ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.5336/nurses.2022-94490

Determining Alarm Fatigue Among Nurses in Paediatric and Adult Intensive Care Units: A Cross-Sectional Study

Çocuk ve Erişkin Yoğun Bakım Ünitelerindeki Hemşirelerde Alarm Yorgunluğunun Belirlenmesi: Kesitsel Bir Çalışma

Eda ERGİN[a], Şeyda BİNAY YAZ[a], Ayşenur ATAY[a]

[a]Department of Nursing, İzmir Bakırçay University Faculty of Health Sciences, İzmir, Türkiye

This study was presented as an oral presentation at 5th International Congress on Agriculture, Environment and Health, February 17-19, 2022, Online.

ABSTRACT Objective: This study was conducted to determine the alarm fatigue of nurses working in pediatric and adult intensive care clinics. **Material and Methods:** The sample of the descriptive and cross-sectional study consisted of 166 nurses. The STrengthening the Reporting of OBservational Studies in Epidemiology checklist was used in the study. Data were collected by contacting nurses and sharing the link to the Google Survey via e-mail and WhatsApp groups between February-April 2021. It took the participants 5-10 minutes to fill in the data collection tools. Nurses' Introductory Information Form prepared by the researchers and the Nurses' Alarm Fatigue Scale was used to collect the data. **Results:** The mean score of the Nurses' Alarm Fatigue Scale was 18.02±5.94 which was moderate. The analysis also demonstrated that the length of service in the profession, the length of service in the intensive care unit (ICU), the ICU worked in, and the work shifts variables did not statistically significantly affect the mean scores obtained by the participants. However, the weekly working hours variable statistically significantly affected the mean scores obtained by the participants (p=0.019). Finally, the variable of the presence of a noise meter in the ICUs where the nurses involved in the study worked statistically significantly affected the mean scores obtained by the participants (p=0.009). **Conclusion:** The nurses experienced alarm fatigue moderately and their sociodemographic characteristics did not affect the level of alarm fatigue. It was concluded that increased weekly working hours and lack of noise meters in the ICUs increased the nurses' alarm fatigue levels.

Keywords: Fatigue; critical care nursing; intensive care units; medical device; pediatrics

ÖZET Amaç: Bu çalışma, çocuk ve erişkin yoğun bakım kliniklerinde çalışan hemşirelerin alarm yorgunluğunu belirlemek amacıyla yapıldı. **Gereç ve Yöntemler:** Tanımlayıcı ve kesitsel tipte olan araştırmanın örneklemini 166 hemşire oluşturdu. Çalışmada "STrengthening the Reporting of OBservational Studies in Epidemiology" kontrol listesi kullanıldı. Veriler, hemşirelerle iletişime geçilerek ve Google Anketinin bağlantısı e-posta ve WhatsApp grupları aracılığıyla paylaşılarak Şubat-Nisan 2021 tarihleri arasında toplandı. Katılımcıların veri toplama araçlarını doldurmaları 5-10 dk sürdü. Verilerin toplanmasında araştırmacılar tarafından hazırlanan hemşireleri Tanıtıcı Bilgi Formu ve Hemşirelerin Alarm Yorgunluğu Ölçeği kullanıldı. **Bulgular:** Hemşirelerin Alarm Yorgunluğu Ölçeği puan ortalaması 18,02±5,94 olup orta düzeydedir. Analiz ayrıca meslekte hizmet süresi, yoğun bakımda hizmet süresi, çalışılan yoğun bakım ünitesi ve vardiya değişkenlerinin katılımcıların ortalama puanlarını istatistiksel olarak anlamlı bir şekilde etkilemediğini göstermiştir. Ancak haftalık çalışma saati değişkeni, katılımcıların aldıkları ortalama puanları istatistiksel olarak anlamlı şekilde etkilemiştir (p=0,019). Son olarak araştırmaya katılan hemşirelerin çalıştıkları yoğun bakım ünitelerinde gürültü ölçer varlığı değişkeni, katılımcıların aldıkları puan ortalamalarını istatistiksel olarak anlamlı düzeyde etkilemiştir (p=0,009). **Sonuç:** Hemşireler orta düzeyde alarm yorgunluğu yaşadığı ve sosyodemografik özellikleri alarm yorgunluğu düzeyini etkilemediği tespit edildi. Yoğun bakım ünitelerinde haftalık çalışma saatlerinin artması ve gürültü ölçer olmamasının, hemşirelerin alarm yorgunluk düzeylerini artırdığı sonucuna varıldı.

