



Geliş Tarihi (Received): 14.10.2025

Kabul Tarihi (Accepted): 06.03.2026

Araştırma Makalesi / Original Research

Assessment of Alarm Fatigue of Intensive Care Nurses

Yoğun Bakım Ünitelerinde Çalışan Hemşirelerin Alarm Yorgunluğunun İncelenmesi

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Alıntı (Cite): Yeşiltaş İ. & Atay S. Assessment of Alarm Fatigue of Intensive Care Nurses. YBH dergisi. 2026; 7(1): 18-30

Abstract

Aims: This descriptive study aims to assess alarm fatigue in intensive care unit nurses.

Method: Participants in this study consisted of 192 nurses from ICUs in state and university hospitals in a city in western Türkiye. The data were collected using the face-to-face survey method. “Demographics Information Form” and “Alarm Fatigue Questionnaire” were used for data collection. For statistical analysis, demographic variables were summarized with frequencies and percentages, while comparisons between demographics and alarm fatigue scores were performed using unpaired t-tests, one-way analysis of variance, and the non-parametric Mann-Whitney U and Kruskal-Wallis tests.

Results: Demographic data showed that 76.0% of the participant nurses were women, 70.8% had obtained a bachelor's degree, and 48.4% reported having 1-9 years of ICU work experience. Average of scores achieved by nurses on the alarm fatigue questionnaire was 13.71 ± 6.018 . There was a statistically significant difference in the nurses' ages, training on the medical devices and alarm management and average scores on the alarm fatigue questionnaire ($p < 0.05$), but there was no relationship between the gender, marital status, professional experience and education variables and the average scores on the alarm fatigue questionnaire ($p > 0.05$).

Conclusion: The findings indicate that the overall level of alarm fatigue among nurses was moderate. It is recommended to regularly assess alarm fatigue levels in ICU nurses and to implement targeted training for those in the higher-risk 21-30 age group.

Key Words: Alarm; Alarm Fatigue; Nursing; Intensive Care Unit.

Özet

Amaç: Tanımlayıcı olarak planlanan bu çalışmanın amacı yoğun bakım ünitelerinde çalışan hemşirelerin alarm yorgunluğunun değerlendirmesidir.

Yöntem: Araştırma Türkiye'nin Batısında bir ilde bulunan devlet ve üniversite hastanelerinin yoğun bakım ünitelerinde görev yapmakta olan 192 hemşire ile gerçekleştirilmiştir. Veriler yüz yüze, anket yöntemi kullanılarak toplanmıştır. Veriler toplanırken “Tanıtıcı Özellikler Bilgi Formu” ve “Alarm Yorgunluğu Ölçeği”nden yararlanılmıştır. Hemşirelerin tanımlayıcı özelliklerinin analizinde frekans ve yüzde dağılımı, alarm yorgunluğu ölçeği puanlarının demografik özellikler ile karşılaştırılmasında ise bağımsız örneklem t testi, tek yönlü varyans analizi, Mann-Whitney U testi ve Kruskal Wallis testleri kullanılmıştır.

Bulgular: Hemşirelerin %76.0'ı kadın, %70.8'i lisans mezunu ve %48.4'ü yoğun bakım ünitesinde 1-9 yıl süredir çalışmaktadır. Araştırmaya katılan hemşirelerin alarm yorgunluğu ölçeğinden aldıkları puan ortalaması $13,71 \pm 6,018$ olarak bulunmuştur. Hemşirelerin yaşı, tıbbi cihaz ve alarm yönetimi eğitimi alma durumları ile alarm yorgunluğu ölçek puan ortalaması arasında istatistiksel olarak anlamlı fark bulunurken ($p < 0,05$) cinsiyet, medeni durum, mesleki deneyim ve eğitim durumu değişkenleri ile alarm yorgunluğu ölçek puan ortalamaları arasında ilişki bulunmamıştır ($p > 0,05$).

Sonuç: Hemşirelerin alarm yorgunluğu düzeyleri orta düzeyde bulunmuştur. Yoğun bakım hemşirelerin alarm yorgunluğu düzeylerinin düzenli olarak değerlendirilmesi ve risk grubuna giren 21-30 yaş grubundaki hemşirelere yönelik eğitimlerin planlanması önerilebilir.

