



SKIN PREPARATION AND ELECTRODE REPLACEMENT TO REDUCE ALARM FATIGUE IN A COMMUNITY HOSPITAL INTENSIVE CARE UNIT

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Background Nurses in intensive care units are exposed to hundreds of alarms during a shift, and research shows that most alarms are not clinically relevant. Alarm fatigue can occur when a nurse becomes desensitized to alarms. Alarm fatigue can jeopardize patient safety, and adverse alarm events can lead to patients dying.

Objective To evaluate how a process intervention affects the number of alarms during an 8-hour shift in an intensive care unit.

Methods A total of 62 patients from an intensive care unit were included in the study; 32 of these patients received the intervention, which included washing the patient's chest with soap and water and applying new electrocardiography electrodes at the start of a shift. The number of alarms, clinical diagnoses, and demographic variables were collected for each patient. A Poisson regression model was used to evaluate the impact of the intervention on the overall number of clinical alarms during the shift, with no adjustments to the alarm settings or other interventions.

Results After relevant covariates are controlled for, the results suggest that patients in the intervention group presented significantly fewer alarms than did patients in the control group.

Conclusions Managing clinical alarms is a main issue in terms of both patient safety and staff workload management. The results of this study demonstrate that a relatively simple process-oriented strategy can decrease the number of alarms. (*American Journal of Critical Care*. 2020;29:390-395)

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Within intensive care units (ICUs), most equipment has safety alarms embedded that alert staff of changes in various patient parameters and situations.¹ This technology can increase the already large number of alarms—sometimes hundreds—nurses encounter during shifts^{1,2}; many of those alarms are not clinically relevant.³ Frequent auditory alarms can result in unintended consequences that have implications for patient safety (eg, patient injuries, fatalities) and quality of care.⁴ Managing these clinical alarms has been identified as a “top 10” safety concern.⁵

Although all alarms must be acknowledged or dismissed, clinically relevant alarms require nursing intervention, whereas false alarms do not. Various factors can create false or nonactionable alarms: the patient’s motion, incorrect alarm parameter settings, the patient’s condition, care being provided to the patient (eg, bathing or turning), improper skin preparation or electrocardiography (ECG) electrode placement, or faulty connections of leads or electrodes. Here we use the term *false alarms* to describe both false alarms and nonactionable alarms.

In its 2013 Sentinel Alert, the Joint Commission reported that between January 2009 and June 2012, alarm-related events led to the death of 80 patients and to a permanent loss of function in 13 patients.⁶ Because of the critical importance of patient safety and the rising number of alarm-related events, the Joint Commission issued a national patient safety goal related to alarm management, mandating that hospitals make establishing an alarm safety system a hospital priority and identify the most important alarms to manage.⁶ In addition, the Joint Commission required accredited hospitals to implement policies and procedures to manage alarms and appropriately educate staff.⁷ When clinical alarms are more likely to be false than clinically relevant, a work culture can emerge wherein nurses may delay responding to alarms, especially when the setting has a large patient census or a high patient to nurse ratio, and thus may miss critical alarms.⁸⁻¹⁰

The ever-increasing number of alarms can lead to a phenomenon known as alarm fatigue.^{7,11} Alarm fatigue can occur when a nurse is exposed to frequent

alarms and becomes desensitized to them.⁸ Alarm fatigue has been described as the most common factor contributing to alarm-related events,^{3,7,12,13} and it is well known that alarm fatigue can jeopardize patient safety and that adverse alarm-related events can lead to patient fatalities^{3,7,12} and staff workload management issues.¹³ A recent study showed that alarm management and nuisance alarms remain problems.¹⁴

Much of the previous research on alarm fatigue has examined the issue from the perspective of technology and alarm parameters.^{8,15,16} A technology-only intervention will not, however, completely alleviate alarm fatigue because factors related to organizational best practices and nursing best practices influence alarm management and subsequent alarm fatigue. The literature focuses on specialized ICUs and ICUs in large academic hospitals,^{2,3,7,15,17} but the patient population in a community hospital’s ICU is typically more diverse than that in specialty ICUs at larger facilities. Common diagnoses and conditions among patients in a community ICU—like the one included in this study—include congestive heart failure, pneumonia, gastrointestinal bleeding, sepsis, cardiac arrhythmia, alcohol withdrawal, suicide attempt, postoperative complications, diabetic ketoacidosis, and chronic obstructive pulmonary disease. This diversity makes managing alarm fatigue through technology-centric strategies (eg, by adjusting alarm parameters) a challenge for nurses.^{8,16,18,19} Therefore, alternative strategies are needed to reduce the number of false alarms and to address and reduce the effects of alarm fatigue and increase patient safety.