Anahtar Kelimeler: Yorgunluk; yoğun bakım hemşireliği; yoğun bakım üniteleri; tıbbi cihaz; pediatri

Florence Nightingale defined the concept of noise as a cruel situation that can harm both sick and healthy people.[1] Due to the high number of technical devices in intensive care units (ICUs), the level of noise generated by such devices is inevitably high. Noise resulting from the operating and alarms of monitors, infusion and feeding pumps, and mechanical ventilators, which occupy a vital place in patient

Correspondence: Şeyda BİNAY YAZ
Department of Nursing, İzmir Bakırçay University Faculty of Health Sciences, İzmir, Türkiye
E-mail: seyda.binay@bakircay.edu.tr

Peer review under responsibility of Turkiye Klinikleri Journal of Nursing Sciences.

Received: 22 Nov 2022 ***Received in revised form:*** 22 Mar 2023 ***Accepted:*** 17 Apr 2023 ***Available online:*** 27 Apr 2023

care, cause a higher level of noise.[2] According to the guidelines of the Environmental Protection Agency, the noise level in hospitals should not exceed 45 dBA during the day and 35 dBA at night.[3] Research emphasizes that the most important factor causing noise in ICUs is alarm systems.[4,5] Studies show that the lowest sound level of alarm systems is about 45 dB(A), and the highest is approximately 120 dB(A).[5,6] Mandatory usage of several devices in the ICU causes a variety of sound levels. Nurses need to manage and respond to the alarms from the devices, each of which has a different alarm limit, category, and stimulation type.[7] With the development of medical technology, the rapidly increasing clinical alarms from various medical devices are becoming an additional problem in ICUs. Alarms from medical devices (clinical alarms), aimed at attracting the attention of medical staff when a patient's symptoms are abnormal, cause a new problem.[8] Nurses perceive alarm sounds as ambient noise after a while and normalize them because of acclimating to the environment.[9] According to one study, nurses are exposed to an average of 771 monitor alarms per patient per day.[10] Personnel exposed to noise experience anxiety, irritability, impaired judgment, changes in perception, and difficulties in concentration, which can lead to mental disorders and a decrease in their work performance.[11] Another adverse effect of noise in ICUs is the probability of interruptions and failure in medical treatment processes. Even when the noise level reaches 40 dB, there are interruptions in an activity that requires intense concentration.[3] The Emergency Care Research Institute (ECRI) defines alarm fatigue as the emotional pressure medical staff face when they are exposed to too many alarm sounds. Alarm fatigue is a phenomenon that affects nurses when they work in a clinical environment where alarm sounds are frequently heard.[12,13]

Not to suffer alarm fatigue, nurses use techniques such as silencing the alarm, disabling it, and setting alarm thresholds to levels that are not safe for the patient.[7,14] Alarm fatigue causes serious adverse patient events to be ignored in life-threatening situations fatigue and thus creates an unsafe environment for patients.[7] As a growing problem, alarm fatigue is so severe that ECRI ranked it first on its list of the top 10 technological threats to health from 2012 to 2015. In their study conducted to investigate nurses' attitudes towards clinical alarms in ICUs, Cho et al. reported that alarm sounds produced by clinical equipment sometimes made nurses impatient and caused them to ignore some of their tasks.[15]

All health professionals, particularly nurses, who are involved in critical patient care work with monitoring equipment and the system as they monitor the patient at the bedside. They are also responsible for responding to alarms.[16] However, in a qualitative study conducted with 406 nurses in the United States, they became desensitized to alarms due to noise pollution, modification of parameters, lack of staff, and obsolete equipment.[17] According to Christensen et al. 93% of the nurses stated that alarm fatigue caused them to ignore alarms, and 81% of the participants stated that an excessive number of false alarms caused them to experience alarm fatigue.[16] In their study, Cho et al. reported that 69.4% of Korean nurses felt fatigued at a moderate or higher level.[15] Nurse managers should determine factors causing stress in nurses working in intensive care and find solutions to individual and workplace stress factors. Nurse managers should be at the forefront of detecting and managing alarm fatigue, which is one of these stress factors.

