Alarm fatigue and patient safety culture from the perspectives of intensive care unit nurses: a cross-sectional study.

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Abstract

Background and aim: Alarm monitoring is a vital practice in the care of patients in intensive care units, and nurses play a crucial role in this process. However, the abundance of electrical devices and the frequent occurrence of alarms can lead to alarm fatigue, which can be dangerous for patient safety. This study aimed to investigate the correlation between alarm fatigue and patient safety culture from the perspectives of nurses.

Method: This cross-sectional descriptive correlational research collected data from October 2021 to February 2022. The sample was selected through a census method and 220 nurses working in intensive care units of hospitals affiliated with Shiraz university of medical sciences were included. The study used three questionnaires to collect data on background information, alarm fatigue, and patient safety culture. The collected data were analysed using descriptive statistics in SPSS25.

Results: The mean score for alarm fatigue in nurses was 9.58 ± 46.27 out of 85 points, indicating an average level of fatigue. The mean total score for patient safety culture was 23.20 ± 96.08 out of 210 points, indicating an unfavourable level. Spearman correlation coefficient revealed a significant inverse relationship between the patient safety culture and alarm fatigue (P=0.03).

Conclusion: Nurse managers are recommended to organize training courses for nurses. These courses can focus on improving alarm management skills and enhancing nurses' perceptions of patient safety culture.

Keywords: Alarm fatigue, Patient safety culture, Nurses, Critical care, Management skills

Introduction

Intensive care units are designed for critically ill patients who require constant and careful monitoring. These patients require the highest level of medical and nursing care and nurses working in these units play an essential role in reducing mortality and complications caused by diseases [1]. They monitor patients and diagnose life-threatening signs and symptoms [2]. However, the intensive care unit is an unpredictable environment with numerous interactions between nurses, patients and their families that can create commotion in the ward. To help nurses manage their multiple responsibilities, monitoring devices have been implemented [3]. Electronic devices for monitoring the symptoms of critically ill patients have become an integral part of intensive care units [4]. These devices provide nurses with audio and visual alarms that inform them about changes in patients' conditions such as oxygen saturation percentage, heart rate and respiration. By knowing these changes, nurses can make informed decisions to manage the condition of their patients [5]. To ensure accurate patient monitoring, alarms in intensive care units are designed to be highly sensitive and varied in number [6]. However, the frequent and long-term exposure to these alarms can lead to alarm fatigue among nurses. Alarm fatigue is a form of mental fatigue that results from prolonged exposure to alarms, leading to nurses becoming desensitized to them and delaying their response and management. Despite the use of technology in patient management, monitoring devices can have unintended negative consequences for patients. This issue is considered one of the top 10 technology related threats to patient health and between 2012 and 2014 [7]. The emergency care research institute ranked it as the first technology threat to patients [8]. The world health organization defines patient safety as the avoidance of unnecessary and potential harm related to healthcare services. Studies have shown that about 10% of all admissions are associated with various degrees of harm to the patient and it is estimated that 75% of these harms are preventable [9]. Unsafe clinical services that cause harm to patients account for 5-10 percent of health related costs [10]. The safety of patients depends on nurses' judgments, decisions and continuous and accurate monitoring. Patient safety encompasses both mental and physical safety and aims to reduce risks and errors, thereby reducing adverse effects of events [11]. Nurses' monitoring in the intensive care unit is key to ensuring patient safety and protecting patients from inevitable errors and injuries [12]. Patient safety culture is a subset of organizational culture and is defined as a set of values, attitudes, perceptions, beliefs and common behaviours that support the safe activities of individuals in healthcare

organizations [13]. A positive safety culture prioritizes patient safety and guides the behaviours of healthcare providers. It includes elements such as organizational learning, teamwork, open communication, feedback, non-punitive responses to errors and perceptions of patient safety [14]. A positive safety culture can encourage healthcare providers to report errors and analyse them, which can be an effective tool for improving safety [15]. The safety committee has recommended proper management and setting of alarms, equipment control and other measures that reduce false alarms in healthcare settings. Intensive care units are known for their noisy environment due to the presence of alarms, which can irritate nurses, affecting their ability to provide adequate patient care. Despite the importance of this topic, few Iranian studies have addressed alarm fatigue. The researcher has observed nurses responding to alarms in an unprincipled manner or ignoring them in intensive care units, with a low patient safety culture prevailing. Therefore, this study aimed to investigate the relationship between alarm fatigue and patient safety culture among intensive care unit nurses in Iran. The results of this study can serve as a basis for increasing awareness of alarm fatigue and patient safety culture.

