine if they contributed to alarm fatigue perceptions. Respondents were able to provide additional comments at the end of the survey.

Of the survey's 20 questions, 8 questions focused on alarm fatigue and were adapted from a nationwide, validated, and reliable survey administered by the Healthcare Technology Foundation (HTF) in 2016. This survey had a Cronbach's alpha of 0.91 showing high internal consistency of items.[14] The other 12 survey questions were developed from themes the literature and policies at other hospitals and each survey item correlated to a potential alarm policy recommendation. Figure 1 was a guide for creating the survey development table which organized the associations between literature findings, survey items and policy recommendations.

Figure 1. Survey Development Flow Chart

Literature Review	Common Themes	Survey Development	Data Collection and Analysis	Policy Recommendations
• Existing policies • Professional organization statements • Regulatory agency recommendations	• Alarm Systems Operation • Alarm Identification • Clinical Alarms Practices • Alarm Fatigue	• Survey items reflect themes in literature and correlate with policy recommendations • Survey validation by expert panel	• Relationships between variables • Calculating means	• Compare means of survey items to establish necessary policy recommendations

Alarm System Operation

SURVEY ITEMS: It is my role and responsibility to check anesthesia alarm settings (mean: 3.53) It is my responsibility to ensure alarms are audible at all times (3.59) strongly agree

Alarm Identification

SURVEY ITEMS: Background noise frequently interferes with alarm recognition (2.74) It would be helpful for critical alarms to also display as a red banner on Epic (2.82) agree

Clinical Alarm Practices

SURVEY ITEMS: I am sensitive to alarms and respond quickly (3.41) Nuisance alarms occur frequently (2.94) and they reduce trust in alarms and cause providers to inappropriately turn alarms off (2.88) agree

Alarm Fatigue

SURVEY ITEMS: I set unique alarm thresholds for my patients' unique conditions at the beginning of the case (2.38) rarely. I turn off alarms that I am not using at the beginning of the case (1.79) rarely. I widen alarm thresholds significantly, disabling the alarm from sounding (3.09) often.

POLICIES: Anesthesia providers who use medical equipment must check alarm settings to ensure they are appropriate at the beginning of each case. Audible alarms will be clearly discernable relative to distance and competing noise.

POLICIES: Alarm volume levels must be maintained at an easily audible level at all times by monitor technician and/or clinical patient care staff. Use of visual alerts should be used whenever possible to reduce noise in the operating room.

POLICIES: Every alarm must be addressed immediately by the anesthesia provider. To reduce false alarms, only alarms that offer significant clinical benefit should be used for the patient.

POLICIES: The anesthesia provider will assure that alarms are activated and set based on patient's clinical condition. Only alarms that offer significant clinical benefit should be used. Alarm parameters will not be set so that it prevents the equipment from sounding.

Policy statements and survey questions were guided by a nursing unit alarm management policy from Northwestern University and a sedation area alarm management policy from The University of Iowa Hospital. Additional information and guidelines were obtained from regulatory agencies' or professional organizations' position statements. These included The Joint Commission (JC), ASA, Anesthesia Quality Institute-Anesthesia Incident

Reporting System (AQI-AIRS), Association for the Advancement of Medical Instruments (AAMI) and the Association of Surgical Technologists (AST). The policy statements were made initially followed by creation of an associated survey question to assess anesthesia providers' agreeance or a need for that specific policy.

To obtain content validity, the survey was distributed to a panel of 5 experts who provided feedback and ratings in the areas of clarity, relevance, simplicity and consistency. Minor edits and revisions were made until there was agreement in all areas amongst the expert panel.

• *Recruitment and Data Collection Procedures.* The research committee chair distributed the recruitment email to the target population using a department Listserv. Data was collected from Qualtrics and exported to a code book on the statistical analysis software, International Business Machines' (IBM) Statistical Software for Social Sciences (SPSS) version 25. Participation in the study was entirely anonymous and voluntary.

• *Human Subjects Protection.* Prior to data collection and analysis, the study obtained approval from the Institutional Review Board (IRB) at DePaul University (DPU) and NSUHS.