Anahtar Kelimeler: Alarm; alarm yorgunluğu; hemşirelik; yoğun bakım ünitesi

Introduction

Globally, alarm fatigue is a significant and growing problem that affects the patient safety.⁽¹⁾ The American Association of Critical Care Nurses defines alarm fatigue as a clinician's desensitization to alarms due to sensory overload from an excessive number of them, resulting in missed alerts.⁽²⁾ Alarm fatigue most often occurs in intensive care settings due to the critical state of the patients and the reliance on multiple modern devices to monitor their vital signs.⁽³⁾ Clinical alarms provide a warning to healthcare professionals about possible complications in patients and changes in their physical condition. Hospital alarms commonly used by the healthcare institutions include electrocardiographic alarms, intravenous pumps, pulse oximeters, ventilators, carbon dioxide monitors, apnea alarms, dialysis devices, and patient-controlled analgesia pumps.⁽⁴⁾ Despite the utility of such devices in facilitating immediate action, the prevalence of excessive alarms poses a significant problem, given that evidence demonstrates 85% to 99% are either false or clinically irrelevant.⁽⁵⁾ According to the Emergency Care Research Institute, medical alarms are considered one of the ten most significant technology-related hazards in healthcare.⁽⁶⁾

Research conducted by Nyarko et al. (2024) found a significant correlation between alarm fatigue and exhaustion among intensive care nurses in Ghana, who reported experiencing high levels of it.⁽⁷⁾ A study conducted by Ding et al. (2023) revealed that ICU nurses had moderate levels of alarm fatigue.⁽⁸⁾ Furthermore, it was found that there was a significant relationship between the alarm fatigue and the emotional exhaustion, desensitization, and reduced personal accomplishment. A Turkish study conducted by Ergezen and Kol found that the frequency of false alarms was high, the rate of nurses to respond the alarms was low, the response time was long, and the rate to acknowledge alarms was significantly high.⁽⁹⁾

Intensive care nurses, due to their role in providing constant patient monitoring, are especially vulnerable to alarm fatigue. A recent literature review found that the high volume of alarms disrupts their focus, leading to potential errors and negligent actions.⁽¹⁾ Furthermore, this overexposure can diminish trust in alarm systems, adversely impacting both nurse and patient safety.^(1,10) The identification of alarm fatigue among healthcare professionals, particularly nurses engaged in direct patient care, is crucial to safeguarding patient safety and mitigating the stress and dissatisfaction caused by alarm burden.⁽¹¹⁾

Research Questions

- What is the degree of alarm fatigue experienced by intensive care unit nurses?

Materials And Methods

Research Type

This descriptive study aims to assess alarm fatigue in intensive care unit nurses.

Study Design and Sample

This research was performed in the university and state hospital located in a city to the west of Türkiye. Population of research was 347 intensive care nurses working in the intensive care units of university and state hospitals between 2022 December and 2023 February. The sample with known population was used for the calculation of sample. The sample of the research was 192 intensive care nurses, which was calculated considering the 95% confidence interval and 5% margin of error.

Data Collection

“Demographics Information Form” was used to obtain the research data, and the “Alarm Fatigue Questionnaire” was used to determine the alarm fatigue of nurses.

Demographics Information Form

The demographics questionnaire was developed by the investigators based on the relevant literature and had three sections: socio-demographic characteristics, professional characteristics and alarm-related questions. ^(10, 12-14)

Alarm Fatigue Questionnaire (AFQ)

The original 13-item AFO, developed by Torabizadeh et al. (2017), was adapted into a 9-item Turkish version by Kahraman (2020), who established its validity and reliability.¹⁰ The scores on the questionnaire ranges from 0 (minimum) to 36 (maximum). The items of the questionnaire are scored between 0 and 4.^(10,15) Higher scores indicate the impacts of alarm fatigue on nurses' performance. Turkish version does not include any items that are reversed. Cronbach's alpha was found to be 0.80 for the Turkish validity and reliability study. ⁽¹⁵⁾ Cronbach's alpha was found to be 0.78 for this study.