Materials and Methods

This cross-sectional descriptive correlational study aimed to investigate the relationship between alarm fatigue and patient safety culture among nurses in intensive care units of hospitals affiliated with Shiraz university of medical sciences in 2021. The study was conducted in the intensive care units of Namazi, Faqihi, Aliasghar, Chamran and Zeinabiyah hospitals. The research sample consisted of all nurses working in the intensive care units of hospitals affiliated with Shiraz university of medical sciences who held at least a bachelor's degree in nursing and had at least 6 months of work experience in the ICU. The census sampling method was used and the exclusion criterion was failure to complete more than 10% of the questionnaire. Thus, 220 participants who met the inclusion criteria were included in the study. The study questionnaires were designed using Porsline software and uploaded to the Whatsapp. A written summary of the study objectives was provided to the participants.

The researcher visited the research setting after obtaining approval for the research proposal and the code of ethics (01400.139 IR.KMU.REC) from Kerman university of medical sciences and receiving a written letter of introduction from the Razi school of nursing and midwifery. Participation in the study was voluntary and the participants were provided with necessary information about the research method, objectives and confidentiality of information before obtaining their informed consent. The data were collected from October 2021 to February 2022 using the background information questionnaire, the alarm fatigue questionnaire and the hospital survey on patient safety culture.

The demographic and background information questionnaire used in this study included variables such as age, gender, marital status, education level, work experience in the intensive care unit, weekly working hours, second job, number of night shifts per month, fixed or rotating shifts, sleep disorder and completion of training on how to manage alarms from intensive care unit equipment.

The alarm fatigue questionnaire used in this study was developed based on a literature review conducted by the researcher and consisted of 17 questions [16-18]. The questions were rated on a 5-point Likert scale ranging from always (5) to never (1), with a minimum score of 17 and a maximum score of 85. To determine the face validity of the questionnaire qualitatively, 10 participants were interviewed face-to-face and the level of difficulty, appropriateness and ambiguity of the questions were evaluated. The necessary corrections were made based on the feedback received from the participants. The content validity of the tool used in this study was determined qualitatively and quantitatively. The questionnaire was given to seven faculty members of the Razi school of nursing and five ICU nurses with a master's degree in intensive care nursing. Their feedbacks and suggestions were used to finalize the tool. To check the content validity quantitatively, the Content Validity Index (CVI) and Content Validity Ratio (CVR) were calculated, with values of 0.85 and 0.78, respectively. The internal consistency method was used to determine the questionnaire reliability. A pilot study was conducted with 30 individuals from the target population who were not included in the final sample size and Cronbach's alpha was calculated to be 0.8.

The Hospital Survey on Patient Safety Culture (HSPSC) was designed by Joann Sorra, et al., in the US in 2004 under the agency for research and quality of health services [19]. It has since been used worldwide as a valid and comprehensive tool for measuring the state of patient safety culture in hospitals. The questionnaire contains 42 questions that measure 12 different dimensions of patient safety culture. Scores range from 42 to 210, with scores of 105 and above considered as favourable safety culture and scores below 104 considered as unfavourable safety culture. Joann Sorra, et al., reported the construct validity of the HSPSC to be 0.23-0.60. Additionally, the HSPSC reliability was calculated separately, with Cronbach's alpha reported for each dimension ranging from 0.63 to 0.86.

Results

Shiraz university of medical sciences participated in this study. The majority of participants were female (76.8%), single (69.9%) and held a bachelor's degree (92.2%). Most of the participants were hired nurses (47.3%) or contract recruiters (32.7%) and did not have a second job (73.6%). The majority of the participants were clinical nurses (92.7%) in rotating shifts (87.7%). More than half of the participants completed the alarm management course (56.4%). The mean age of the studied nurses was 63.68 ± 33, and the mean total work experience was 4.86 ± 8.92, with an average of 3.34 ± 4.89 years of work experience in ICU (Table 1).