One possible way to reduce the number of false alarms is to improve skin preparation before placing ECG electrodes. Cvach et al²⁰ reported that daily electrode changes reduced by 46% the number of alarms per bed day in 2 acute care units. Hermens et al²¹ recommended changes in sensor placement procedures in an effort to reduce the number of false

Alarm events can lead to potential harm for patients.

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Red and yellow alarms were counted for an 8-hour shift in an intensive care unit at a community hospital.

alarms related to surface electromyography, and they proposed that preparing patients' skin could improve electrode-skin contact, thereby resulting in fewer non-relevant alarms. In addition, an American Association of Critical-Care Nurses Practice Alert outlined 7 nursing actions related to false alarms that may reduce the number of such alarms²²: properly preparing the skin for ECG electrodes, changing ECG electrodes daily, customizing alarm parameters and levels on ECG monitors, customizing delay and threshold settings for oxygen saturation via pulse oximetry, providing initial and ongoing nursing education about devices with alarms, establishing interprofessional teams to address issues related to alarms (eg, developing policies and procedures), and monitoring only those patients who

present clinical indications for monitoring.^{1,22} Several of these clinical decision-related or technology-mediated interventions can affect the number of alarms that occur in an ICU, and they are well documented in the literature.^{5,8,15,16,18} We must, however, further evaluate how preparing the skin

for ECG electrodes and changing the electrodes affect the number of alarms while accounting for specific patient types and characteristics. Therefore, the objective of this study was to evaluate how a process intervention of preparing the skin (ie, washing a patient's chest with soap and water) and changing electrodes at the start of each shift affected the number of alarms throughout an 8-hour day shift in an ICU.

Methods

Study Design

This study included 2 groups. For patients in the intervention group, a nurse prepared their skin for electrode placement (by washing the patient's chest with soap and water) and changed the electrodes daily (before 8:00 AM). The same clinical staff member prepared the skin and changed electrodes throughout the entire study. We collected data only on weekdays to ensure that the intervention was consistent and done by the same provider. Patients in the control group received standard care that included changing electrodes only as needed, per standard hospital procedure. We used 3M Red Dot monitoring electrodes with foam tape and sticky gel and Philips IntelliVue MP70 Patient Monitors for all patients. Throughout the study, we did not modify or adjust any parameters (eg, alarm thresholds) for the equipment and monitors for any patient.

Study Setting and Sample

This study was conducted after we obtained approval through the Prisma Health institutional review board (no. Pro00049513). The study took place in the ICU at a community hospital. The ICU is not specialized and is similar to a medical-surgical ICU in that the patient population varies daily and can include patients with diagnoses of cardiac, respiratory, or gastrointestinal diseases, sepsis, alcohol withdrawal, postsurgical complications, suicide attempt, and others.

Data Collection

The study included 100 patients, with 50 patients in each group. Each patient was included in the study for a single 8-hour shift, and no individual patient was included in both groups. If a patient experienced no alarms during the 8-hour period, they were excluded from the analysis. After exclusions, the study included 62 patients. We counted alarms hourly during the 8-hour period to calculate the total number of alarms during the work shift. Several demographics were collected for each patient: age, primary and secondary diagnoses, body mass index, activity level, and alertness. Prisma Health's clinical engineering department automatically extracted the hourly counts for red, yellow, and blue alarms for each patient during the study, but we included only red and yellow cardiac alarms in the analyses. A yellow alarm is a low-priority patient alarm and a red alarm is a high-priority patient alarm. According to the Philips IntelliVue MP70 Patient Monitors documentation, a blue alarm is a technical alarm that indicates that the monitor cannot reliably measure or detect alarm conditions.

Statistical Analysis

We conducted all analyses in R statistical software version 3.3.2 (The R Foundation for Statistical Computing). Poisson regression is used when the dependent variable is a count variable, and in this study the dependent variable was the number of alarms during an 8-hour work shift. Thus we used a Poisson regression model to examine the impact of skin preparation on the patient alarms. We included in the model 2 covariates: the age of the patient and a binary variable that indicated whether the patient was active and alert during the 8-hour study period. We also created binary covariates as indicator variables for the presence of several diagnoses including alcohol withdrawal, pulmonary disease, gastrointestinal disease, sepsis, and cardiac disease.