Evaluation of Data

The data from the research were evaluated by a statistical software “Statistical Package for the Social Sciences 20.0 (SPSS)”. The demographic characteristics of participants were interpreted by frequency and percentage analysis. The assumption of normality was tested by examining the skewness and kurtosis of the data. For the dependent variable, the obtained

values for both statistics were within the ± 3 range, and the means were closely aligned, supporting the conclusion of a normal distribution.^(16,17) The unpaired t test, one-way analysis of variance, Mann-Whitney U test, and Kruskal-Wallis test were used to compare the average of participants' responses to AFQ with their demographic characteristics.

Ethical and Research Approvals

To conduct the study, Ethics Committee of the Graduate Education Institute of Çanakkale On Sekiz Mart University granted an ethical approval on 04.02.2022 (resolution number: E-84026528-050 13/16). In addition, for data collection Çanakkale Provincial Directorate of Health granted a written approval on 25.11.2022 (number: E-97769597-799) and Çanakkale On Sekiz Mart University Hospital granted a written approval on 17.11.2022 (number: E27222899-811). The author who conducted Turkish validity and reliability study granted permission by e-mail for the use of Alarm Fatigue Questionnaire in the study.

Results

Of intensive care nurses who participated into study, 76.04% were women, 46.35% were 21 years old to 30 years old, 70.83% had a bachelor's degree, and 67.19% were married. Of the nurses, 58.85% worked in the general intensive care unit, 63.54% worked in the Level 3 ICU, 29.69% worked in the Level 2 ICU, and 6.77% worked in the Level 1 ICU. Of nurses, 47.4% had a working period 1 year to 5 years in the intensive care unit and 77.6% had weekly working hours more than 40 hours.

Table 1. Opinions of intensive care nurses on the medical device alarms

Nurses' opinions on the medical device alarms	Number (n)	Percentage (%)
Their opinions on the meaning of the alarms*		
Patient-related stimulus	179	93,23
High Volume	91	47,4
Workload	23	11,98
Fatigue	18	9,38
Other	3	1,56
Their opinions on the necessity of alarms for patient safety		
Very necessary	105	54,69
Necessary	63	32,81
Occasionally	23	11,98
Unnecessary	1	0,52

*More than one option was marked.

Table 1 lists the opinions of intensive care nurses on the medical device alarms. In the table, the nurses were asked to mark more than one option to order the meaning of the alarms, and patient-related stimulus was 93.23%, the high volume was 47.4%, the workload was 11.98%,

and the fatigue was 9.38%. For the opinions of nurses on the necessity of alarms for patient safety, 54.69% of nurses reported that it was very necessary, 32.81% reported that it was necessary, and 11.98% reported that it was occasionally necessary.

Table 2. Average of scores on the alarm fatigue questionnaire

AFQ	n	Min	Max.	\bar{x}	S.S.
AFQ General	192	1,0	33,0	13,71	6,018

Average of scores of intensive care nurses on the Alarm Fatigue Questionnaire was calculated to be 13.71 ± 6.018 (Table 2).

Table 3. Certain demographic characteristics of intensive care nurses vs. average of their scores on the alarm fatigue questionnaire

Demographic Charac.	n	AFQ \bar{x}	S.S.	Test /Significance
Gender				t= -1,396
Female	146	13,42	5,96	sd= 190
Male	46	14,85	6,09	p= 0,160
Age Group				F= 9,863
21 to 30 years old (a)	89	15,67	6,42	191
31 to 40 years old (b)	50	12,78	5,57	p= 0,000
41 to 50 years old (c)	53	11,47	4,60	a>b>c
Education				KW= 0,498
High school diploma	12	14,67	6,07	sd= 3
Associate degree	17	13,35	5,72	p= 0,919
Bachelor's degree	136	13,61	5,98	
Postgraduate	27	14,37	6,55	