Table 1. *Background information of the nurses.*

Variable		Number (%)
Sex	Male	51 (23.2)
	Female	169 (76.8)
Marital status	Married	86 (39.1)
	Single	134 (69.9)
Education level	Bachelor's	200 (92.2)
	Master's	20 (9.1)
Employment status	Hired	104 (47.3)
	Contract recruiters[1]	72 (32.7)
	Contract recruiters[2]	26 (11.8)
	Committed[3]	18 (8.2)
Having a second job	Yes	58 (26.4)
	No	162 (73.6)
Position	Head nurse	6 (2.7)
	Staff nurse	10 (4.5)
	Clinical nurse	204 (92.7)
Shift type	Rotating	193 (87.7)
	Fixed	27 (12.3)
Hospital	Namazi	90 (40.9)
	Zeinabiyeh	17 (7.7)
	Chamran	27 (12.3)
	Aliasghar	40 (18.2)
	Faqihi	46 (20.9)
Alarm management training course	Passed	124 (56.4)
	Not passed	96 (43.6)

Note: [1]Annually contracted with payment similar to hired nurses; [2]Annually contracted with payment less than hired nurses; [3]It is obligatory to work for government for two years at a lower rate of pay.

The mean score of alarm fatigue among nurses was 9.58 ± 46.27 out of 85, indicating an average level of fatigue. The item with the highest mean score of fatigue was "I believe that the purpose of alarms is to inform the personnel about the dangers threatening the patients" (1.76 ± 3.63 out of 5 points), while the item with the lowest mean score of alarm fatigue was "I wait when I hear the sound of alarms, maybe it will go away by itself" (1.09 ± 1.95 out of 5 marks) (Table 2).

Table 2. *Alarm fatigues from the perspectives of ICU nurses.*

Items	Mean ± SD
The repeated sound of alarms desensitizes me to their importance.	2.23 ± 1.04
I often turn off the alarms in order not to disrupt my work.	2.29 ± 1.03
When I hear the alarms, I sometimes wait to see if they go away by itself.	1.95 ± 1.09
Instead of addressing the root cause of the alarms, I frequently silence them with the button.	2.19 ± 1.05
I increase the pause and silence time of alarms.	2.20 ± 1.56
I set alarms with a wider range of sensitivity to avoid false alarms.	2.37 ± 1.04

I believe that the monitors are overly sensitive and trigger false alarms too often.	2.18 ± 1.34
I tend to ignore alarms related to the devices of other patients being monitored by my colleagues during my shift.	2.51 ± 0.95
I expend a significant amount of energy trying to identify and fix the causes of the alarms during my work shift.	2.11 ± 1.02
I find it challenging to manage alarms effectively.	2.05 ± 0.89
I believe that the primary purpose of alarms is to alert staff to potential dangers for patients.	3.63 ± 1.76
The sound of alarms often makes me anxious.	2.34 ± 1.07
I become confused when I hear alarms.	2.45 ± 1.34
The constant sound of alarms can make me nervous and irritable.	2.38 ± 0.96
The repetitive nature of alarms can be tedious and boring.	2.40 ± 1.03
I become restless when I hear alarms.	2.41 ± 1.10
Alarms can be distracting and cause me to lose focus on other tasks.	2.36 ± 1.17
Total score	46.27 ± 9.58

The mean total score of patient safety culture was 23.20 ± 96.08 out of 210, indicating an unfavourable level of safety culture. The dimensions of safety culture obtained following scores, respectively: Non-punitive response to errors (1.64 ± 2.97), organizational learning continuous improvement (1.03 ± 2.78), management support for patient safety (1.09 ± 2.56), teamwork within units (1.21 ± 2.39), communication openness (1.07 ± 1.98), frequency of events reported (0.98 ± 1.98), staffing (1.55 ± 1.95), feedback and communication about errors (1.56 ± 1.93), handoffs and transitions (0.74 ±1.91), manager expectations and actions promoting safety (1.37 ± 1.84), overall perception of patient safety (1.05 ± 1.78) and teamwork across units (0.76 ± 1.55) (Table 3).