AIM

This study aimed to investigate how much nurses working in pediatric and adult ICUs suffer from alarm fatigue.

MATERIAL AND METHODS

DESIGN

The study was conducted as descriptive and cross-sectional research. The report of this study was performed by the STrengthening the Reporting of OBservational Studies in Epidemiology checklist for interviews.

SETTING

The research was conducted with nurses who worked in the pediatric ICUs and adult ICUs of university and state hospitals in İzmir between February 2021 and

April 2021 and who agreed to participate in the research.

SAMPLE

According to the data published by the Ministry of Health based on the statistics of the TURKSTAT (Turkish Statistical Institute), the number of nurses working in university and public hospitals/non-profit hospitals in İzmir, a province in western Türkiye is 8,271.[18] There is no exact figure for the number of nurses working in ICUs. In the present study, only nurses working at universities and government hospitals in İzmir were included. The number of nurses included in the sample was calculated as 166 using the OpenEpi Info Statcalc program™ (2008 Andrew G. Dean and Kevin M. Sullivan, Atlanta, GA, USA) (power: 0.50, confidence level: 80%, possibility of losses to follow-up: 5%) (Figure 1).

Eligibility Criteria

The following nurses were included:

I. Being 18 years and older,

II. Agreeing to participate in the study,

III. Working in a pediatric and adult ICU.

Measurement

The personal information form and Nurses' Alarm Fatigue Scale were used to collect the research data.

The Personal Information Form

The form contains ten items questioning the participants' characteristics such as sex, age, marital status, educational status, length of service in nursing, the department worked in, type of work schedule, length of service in critical care, and average weekly working hours, and the features of the noise meters used in the units.

Nurses' Alarm Fatigue Scale

The scale was developed by Torabizadeh et al.[19] The scale consists of 13 items whose responses are rated on a five-point Likert-type scale ranging from 0 to 4. The minimum and maximum possible scores to be obtained from the overall scale are 0 and 36 respectively. The higher the score is the stronger the effect of alarm fatigue on nurses is. The Cronbach's alpha of the original scale was 0.91.[19] A valid and reliable scale was used in the study. The validity and reliability study of the Turkish version of the scale was

Start | Enter | Results | Examples | Help

Sample Size for Frequency in a Population

Population size (for finite population correction factor or fpc) (N): 8271
Hypothesized % frequency of outcome factor in the population (p): 50%+/-5
Confidence limits as % of 100 (absolute +/-%) (d): 5%
Design effect (for cluster surveys-DEFF): 1

Sample Size (n) for Various Confidence Levels

Confidence Level (%)	Sample Size
95%	368
80%	162
90%	263
97%	446
99%	615
99.9%	958
99.99%	1.281

Equation

Sample size $n=[DEFF*Np(1-p)]/[(d^2/Z^2_{1-\alpha/2}*(N-1)+p*(1-p)]$

Results from OpenEpi, Version 3, open source calculator—SSpropor
Print from the browser with ctrl-P
or select text to copy and paste to other programs.

FIGURE 1: Sample size for frequency in a population.

conducted by Kahraman.[20] The Cronbach's alpha of the scale was 0.80 and it consists of 9 items for The Turkish version.[20] In this study, the Cronbach's alpha coefficient of the scale was found to be 0.73.

DATA COLLECTION

Before starting the data collection phase, a pilot study was conducted with a group of 5 nurses to determine the usability of the questionnaire. Pilot study data were not included in the sampling. Data were collected by contacting nurses working in the ICU and sharing the link to the Google Survey (Google, Collaborative software web survey, Vanix: USA) via e-mail and WhatsApp (Proprietary software with EULA, California) groups. The questionnaire form was shared with all participants once. Participants who filled in the questionnaire incompletely (5 nurses) were not included in the study. It took the participants 5-10 minutes to fill in the data collection tools. The answers were transferred to International Business Machines (IBM), Statistical Package for the Social Sciences Statistics (SPSS) Version 26.0 via excel and checked one by one to avoid possible duplicate entries from the same user. Only completed questionnaires were analysed. Questionnaires terminated early were not included in the analysis.