Table 3 displays selected demographic information for the ICU nurse participants and their corresponding average alarm fatigue scores. In the Table, average of scores of male nurses was found to be $=14.85 \pm 6.09$ and average of scores of female nurses was found to be $=13.42 \pm 5.96$. The analysis that was performed did not show any significant difference between the averages ($t=-1.396$ $p>0.05$). As to the average of scores of intensive care nurses on the AFQ by the age groups, the age group of 21 to 30 years old had the highest (15.67 ± 6.42). There was a significant difference in the comparison of averages of scores on the AFQ by the age groups ($F=9.863$ $p<0.05$). Post-hoc analysis showed that the scores of the 21-30 age group were significantly higher than those of the 31-40 and 41-50 age groups. In other words, alarm fatigue was higher in younger age groups. As to the average of scores of intensive care nurses on the AFQ by the

education, average of scores of postgraduate nurses (14.37 ± 6.55) was higher than that of the others. There was no significant difference in the comparison of averages of scores on the AFQ by the education ($KW = 0.498$ and $p > 0.05$)

Table 4. Working conditions of intensive care nurses vs. average of scores on the alarm fatigue questionnaire

	n	AFQ \bar{x}	S.S.	Test /Significance
Nurses' Service				KW= 10,144
General ICU	113	14,07	6,03	sd= 5
Neurology ICU	15	9,53	3,31	p= 0,071
Surgery ICU	9	15,22	5,21	
Newborn ICU	15	13,33	6,53	
Anesthesia and Reanimation	20	13,50	5,98	
Coronary ICU	20	15,10	6,64	
Level of ICU				KW= 1,815
Level 1	13	15,15	3,85	sd= 2
Level 2	57	13,37	6,18	p= 0,404
Level 3	122	13,80	6,13	
Working Years in ICU				KW= 0,766
Less than 1 year	63	13,71	5,22	sd= 3
1 to 5 years	91	13,84	6,59	p= 0,858
6 to 10 years	18	14,50	6,64	
11 years and over	20	12,90	5,22	
Weekly Working Hours				KW= 0,053
Less than 40 hours	9	13,89	6,15	sd= 2
40 hours	34	13,94	6,33	p= 0,974
More than 40 hours	149	13,71	5,97	

Table 4 lists the working conditions of ICU nurses participated into the study vs. average of scores on the alarm fatigue questionnaire. In the Table, nurses who worked in the Surgery ICU had the highest average scores on the AFQ (15.22 ± 5.21) according to intensive care units of participants, and there was no statistically significant difference between the averages of scores on the AFQ by their intensive care units ($KW = 10,144$ and $p > 0,05$). The average of scores of intensive care nurses participated into the study on the AFQ were compared by the level of their intensive care units. As a result, the average of scores of nurses who were assigned to level 1 intensive care was the highest (15.15 ± 3.85), and there was no significant difference between the average of scores ($KW = 1.815$ and $p > 0.05$). As to the average of scores of nurses on the

AFQ by the number of working years in the intensive care, the nurses who worked for 6 to 10 years (14.50 ± 6.64) had higher fatigue compared to other working years, and there was no significant difference between the average scores ($KW=0.766$ and $p>0.05$). The average of scores of intensive care nurses participated into the study on the AFQ were compared by the weekly working hours, and there was no significant difference between the average scores ($KW=0.053$ and $p>0.05$).

Table 5. Training of intensive care nurses on the medical device and alarm management vs. average of scores on the alarm fatigue questionnaire

	n	AFQ \bar{x}	S.S.	Test/Significance
Training on Medical Devices				t = -2,049
Yes	143	13,24	5,95	sd= 190
No	49	15,27	6,00	p= 0,042
Training on Alarm Management				t = -2,386
Yes	100	12,78	6,09	sd= 190
No	92	14,83	5,76	p= 0,018

The average of scores of ICU nurses participated into the study on the AFO were compared by the training on medical devices and alarm management in Table 5. In the Table, nurses who were not trained on medical devices had higher average scores on the AFQ (15.27 ± 6.00) compared to the average scores of nurses who were trained (13.24 ± 5.95), and the difference between them was statistically significant ($t=-2.049$ and $p<0.05$). Nurses who were not trained on the alarm management had higher average scores on the AFQ (14.83 ± 5.76) compared to the average scores of nurses who were trained on the alarm management (12.78 ± 6.09), and the difference between them was statistically significant ($t=-2.386$ and $p<0.05$). Nurses who were trained on the alarm management had lower alarm fatigue than those who were not trained on the alarm management.