Table 3. *Mean score of patient safety culture from perspectives of ICU nurses.*

Patient safety culture composite	Mean	Standard deviation
Communication openness (3 items)	5.94	1.07
Feedback and communication about error (3 items)	5.79	1.56
Frequency of events reported (3 items)	5.45	1.98
Handoffs and transitions (4 items)	7.66	1.74
Management support for patient safety (3 items)	7.69	1.09
Non-punitive response to error (3 items)	8.93	1.64
Organizational learning-continuous improvement (3 items)	8.34	1.03
Overall perceptions of patient safety (3 items)	7.13	1.05
Staffing (4 items)	7.83	1.55
Manager expectations and actions promoting patient safety (4 items)	7.36	1.37
Teamwork across units (4 items)	6.21	1.76
Teamwork within units (4 items)	9.59	1.21
Total score	96.08 ± 23.20	

The spearman test revealed a significant inverse relationship between the total scores of the HSPSC and the alarm fatigue questionnaire (P=0.03). Additionally, there was a significant inverse relationship between alarm fatigue and all dimensions of the HSPSC, except for non-punitive response to errors and manager expectations and actions promoting safety (Table 4).

Table 4. *The relationship between patient safety culture and alarm fatigue in ICU nurses.*

Variable	Total score	Alarm fatigue
Total score of patient safety culture	R=0.349	P=0.03
Communication openness	R=-0.156	P<0.0001
Feedback and communication about error	R=-0.156	P<0.0001
Frequency of events reported	R=-0.144	P=0.03
Handoffs and transitions	R=-0.164	P=0.01
Management support for patient safety	R=-0.234	P<0.0001
Non-punitive response to error	R=-0.054	P=0.71
Organizational learning-continuous improvement	R=-0.154	P=0.02
Overall perceptions of patient safety	R=-0.194	P=0.01
Staffing	R=-0.514	P=0.04
Manager expectations and actions promoting patient safety	R=-0.054	P=0.63
Teamwork across units	R=-0.164	P=0.01
Teamwork within units	R=-0.314	P<0.0001

Nurses with a master's degree had lower mean scores of alarm fatigue compared to those with a bachelor's degree. The mean score of alarm fatigue decreased with an increase in work experience, age and having hired position, while it increased with an increase in the number of night shifts per month (Table 5).

Table 5. *The relationship between alarm fatigue and demographic characteristics of the ICU nurses.*

Variable	Standard regression coefficients	Confidence interval (0.95)	p-value
Age	-0.3	0.18, 0.79	0.02
Education	-0.34	-16.72, 5.91	<0.001
Employment status			
Hired nurses	-0.28	-4.54, 9.87	0.01
Contract recruiter	0.76	-2.23, 7.65	0.09
Committed (reference)	0.43	-9.91, 8.32	0.45
Work experience	-0.49	-0.15, 0.95	0.04
Number of night shifts	0.5	0.13, 0.29	<0.001

There was a significant and direct relationship between the mean score of patient safety culture, education level and employment status (Table 6).

Table 6. *The relationship between patient safety culture and demographic characteristics of the ICU nurses.*

Variable	Standard regression coefficients	Confidence interval (0.95%)	p-value
Education	0.009	-5.87, 0.34	<0.001
Employment status			
Hired	0.36	2.67, 8.14	0.01
Contract recruiter	0.47	-9.78, 0.34	0.24
Committed (reference)	0.91	0.13, 0.65	0.79

Position			
Head nurse			
Staff nurse	0.69	-6.61, 0.65	0.03
Clinical nurse	0.45	-34.12, 0.54	0.46
Others (reference)	0.64	-2.56, 9.65	3.13

Discussion

This study aimed to determine the relationship between alarm fatigue and patient safety culture from the perspectives of intensive care unit nurses. The results indicated an average level of alarm fatigue among ICU nurses, which is consistent with the results of other studies by Selçuk Akturan and Fatma Dursun Ergezen. However, Ok Min Cho, et al. reported a higher than average alarm fatigue score among nurses, which is inconsistent with the present study. This discrepancy may be due to differences in methods, as Ok Min Cho, et al. included alarms from ward devices and used a different questionnaire [20].