DATA ANALYSIS

Data were analysed using IBM SPSS Statistics for Windows, Version 26.0. (Armonk, NY: IBM Corp). Data related to the categorical variables were given as mean, standard deviation, numbers, and percentages in the descriptive statistics. The Kolmogorov-Smirnov test was used to find out whether the numerical variables (scale and subscales) were distributed normally. Therefore, parametric statistical methods were used in the study. While the t-test was used to compare two independent groups, the one-way ANOVA was used to compare more than two independent groups. Statistical significance was accepted at $p<0.05$.

ETHICAL CONSIDERATIONS

The study was approved by the Non-Invasive Clinical Research Ethics Committee at İzmir Bakırçay University in Turkey (Decision date: 29.01.2021, decision number: 2021/165). The study was carried out by the ethical standards established in the Declaration of Helsinki. The questionnaire was prepared using the website Google Documents (Google, Collaborative software word processor, JavaScript: USA). At the beginning of the questionnaire were stated "yes" and "no" questions. The participant's marking of the "yes" option indicated that he or she gave his or her consent and volunteered to participate in the study. The participants were informed that they had the right to withdraw from the study without giving any reason.

RESULTS

In the present study, 166 nurses from pediatric ICUs and adult ICUs were enrolled to assess the extent of alarm fatigue. Their socio-demographic characteristics are shown in Table 1. Of the nurses, 79.5% (n=132) were women, 73.5% (n=122) had a university degree, 65.7% (n=109) were single, and 38.6% (n=64) were in the age group of 26-35 years (Table 1). The mean score the nurses obtained from the Alarm Fatigue Scale was 18.02±5.94, which was considered moderate since the possible score to be obtained from the scale ranges between 0 and 36 (Table 2). Table 3 summarises the nurses' general work

TABLE 1: Distribution of Nurses' Alarm Fatigue Scale mean scores according to the sociodemographic characteristics of the nurses (n=166).

Descriptive characteristics	n	%	X±SD	p value*
Gender				
Female	132	79.5	18.00±5.85	0.918[a]
Male	34	20.5	18.11±6.35	
Age				
18-25	44	26.5	18.38±4.88	0.276[b]
26-30	64	38.6	19.01±6.95	
31-35	37	22.3	16.81±5.27	
36-40	12	7.2	16.16±6.36	
41 and above	9	5.4	16.66±4.06	
Education				
High school	26	15.7	19.80±5.70	0.242[b]
Bachelor	122	73.5	17.63±5.73	
Graduate	18	10.8	18.05±7.41	
Marital status				
Single	109	65.7	18.09±5.86	0.840[a]
Married	57	34.3	17.89±6.13	

*p<0.05; [a]Independent samples t-test; [b]One-way ANOVA test; SD: Standard deviation.

TABLE 2: Nurses' Alarm Fatigue Scale average scores of nurses (n=166).

	X±SD	Median (Minimum-maximum)
Nurses' Alarm Fatigue Scale	18.02±5.94	18 (0-36)

SD: Standard deviation.

characteristics. According to the table, 38.6% (n=64) of the nurses' length of service in the profession was 6-10 years, and 39.8% (n=66) of the nurses' length of service in the ICU was 1-5 years. Of them, 51.2% (n=85) worked in the adult ICU, 42.8% (n=81) worked in the pediatric ICU, and 91.6% (n=152) worked night and day shifts alternately, 50% (n=83) reported that they worked 48 hours a week, and 95.2% (n=158) reported that no noise meter was available in the ICU (Table 3).