Results

• **Sample Characteristics.** Of the 150 NSUHS anesthesia providers included on the recruitment email distributed by the research committee chair, 35 participants chose to take the survey with an overall response rate of 23.3%. One survey was discarded because it was incomplete leaving a total of 34 surveys for data analysis. The sociodemographic data of the samples are described in frequencies and cumulative frequencies as shown in Table 1.

Table 1. Sociodemographic Characteristics of Study Participants (N=34)

Variable	No. (%)
Gender	
Female	29 (85.3)
Male	5 (14.7)
Age	
66 years and above	2 (5.88)
56 – 65	2 (5.88)
46 – 55	1 (2.94)
36 – 45	12 (35.2)
25 – 35	17 (50.0)
Ethnicity	
Mixed race	2 (5.88)
Asian	3 (8.82)
Black	1 (2.94)
White	28 (82.4)
Years of Experience	
Greater than 20 years	4 (11.8)
11 – 20 years	5 (14.7)
6 – 10 years	5 (14.7)
3 – 5 years	5 (14.7)
1 – 2 years	5 (14.7)
Less than a year	10 (29.4)
Working Status	
Part-time (16-31 hours)	2 (5.88)
Full- time (32 hours or more)	32 (94.1)
Job Title	
SRNA	11 (32.4)
CRNA	21 (61.8)
MD	1 (2.94)
Resident	1 (2.94)

• **Anesthesia Alarm Practices and Attitudes on Alarm Fatigue Survey.** A reliability

analysis for the online survey tool revealed a Cronbach's alpha of 0.707 indicating good

reliability of the instrument used for this study. Table 2 shows the mean scores of each item on

the Alarm Practices and Alarm Fatigue Survey. Each of the four subsets of the online survey tool

were separately analyzed for reliability.

Subset 1: Questions 1-6 assessed the respondents' responsibilities related to alarm management.

The highest rated item in subset 1 (mean score = 3.588) was "It is my responsibility to ensure

alarms are audible at all times." The lowest rated item in subset 1 (mean score = 2.324) was

"Properly setting alarm thresholds is overly complex on existing devices." The Cronbach's alpha measurement of reliability of subset 1 was 0.714 signifying good reliability.

Subset 2: Questions 7-11 assessed the respondents' perceptions of alarm identification. The highest rated item in subset 2 (mean score = 2.824) was "It would be helpful for critical alarms to also display a red banner on Epic." The lowest rated item in subset 2 (mean score = 2.265) was "There have been frequent instances where alarms could not be heard and were missed." The reliability of subset 2 was 0.467. This score suggests a possible unrelated item or inconsistent phrasing or scoring of an item in the subset. Question 9 was noted to have confusing phrasing and the Likert scale needed to be reversed with "Strongly agree" earning a score of 1 and "Strongly disagree" earning a score of 4 in order to be congruent with the scoring of the remainder of the survey. For this reason, this question was removed and the Cronbach's alpha of subset 2 increased to 0.747, a score representative of a reliable subset.

Subset 3: Questions 12-16 assessed anesthesia provider opinions on false alarms and alarm fatigue. The highest rated item in subset 3 (mean score = 2.941) was "Nuisance alarms occur frequently." The lowest rated item in subset 3 (mean score = 2.706) was "Frequent alarms cause me increased stress as the anesthesia provider." The reliability of subset 3 was 0.802 indicating good reliability.

Subset 4: Questions 17-20 assess alarm management among anesthesia providers. The highest rated item in subset 4 (mean score = 3.09) was "I widen alarm thresholds significantly, disabling the alarm from sounding." The lowest rated item in subset 4 (mean score = 1.79) was "I turn off alarms that I am not using at the beginning of the case." The reliability of subset 4 was 0.522. This denotes a need for reconstruction of this section for proper reliability, possibly changing the questions so the Likert-scale can be consistent throughout the entire survey.