Another key result of this study was unfavourable mean score of patient safety culture. The dimensions with the lowest mean scores were teamwork across units, perceptions of patient safety and manager expectations and actions promoting safety, while the dimensions with the highest scores were non-punitive response to errors, organizational learning-continuous improvement and teamwork within units. These results were consistent with the results of Jafarpana and Farhad Jabari [21, 22]. Lilis Suryani, et al., reported an unfavourable patient safety culture, with the highest mean score for the teamwork dimension and the lowest mean score for the frequency of events reported dimension, which was consistent with the present study [23]. Loal M Zabin, et al., supported this study and found that the dimensions of organizational learning-continuous improvement, teamwork within units, frequency of events reported, and feedback and communication about errors received the highest scores. Nurses believed that continuous teamwork could prevent a large number of errors and improve patient safety. They also suggested that respectful communication with colleagues and mutual support were important factors in achieving these goals [24].

Malekzadeh, et al., conducted a similar study and reported a favourable level of patient safety culture, with the lowest mean score related to the dimensions of organizational learning continuous improvement. This difference may be due to the fact that we only included ICU nurses, while Malekzadeh, et al., considered all healthcare workers. They suggested that organizational training on patient safety culture should be expanded and a favourable reporting system should be implemented [25]. These results demonstrate the importance of patient safety culture and the opinions of nurses on patient safety should be taken seriously to ensure safe care practices.

Another key result of this study was the significant and inverse relationship between the total scores of the HSPSC and the Alarm Fatigue Questionnaire. This result was consistent with the results of studies by Oliveira, Funk and Lee. As patient safety culture improves, the management of alarms by nurses improves and alarm fatigue decreases. They suggested that nurses' perception of alarms and patient safety culture could affect the proper management of alarms. When nurses understand the usefulness of alarm information, they are better equipped to control the situation and provide appropriate clinical care to patients. Mamdouh, et al., showed that the most common problems threatening patient safety were diagnostic errors, medication errors, errors in the use of equipment and mechanical ventilation. The inconsistency between their results and the present study may be due to the fact that alarm fatigue was not specifically investigated in their study. While alarm fatigue among nurses is one of the factors that can compromise patient safety, there are also other factors that can affect patient safety.

The present study found that the mean score of alarm fatigue increased with an increase of one night shift per month, while it decreased with one year increase in work experience, age and having a hired position. Additionally, the mean score of alarm fatigue was lower in nurses with a master's degree compared to those with a bachelor's degree. These findings are consistent with a study by Sanliturk, et al., which reported that nurses who worked night shifts, rotating shifts and longer hours, as well as those with less than nine years of work experience, experienced more alarm fatigue. Storm, et al., reported that alarm fatigue had a significant and inverse relationship with nurses' age. Nurses aged 21-40 years experienced less alarm fatigue, while younger nurses experienced more fatigue. Newly graduated nurses also reported more alarm fatigue due to lack of familiarity with nursing department conditions. However, Ok Min Cho, et al., indicated that alarm fatigue had no significant relationship with age, education level, job position and work experience, which is inconsistent with the present study. This discrepancy may be due to differences in the research setting and general departments.

The present study found a significant and direct relationship between the mean score of patient safety culture, education, employment status and position. This finding is consistent with Badr's study, which reported a significant relationship between patient safety culture and education, where higher levels of education were associated with higher patient safety culture. However, Nikoloz Gambashidze, et al., reported that profession, type of position and gender had a significant relationship with patient safety culture. Women and personnel with a history of managerial activity had a better understanding of patient safety culture. This study may be inconsistent with

the present study due to differences in the study method and the study setting. Yousefiasal, et al., reported a significant relationship between patient safety culture, the level of education and work experience. Individuals with less than ten years of work experience and higher degrees reported more mistakes and had less safety culture. This study was conducted in five different departments that may be a reason for the difference in results. Additionally, the organizational policies and operational plans of each hospital for the recruitment and use of nursing staff may be different, which can also affect the results of the study.

Conclusion

The present study found an association between an increase in patient safety culture and a decrease in alarm fatigue among nurses in intensive care units. Therefore, it is suggested to improve nurses' general perception of patient safety by providing training courses. The mean level of alarm fatigue was observed among nurses in intensive care units and the energy required to identify and eliminate the causes of alarms can lead to desensitization among nurses. To address this issue, managers should pay special attention to the regular calibration and maintenance of devices and equipment in intensive care units. Additionally, regular alarm management courses should be provided for nurses to enhance their skills in managing alarms.

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