Results

After exclusion, this study included 32 patients in the intervention group (receiving skin preparation and new electrodes) and 30 in the control group (receiving standard care). The patients' characteristics are described in Table 1. As mentioned, the patients' primary and secondary diagnoses were separated into binary variables for several conditions, including some disease categories. A patient was defined as experiencing alcohol withdrawal when a physician had documented alcohol dependence in the patient's electronic health record. Pulmonary diseases were identified broadly and included respiratory failure, chronic obstructive pulmonary disease, and pneumonia. The intervention group had more patients with pulmonary disease than did the control group. Cardiac diseases included hypertension, hypotension, and cardiac dysrhythmia; these were distributed among the study population in a way similar to the pulmonary diseases. Gastrointestinal diseases also had a similar prevalence between the groups and included all diagnoses related to the gastrointestinal system. Patients with sepsis were identified in both of the groups. Patients were defined as being alert if they were alert and oriented (eg, not confused about person, place, or time).

The number of alarms across all patients is shown in the Figure. For most patients, between 1 and 10 alarms occurred during the 8-hour shift, but more than 20 alarms occurred for 16 patients during that period. One patient experienced 70 alarms during the 8-hour shift—the maximal number of alarms during a shift within this study. Because we automatically extracted from the system all alarms for each patient, we do not know how many of the alarms were clinically relevant and how many were not.

We constructed a Poisson regression model to predict the number of clinical alarms that would occur for each patient during the 8-hour study period (Table 2). We included all demographic and diagnosis indicator variables in the initial model. We used stepwise deletion to identify the best-fit model. In that model, older patients were more likely to have more alarms than were younger patients. Patients who were alert and oriented were more likely to have more alarms than if they were not alert and oriented. Finally, patients in the intervention group were less likely to have more alarms than if they were in the control group. No other demographic or diagnostic indicator variables were included in the final best-fit model.

Table 1
Characteristics of patients in the intervention and control groups^a

Variable	Intervention group (n=32)	Control group (n=30)
Age, mean (SD), y	66.47 (15.41)	65.43 (17.21)
Female	53	57
Body mass index ^b		
Normal or underweight (≤ 24.9)	34	40
Overweight (25-29.9)	19	13
Obese (≥ 30)	47	47
Conditions		
Alcohol withdrawal	16	3
Pulmonary disease	63	37
Cardiac disease	69	33
Gastrointestinal disease	31	33
Sepsis	31	17
Alert and oriented	66	77

^a Data are percentages unless otherwise indicated.

^b Calculated as weight in kilograms divided by height in meters squared.

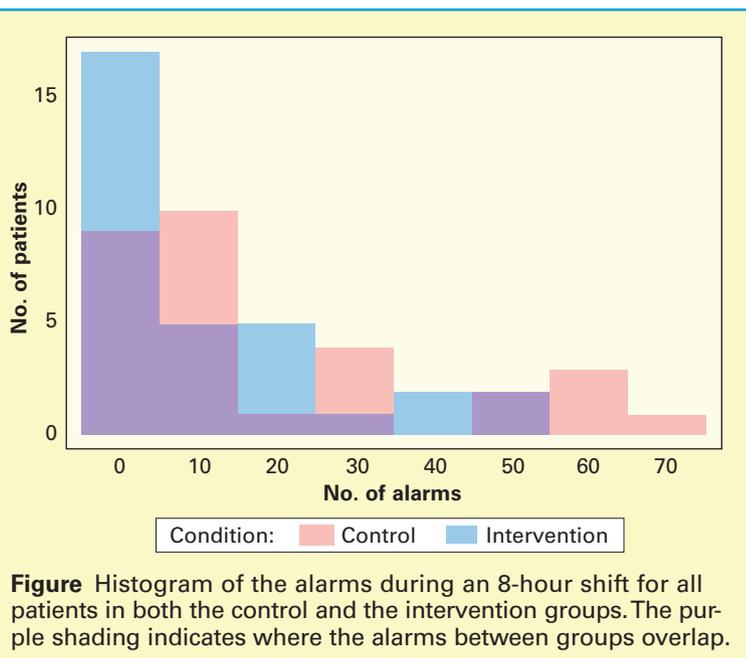


Figure Histogram of the alarms during an 8-hour shift for all patients in both the control and the intervention groups. The purple shading indicates where the alarms between groups overlap.