Discussion

In this study, the nurses were asked “What does an alarm mean to you?” and majority of nurses (93.23%) responded “patient-related stimulus”, and responses of others included high volume (47.4%), workload (11.98%), and fatigue (9.38%). Perception of alarms as patient-related stimulus is important for the patient safety, and perception of it as high volume was substantial (47.4%). Indeed, in a Chinese study conducted with intensive care nurses, 41% of nurses reported that disturbing alarms occurred frequently, 62% reported that it disrupted the

patient care, and 49% reported that it reduced the trust of nurses in alarms and therefore nurses disabled the alarms instead of setting them as necessary. ⁽¹⁸⁾ A study conducted by Sowan et al., (2015) reported that false alarms occurred frequently as stated by 95% to 98% of nurses, it disrupted the patient care, and it reduced the trust in alarm systems and caused nurses to disable them inappropriately. ⁽¹⁹⁾

Considering the number of nurses who regarded alarms as very necessary and necessary for patient safety, intensive care nurses found medical device alarms necessary. A study conducted by Wang et al., (2023) reported that 72.04% of intensive care nurses regarded alarm systems as necessary. ⁽¹⁸⁾

Average scores of intensive care nurses on the alarm fatigue questionnaire were close to average. Because the total average scores on the AFQ were between 0 and 36, nurses had medium level of alarm fatigue. Alarm fatigue undermines nurse performance and concentration, thereby threatening patient safety. In the literature, a study conducted by Erdoğan (2023) found total average scores of nurses on the AFQ to be 20.02 ± 6.15 . ⁽¹⁴⁾ Other studies that used the same questionnaire in different countries found total average scores of alarm fatigue varying from 19.08 ± 4.4 to 30.57 ± 4.4 ^(1; 20-22). Bi et al. (2020) assessed the level of alarm fatigue using different measuring tools and found that scores of nurses for alarm fatigue were higher than the average with 27.70 ± 2.19 . ⁽²³⁾ A study performed by Jeong and Kim (2022) reported that level of alarm fatigue was medium or high. ⁽²⁴⁾ A study conducted by Cho et al., (2016) found the scores of nurses for alarm fatigue to be 24.3 ± 4.0 and reported that nurses felt a little tired because of clinical alarms. ⁽²⁵⁾ The fact that the scores were lower in this study might be attributed to the population.

Gender and education are the important variables that affect alarm fatigue. In our study, no significant difference ($p > 0.05$) was found between the average scores of male and female nurses on the AFQ. In the literature, there are studies demonstrating that alarm fatigue varies by the gender and education, as well as studies showing that it is not affected by them. ^(14,20-21,26-27) For example, the study conducted by Erdoğan (2023) found that average of females' alarm fatigue was significantly higher than that of males' alarm fatigue, and average scores on the AFQ were not different ($p > 0.05$) in terms of education. ⁽¹⁴⁾ In contrast to our results, Asadi et al. (2022) found that nurses who were female or had more advanced education were more susceptible to alarm fatigue. The study by Whittaker (2018) suggested that alarm fatigue was more prevalent among female nurses. ⁽²⁶⁾ A study performed by Bourji et al. (2020) demonstrated that male

nurses and nurses with higher levels of education had higher scores of alarm fatigue. ⁽²⁰⁾ A study conducted by Zhao et al. (2021) presented a negative correlation of higher education with alarm fatigue. ⁽²⁷⁾

The analysis revealed a statistically significant association between nurses' age groups and their mean scores on the Alarm Fatigue Questionnaire ($p < 0.05$). This finding is supported by Erdoğan (2023) but stands in contrast to the results of Seok et al. (2023), which indicated that age did not have a significant impact on alarm fatigue levels in a Korean sample. ^(14,22)