The analysis of the mean scores obtained from the Alarm Fatigue Scale demonstrated that the sex variable did not statistically significantly affect the mean scores obtained by the participants (p=0.918). However, there were statistically significant differences between the participants' scores in terms of age, education, and marital status variables (p=0.276, p=0.242, p=0.840) (Table 1). The analysis also demonstrated that the length of service in the profession, the length of service in the ICU, the ICU worked in, and work shifts variables did not statistically significantly affect the mean scores obtained by the participants (0.463, 0.450, 0.620, and 0.365, respectively). However, the weekly working hours variable statistically significantly affected the mean scores obtained by the participants (p=0.019). Finally, the variable "the presence of a noise meter in

TABLE 3: Distribution of Nurses' Alarm Fatigue Scale mean scores according to the working characteristics of the nurses (n=166).

	n	%	X±SD	p value*
Working year in nursing				
0-1 years	25	15.1	17.96±6.58	0.463[b]
1-5 years	49	29.5	18.79±4.95	
6-10 years	64	38.6	18.25±6.53	
11-20 years	20	12.0	16.45±5.91	
21 years and above	8	4.8	15.62±4.20	
Working shifts				
Day and night shifts	152	91.6	18.22±5.87	0.361[b]
Only day shifts	10	6.0	16.00±6.68	
Only night shifts	4	2.4	15.50±7.14	
Unit				
Pediatric intensive care unit	81	48.8	18.25±5.59	0.620[a]
Adult intensive care unit	85	51.2	17.80±6.28	
Working year in intensive care				
0-1 years	36	21.7	17.86±6.35	0.450[b]
1-5 years	66	39.8	17.86±5.59	
6-10 years	45	27.1	19.17±6.12	
11-20 years	16	9.6	16.31±6.22	
21 years and above	3	1.8	15.33±2.88	
Average working time per week				
40 hour	41	24.7	17.56±6.14	**0.019**[b]
48 hour	83	50.0	18.46±5.47	
56 hour and above	27	16.3	19.62±6.66	
Other (flexible)	15	9.0	13.93±5.06	
Use of a device that measures the sound level in the unit				
Yes	8	4.8	13.75±3.57	**0.009**[a]
No	158	95.2	18.24±5.96	
Total	166	100.0		

*p<0.05; aIndependent samples t-test; bOne-way ANOVA test; SD: Standard deviation.

the ICUs where the nurses involved in the study worked" statistically significantly affected the mean scores obtained by the participants (p=0.009) (Table 3).

DISCUSSION

Alarm fatigue occurs when medical staff is overwhelmed by excessive clinical alarms.[15] in particular, alarm fatigue can negatively affect nurses' productivity and concentration.[19] The minimum and maximum possible scores to be obtained from the overall scale are 0 and 36 respectively. Because the mean scores the participants obtained from the Alarm Fatigue Scale was 18.02±5.94, it was considered moderate. In Kahraman's study, the mean score obtained from the Alarm Fatigue Scale was 22.2±6.8, consistent with our results.[20] However, the mean scores for alarm fatigue were 24.3 out of 35 (±4.0) and 69.4 out of 100 in Cho et al. study, and 24.63±8.99 out of 35 (±4.0) in Zhao et al. study, which indicates that alarm fatigue among the ICU nurses has reached a severe level.[15,21]

One finding of our research was that the level of alarm fatigue was the highest among nurses with a high school education. In their study, Zhao et al. stated that young nurses with a college education had high levels of alarm fatigue and that these nurses needed awareness-raising training on missed alarms, false alarms, and alarm management policies and the new monitoring system.[21] In a study conducted by Graham and Cvach, where nurses were trained in alarm management for one year, the number of alarms decreased by 47% from 16,953 before the training, to 9,647 after the training.[14] This result indicates that nurses should be given more in-service training, which will enable them to be aware of the intensity of the alarms they are exposed to and of the alarms that occur due to technical reasons, and which will, in turn, reduce their alarm fatigue levels.