Table 2. Mean Scores of Anesthesia Alarm Practices and Alarm Fatigue Survey Items

Set	Type	Questionnaire Item	Mean	SD	
Subset 1 (reliability= 0.714)	ASO	1. I routinely check functionality of monitors and equipment before a case.	3.35	.734	1=strongly disagree 4=strongly agree
	ASO	2. It is my role and responsibility to check anesthesia alarm settings.	3.53	.563	
	ASO	3. It is my responsibility to ensure alarms are audible at all times.	3.59[a]	.499	
	ASO	4. I routinely place physiological electrodes and equipment uniquely for each patient/case to reduce interference or artifact.	3.32	.638	
	AF	5. I am sensitive to alarms and respond quickly.	3.41	.499	
	CAP	6. Properly setting alarm thresholds is overly complex on existing devices.	2.32[b]	.589	
Subset 2 (reliability= 0.747)	AI	7. There have been frequent instances where alarms could not be heard and were missed.	2.27[b]	.618	
	AI	8. Background noise frequently interferes with alarm recognition.	2.74	.751	
	AI	9. Alarm tones properly represent the priority of the issue signaled by the alarm.*	2.68	.589	
	AI	10. It would be helpful for critical alarms to also display a red banner on Epic.	2.82[a]	.797	
	AF	11. When multiple devices are used with a patient, it can be confusing to determine which device is in alarm condition.	2.59	.743	
Subset 3 (reliability= 0.802)	AF	12. False alarms disrupt patient care.	2.77	.554	
	AF	13. Nuisance alarms occur frequently.	2.94[a]	.489	
	AF	14. I experience alarm fatigue from frequent false and/or non-actionable alarms.	2.77	.654	
	AF	15. Frequent alarms cause me increased stress as the anesthesia provider.	2.71[b]	.629	
	AF	16. Nuisance alarms reduce trust in alarms and cause anesthesia providers to inappropriately turn alarms off.	2.88	.640	
Subset 4 (reliability= 0.522)	CAP	17. I set unique alarm thresholds for my patient's unique conditions at the beginning of the case.*	2.38	.697	1=rarely 4=always
	CAP	18. I turn off alarms that I am not using at the beginning of the case.*	1.79[b]	.729	
	CAP	19. I adjust alarm thresholds throughout the case to reduce the number of non-actionable alarms*	2.71	.676	
	CAP	20. I widen alarm thresholds significantly, disabling the alarm from sounding.*	3.09[a]	.621	

*items not included in data analysis   [a]highest mean score for each subset   [b]lowest mean score for each subset
ASO: Alarm System Operation AI: Alarm Identification AF: Alarm Fatigue CAP: Clinical Alarm Practices

• **Sociodemographic Variables.** Subsets 1, 2, and 3 were deemed reliable and were therefore used for analysis of inferential statistics. Each of the sociodemographic items were used to compare means for statistical significance.

The majority of survey respondents were SRNAs (n=11) and CRNAs (n=21). The mean scores of the survey responses assessing responsibilities related to alarm management, perceptions of alarm identification, and opinions on false alarm and alarm fatigue of the two groups were analyzed using independent sample t-tests. The maximum possible score (indicative all survey items were answered with "Strongly Agree") was 56. There is a statistically significant higher overall mean score among SRNAs (43.7) compared to CRNAs (39.1). The difference in

the mean scores was 4.6. With equal variances assumed, the *p* value was 0.007 indicating the means are significantly different.

Years of experience was divided into two groups: 5 years or less and 6 to >20 years. The mean scores of their responses were analyzed using independent sample T-tests and were found to be statistically significant with a higher mean score (42.4) among those practicing less than five years than those practicing for 6 years or greater (38.3). Mean scores of those practicing less than 5 years were 4.1 higher than the mean scores of those practicing for 6 years or greater (42.4 vs 38.3, respectively). With equal variances assumed, the *p* value was .011 indicating significantly different means.

When comparing groups of different sex, ethnicity, and age, no statistically significant results were found.