In this study, it was concluded that there were no statistically significant differences between the intensive care units where the nurses worked and their average scores on the AFQ ($p > 0.05$). Conversely, Ding et al. (2023) reported that alarm fatigue levels differed across intensive care units, and were highest among nurses in pediatric intensive care. ⁽⁸⁾ A study performed by Gündoğan (2023) concluded that nurses working in surgical ICU experienced alarm fatigue at higher levels. ⁽¹³⁾ Likewise, a study conducted by Gül (2023) reported that number of alarms was higher in the surgical intensive care units. ⁽²⁸⁾

The analysis found no significant differences in the average AFQ scores when comparing nurses from different levels of intensive care units ($p > 0.05$). The study performed by Erdoğan (2023) found that average scores of alarm fatigue of nurses working in the second line intensive care units were higher as compared to the nurses working in the third line intensive care units. ^[14] The study performed by Gül (2023) found that alarm fatigue became higher as the level of intensive care units increased ⁽²⁸⁾. Research conducted by Storm and Chen (2021) reported a 50% incidence of alarm fatigue in nurses working in secondary intensive care units, contrasting with a 36.8% incidence in tertiary intensive care unit nurses. ⁽²⁹⁾ The authors also found that alarm fatigue increased as the number of patients per nurse increased. ⁽²⁹⁾

When comparing nurses' average scores on the AFQ by their years of ICU experience, no significant differences were found ($p > 0.05$). The study conducted by Erdoğan (2023) found that there was a decrease in alarm fatigue as the number of working years of nurses increased, and the average scores of alarm fatigue of those who worked in the intensive care units for 0 to 3 years were significantly higher than that of those who worked for 12 years or more. ⁽¹⁴⁾ Kim and Kim (2021) conducted a study in Korea to investigate the experience of intensive care nurses who responded medical device alarms and concluded that nurses who had an experience in intensive care for less than 3 years had difficulty in recognizing the alarm produced by what medical device and asked for help of the senior nurses. ⁽³⁰⁾

In comparison of average scores of ICU nurses participated into the study on the AFQ by the weekly working hours, there were no significant differences between the average scores ($p>0.05$). Even though most nurses worked more than 40 hours per week, the lack of a difference served as an important indicator. It suggested that they had effectively managed the alarm system, while also pointing to the potential silencing of alarms. The study conducted by Gündoğan (2023) concluded that nurses who worked for less than 40 hours experienced alarm fatigue more in terms of total average scores of nurses on the AFQ by their working hours. ⁽¹³⁾

It was found that nurses who received alarm management training had lower alarm fatigue than other nurses ($p<0.05$). This finding serves as a key indicator of the effectiveness of alarm management training for nurses. Karapas and Bobay (2021) suggested that implementing training programs to reduce alarms would positively affect the alarm fatigue. The study's findings indicated that the alarm management training intervention significantly improved nurses' knowledge; however, no statistically significant difference was observed in the volume of nuisance alarms.⁽³¹⁾ The implementation of an alarm management training program by Bi et al. (2020) in a randomized controlled trial with two cohorts resulted in two key outcomes: a significant decline in non-actionable alarms and lower self-reported levels of alarm fatigue among nurses. ⁽²³⁾ It is recommended to implement regular and repetitive training programs for alarm management, to support training with different learning techniques, and to supervise alarm management behaviors. In addition, it is recommended that the true and false alarm rates be considered as an indicator of care and that healthcare managers should focus more on this issue. ^(4, 23,32)

Similar to the results in the literature, this study suggests that intensive care nurses regarded alarms as necessary for patient safety and they experienced alarm fatigue. The analysis revealed that age and training in medical devices/alarm management were significantly correlated with alarm fatigue questionnaire scores. Conversely, no significant associations were detected for gender, marital status, years of experience, or educational background. It may be recommended to improve the noise ergonomics in the intensive care units to ensure patient safety, to periodically assess the level of nurses' alarm fatigue, to focus more on the alarm management during the in-service training provided to the intensive care nurses.

Limitations

Limitations of this study are to include only the intensive care units in one city in the study sample.

Conclusion

The findings indicate that the overall level of alarm fatigue among nurses was moderate. It is recommended to regularly assess alarm fatigue levels in ICU nurses and to implement targeted training for those in the higher-risk 21-30 age group

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