The results of the present study demonstrated that alarm fatigue levels were higher in nurses working both night and day shifts alternately. Paine et al. concluded that there was a relationship between exposure to alarm and the reaction time that alarm fatigue could cause.[22] In our study, we also concluded that as the working hours of the nurses increased, so did their alarm fatigue level, and that there was a statistically significant correlation between the participants' weekly working hours and the mean scores they obtained from the Alarm Fatigue Scale. In their study, Zhao et al. concluded that nurses who worked night shifts over 11 days a month suffered from alarm fatigue highly.[21] In their observational study conducted in 5 ICUs in northern France with 131 patients in which the frequency of false or irritating alarms was highlighted Chambrin et al., reported that 246 observations were performed during 1,971-hour care.[23] During the observations, 3,188 alarms occurred. In a study conducted by Atzema et al. by observing patients with continuous cardiac monitoring in the emergency department, 1,762 alarms were recorded over 371 hours, and 99.4% of the alarms were "false alarms", which increased the nurses' alarm fatigue levels.[24] This result indicates that nurses' level of alarm fatigue increases as the time they are exposed to the alarm increases.

In the present study, the nurses working in the pediatric ICUs suffer from alarm fatigue more. In their study, Neille et al. recorded noise levels in 5 neonatal ICU areas 4 times over 3 days.[25] Because the noise levels were above 14.8-22.6 dB(A), they decided that programs on the negative effects of noise should be implemented. In a prospective study conducted in the Alfred Paediatric ICU, personnel working in the ICU for 7 days were asked to record the type and number of alarm sounds (false, true, and essential, as a call to action). During the 7 days, 2,176 alarms were recorded. Of the alarms, 1,481 (68%) were false, 119 (5.5%) were correct and essential, and 576 (26.5%) were a warning to the nursing staff of a possible bad situation.[26]

There were no significant differences between the mean scores obtained from the Alarm Fatigue Scale by the nurses participating in the present study in terms of the variables such as the length of service in the profession, the length of service in the ICU, the ICU worked in and the type of work schedule. Similarly, in the study by Zhao et al., no difference was found between the alarm fatigue scores of the participants who were married, whose academic qualifications were, and whose length of service in the

profession was short.[21] In our study, the nurses who worked in the ICUs where there were no noise meters had higher levels of alarm fatigue, which significantly affected the mean scores they obtained from the Alarm Fatigue Scale. In many studies conducted in ICUs, noise levels are above the level recommended by the World Health Organization. While Knauert et al. measured it as 63 dB at night, Bosch et al. measured it as 57.6±3.6 dB during the day and 55.4±3.1 dB at night.[27,28] As a result of the absence of noise meters in ICUs in our country, nurses suffer from alarm fatigue since the intensity of noise they are exposed to during the day is not calculated.

LIMITATIONS

The present study has some limitations. First, it was conducted with ICU nurses working in İzmir. Therefore, its results cannot be generalized to other nurses in Türkiye. Second, data collection forms were filled in online, and we did not have the chance to control the data collection process.

CONCLUSION

In this study, the nurses experienced alarm fatigue moderately and their sociodemographic characteristics did not affect the level of alarm fatigue. It was concluded that increased weekly working hours and lack of noise meters in the ICUs increased the nurses' alarm fatigue levels. Nurses feel overburdened by an excessive number of tasks and a constant influx of clinical alarms. Nurses often do not recognise the need for education about alarms, which is an important component of any alarm management strategy. Evaluation of alarm fatigue should be a priority in the future, helping to provide safety to both patients and nurses and verifying the effectiveness of strategies implemented.

Acknowledgment

We would like to thank the and all the parents who participated in the questionnaire.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Eda Ergin, Ayşenur Atay;* ***Design:*** *Eda Ergin, Şeyda Binay Yaz, Ayşenur Atay;* ***Control/Supervision:*** *Eda Ergin;* ***Data Collection and/or Processing:*** *Ayşenur Atay;* ***Analysis and/or Interpretation:*** *Eda Ergin, Şeyda Binay Yaz;* ***Literature Review:*** *Eda Ergin, Şeyda Binay Yaz, Ayşenur Atay;* ***Writing the Article:*** *Eda Ergin, Şeyda Binay Yaz, Ayşenur Atay;* ***Critical Review:*** *Eda Ergin;* ***References and Fundings:*** *Eda Ergin, Şeyda Binay Yaz, Ayşenur Atay.*

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