Discussion

In this study, we evaluated how preparing the skin and changing ECG electrodes affected the number of alarms that occurred during a work shift in an ICU at a community hospital. Some of the literature suggests that this approach is one of several strategies that might affect the number of alarms that occur in this setting and thereby affect the likelihood of alarm fatigue.^{9,22} When patient age and alertness are controlled for, preparing the skin and changing electrodes did significantly reduce the total number of alarms that occurred during the 8-hour work shift,

Table 2
Poisson regression model predicting the likelihood of more alarms^a

Parameter	Regression coefficient	SE	Z statistic	Odds ratio (95% CI)
Intercept	1.826	0.185	9.887	6.210 (4.302-8.874)
Intervention: wash condition	-0.484	0.065	-7.457	0.616 (0.542-0.700)
Patient's age	0.014	0.002	6.527	1.015 (1.010-1.019)
Alert and oriented	0.296	0.077	3.837	1.344 (1.158-1.566)
Null deviance	1187.3	df=61		
Residual deviance	1074.0	df=58		

^a All model parameters were significant at $P < .001$.

Some practice-based interventions may reduce the number of alarms in an intensive care unit.

consistent with the types of reductions Cvach et al²⁰ identified in their previous study.

Reducing alarm fatigue is critical in terms of patient safety and nurse workload management.¹ Many studies have been focused on technological interventions related to alarm management and alarm fatigue,¹⁵ but more straightforward and simple interventions may be beneficial, as organizational and process factors also affect alarm management. Given the Joint Commission's suggestion to prioritize managing alarms⁶ and the need for effective strategies to address alarm fatigue, our relatively simple intervention can help meet the goal of reducing the number

of alarms that occur. Given that our team used no other interventions during this study, that they did not adjust parameters, and that this intervention did not influence the clinical relevance of alarms, we expect that nurses missed no clinically important alarm. Rather, this intervention most likely reduced

the number of alarms related to connection issues and movement of patients.

Several limitations are associated with this study and can be addressed in future research. Our study sample was relatively small and included only 1 shift per day. Skin preparation and electrode changes for a full 24 hours may have implications that differ from skin preparation and electrode changes within an 8-hour shift, so future work should investigate the effects of this practice when 24 hours go by between intervention events. We included only uninterrupted monitoring, and we excluded from the study any patient who was moved for a procedure or imaging. Although we did not select any particular patients within the patient census for inclusion in or exclusion from the study, patients with specific diagnoses were unequally represented in each group. It may be possible to address this limitation in future research by focusing on specific diagnoses and populations of patients. We were not able to identify any statistical outliers or any impact

of diagnoses, but unobserved variables might exist that could affect these results. Future researchers should examine more homogeneous populations of patients, including pediatric patients and patients in other telemetry units.

We conducted the intervention first and did not randomize assignment to the intervention and control groups because of operational restrictions in implementing the interventions. With targeted populations or adequate samples from groups with specific diagnoses, future research might indicate an interaction between a diagnosis and the intervention. Finally, we did not document a distinction between the alarms that were and were not clinically relevant, but we do not believe that skin preparation and new electrodes would have limited or reduced the number of clinically relevant alarms. False alarms and nonactionable alarms, however, can result from various causes in different contexts and for different patients.

Conclusion

Alarm fatigue is dangerous, and organizations should implement practices that minimize the effect of an excessive number of alarms that are not clinically relevant on patient safety. Intensive care nurses need to be aware of the potential risks for patients associated with alarm fatigue. Our study focused on 2 nursing actions: preparing the skin for and changing ECG electrodes daily. Our results showed that the number of alarms was reduced during a shift when these nursing actions were implemented in the ICU at a community hospital. Future work should evaluate these interventions in other clinical settings.

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FINANCIAL DISCLOSURES

None reported.

SEE ALSO

For more about alarm management, visit the *Critical Care Nurse* website, www.ccnonline.org, and read the article by Nguyen et al, "Double Trouble: Patients With Both True and False Arrhythmia Alarms" (April 2020).

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