Discussion

Respondents consistently recognized alarm management as their responsibility to patient care and acknowledged false alarms and alarm fatigue as relevant to anesthesia practice. SRNAs more frequently perceived alarm management as pertinent to their roles and alarm identification and fatigue as concerns in their practice compared to CRNAs. This can most likely be attributed to the stress and anxiety associated with being a novice anesthesia provider. SRNAs perceive their stress and anxiety as above average.[15] Toung, Donham & Rogers measured the heart rate of anesthesiologists at the time of anesthetic induction and there was a 60% increase in baseline heart rate in first year residents.[16] More experienced clinicians had less of an increase in heart rate. In addition to the anxiety of being a new provider in a stressful environment, chronic exposure to high noise levels produces physiological changes consistent with stress by stimulating the sympathetic nervous system.[17] As a result, noise levels similar to those in

operating rooms deleteriously affect short-term memory tasks and can also mask task-related cues and cause distractions during critical periods.[17]

Those with five years or less of practice compared to those with six years or greater of experience also perceived a higher sense of responsibility in alarm management, mores issues with alarm misidentification, and more alarm fatigue. These findings indicate that deleterious effects of excessive noise in the operating room more frequently contributes to alarm fatigue in new, vulnerable providers already feeling anxious in the stressful O.R. environment.

Based on these findings, the researchers confirmed that an alarm management policy for the NSUHS anesthesia department was warranted. Currently, the NSUHS Anesthesia Department does not have an alarm management policy. After conducting a literature review, the researchers studied existing alarm management recommendations, strategies, and policies from surrounding hospitals, professional organizations, and regulatory agencies. A policy development table (Figure 1) outlining these policies and recommendations relevant to alarm fatigue and appropriate alarm management was created by the researchers. Individual survey questions were established based on policies the researchers found to be applicable to potential NSUHS policy and were utilized in the Anesthesia Alarm Practices and Alarm Fatigue Survey. Upon completion of the survey data analysis, the researchers assessed the survey items with the highest mean scores, indicating a significant relevance to NSUHS anesthesia practice, and further developed alarm management policy recommendations. These policy recommendations will function as a resource to facilitate safe and appropriate alarm management strategies, reduce false or non-actionable alarms, improve alarm specificity making pertinent alarms easier to detect, and reduce overall alarm fatigue.

Limitations

The study participants included only anesthesia providers at NSUHS, so the results may not be universal among all providers practicing anesthesia. However, the NorthShore HealthSystem consists of 4 hospitals with significantly variable practice patterns making the results more generalizable.

The Cronbach's alpha for subset 2 and subset 4 of the survey tool did not meet a value of 0.7, indicating unreliability of these subsets. The survey was assessed for factors potentially affecting the reliability such as unclear language and inconsistencies. Question 3 of subset 2 was removed due to confusing phrasing and inconsistent Likert scoring. For this reason, this question was removed and the Cronbach's alpha of subset 2 increased to 0.747. Subset 4 was removed entirely due to the scoring of the Likert scale being inconsistent with the first three subsets. With the removal question 3 from subset 2 and subset 4 from the survey, the overall Cronbach's alpha of the survey increased to 0.802. For these reasons, the researchers recommend the removal of these questions in future use of this instrument.

Future Direction for Research and Implication for Practice

Going forward, the department can implement the proposed policy with associated procedures for managing alarms for which anesthesia providers are responsible. The researchers' policy recommendations focused on the assessed needs of the NSUHS Anesthesia Department with emphasis on equipment, device alarms, and telemetry alarms as well as the responsibility for alarm maintenance and management. After implementation, effectiveness can be determined by redistributing a refined survey and comparing results.

Conclusion

Alarm fatigue has been well documented and discussed among the bedside nursing population as it has attributed to serious patient injuries and death. This has led to widespread

efforts to combat alarm fatigue among nurses. However, less of the alarm fatigue emphasis has been focused on anesthesia providers.

This study assessed anesthesia providers' perceptions of alarm fatigue and their management of alarms and monitors. It was concluded that alarm fatigue is experienced among anesthesia providers and identified as a problem, especially among novice practitioners. To improve anesthesia provider interactions with monitors and alarms and minimize alarm fatigue among providers and its burden on patient safety, the implementation of policies and procedures for managing patient monitoring alarms is warranted.

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