International Journal of Africa Nursing Sciences 16 (2022) 100403

Contents lists available at ScienceDirect

International Journal of Africa Nursing Sciences

journal homepage: www.elsevier.com/locate/ijans

Sources of noise and their effects on nurses in intensive care units: A cross sectional study

Zahra Kooshanfar [a], Sadra Ashrafi [b,*], Ezzat Paryad [c], Yalda Salmanghasem [d], Tahereh Khaleghdoost Mohammadi [c], Ehsan Kazemnezhad Leili [e], Seyyed Mohammad Javad Golhosseini [f]

[a] Nursing (MSN), School of Nursing and Midwifery, Guilan University of Medical Sciences, Rasht, Iran
[b] Student Research Committee, Chronic Kidney Disease Research Center(CKDRC), Shahid Beheshti University of Medical Sciences, Tehran, Iran
[c] Social Determinants of Health Research Center (SDHRC), Instructor, Guilan University of Medical Sciences, Rasht, Iran
[d] Master of Architecture, Rasht, Iran
[e] Social Determinants of Health Research Center (SDHRC), Bio-Statistics, Associate Professor, Guilan University of Medical Sciences, Rasht, Iran
[f] Department of Health, Instructor, School of Health, Guilan University of Medical Sciences, Rasht, Iran

ARTICLE INFO

Keywords:
Health
Intensive care unit
Nurse
Noise

ABSTRACT

Background: Noise is a serious threat to the health of people. In Intensive Care Units (ICU), the higher level of noise may negatively affect the health of the patients and health care staff.
Objectives: To determine the sources of noise and the related adverse effects from the ICU nurses' viewpoints.
Methods: The study sample included all nurses (148) working in ICUs. The data collection tool was a three-section questionnaire. The first section was related to personal- occupational characteristics. The second part evaluated internal and external noise sources from the nurses' viewpoints. The third section assessed the effect of noise on four domains: physiology, emotions, subjective perception, and performance. The data were analyzed by SPSS version 22, using descriptive and inferential statistics.
Results: The results showed that the major internal sources of noise were monitoring alarms and ventilators (61.5%).The highest and lowest mean ± SD of the scores about the effect of noise on the study domains were related to physiology (16.1 ± 4.8) and performance (14.9 ± 5.25). The three domains' scores (subjective perception, emotions, physiology) had significant relationship with the bed occupancy rate, the type of ICU, and the number of beds ($P < 0.05$). Also, the performance domain's scores had a significant relationship with work experience, bed occupancy rate, and shift type ($P < 0.05$).
Conclusions: Since ambient noise is a threat to health and disturbs the patients and ICU staff, we believe that proper strategies should be designed to reduce its levels.

1. Introduction

Environmental noise pollution is a common problem faced by people nowadays (Otenio, Cremer, & Claro, 2007). Noise is an irregular sound that is unpleasant, unwanted, and usually unavoidable (Basner et al., 2014; Khademi & Imani, 2015). Noise is a stressor, and a severe threat to the health of people all over the world (Tsara et al., 2008).

The World Health Organization (WHO) defines health as a state of complete physical, mental, and social well-being and not merely the absence of disease or disability (Cunha & Silva, 2015; Khademi & Imani, 2015). Noise can cause an unwanted physiological or psychological reaction in people, and its consequences can chronically affect mental and physical health (Clark & Paunovic, 2018; Cunha & Silva, 2015). The hospital, as healthcare delivery, is affected by the sources of noise pollution (Potter, Perry, Stockert, Hall, Astle, & Duggleby, 2018). Environmental noise causes a series of health problems and discomfort in patients and hospital personnel, such as; sleep disturbance, delay in wound healing, and sympathetic nervous system abnormal activity. Moreover, moderate levels of noise cause vasoconstriction (Delaney, Litton, & Van Haren, 2019; Tsara et al., 2008). Associations between

Abbreviations: ICU, Intensive Care Unit; SD, Standard Deviation; ENT, Ear-Nose-Throat; BOR, Bed Occupancy Ratio; WHO, World Health Organization.

* Corresponding author.
E-mail address: sadra.ashrafi@sbmu.ac.ir (S. Ashrafi).

https://doi.org/10.1016/j.ijans.2022.100403
Received 12 October 2021; Received in revised form 22 February 2022; Accepted 24 February 2022
Available online 28 February 2022

noise and sleep quality were found in studies (Horsten, Reinke, Absalom, & Tulleken, 2018; Simons et al., 2018). The noise in the hospital environment may have adverse effects on the visual and balance systems, social interactions, psychological and mental status (anxiety, irritability, and psychiatric disorders), and vital signs (the heart rate, blood pressure, oxygen consumption, and respiratory rate). These adverse effects are dangerous in patients with cardiovascular diseases and pregnant women (Fallah & Takhsha, 2013; Tirgar, Koohpaei, Allahyari, & Alimohammadi, 2007). Noise is associated with signs (increase in heart rate) and symptoms (stress-related annoyance) of stress in intensive care units' (ICUs') nurses and is a significant risk factor for nursing staffs' exhaustion (Pugh, Jones, & Griffiths, 2007). Employees feel uncomfortable after hours of working in a noisy environment due to the stress created by enduring that noise (Andrade, Oliveira, Souza, & Matos, 2016). Noise reduces the performance of healthcare providers. In fact, patients reported less attention from the staff in noisy situations (Pugh et al., 2007).

Hospitals all over the world, including Iran, don't have rather good conditions in terms of noise pollution (Rabiyan & Gharib, 2004; Salandin, Arnold, & Kornadt, 2011). In other words, the sound levels measured in different parts of the hospitals are higher than standard (Mehran, Sahra, Mohammad Asghari, & Akbar, 2017; Yarar, Temizsoy, & Günay, 2019). A study conducted in 2005 revealed that noise pollution in health care facilities increased by 0.38 dB during the day and 0.42 dB during the night from 1960 to 2005 (Busch-Vishniac et al., 2005; Mardomi, Bagheri, & Hasanpoor Rahimabad, 2012). Furthermore, according to another study conducted by Kooshanfar (2016), the mean noise level in ICU was higher in the morning than in the evening (Kooshanfar, Khaleghdoost Mohammadi, Paryad, Kazemnezhad, & Golhosseini, 2016).

Most studies show that noise level in ICU is higher than that recommended by US Environmental Protection Agency and the World Health Organization. Noise pollution is mostly caused by human activities and equipment in ICUs and other hospital wards (Khademi & Imani, 2015). The results of Andrade's research showed that the noise level is at least 52.5 dB in the neonatal intensive care unit (NICU) and a maximum of 85 dB in the gynecology ward, which is significantly different between days of the week. There is the same level of noise in the emergency room (Andrade, Oliveira, & d., Souza, R. d. P., & Matos, I. M. D., 2016). Whereas according to the Environmental Protection Agency, the noise level should not exceed 45 dB during the day and 35 dB during the night (Clark & Paunovic, 2018; Darbyshire, 2016; Morton, Fontaine, Hudak, & Gallo, 2013). Approximately, 80–90% of alarms are inessential (Sahoo, Joshi, Madathil, Verma, & Sankar, 2019). Although the employees know that they can lower the level of noise by adjusting the volume and pattern of devices' alarms, they prefer to use the routine and not to change them (Darbyshire, 2019).

Studies conducted in Iran have shown that the noise level in hospitals is louder than that recommended by WHO. Therefore, it is important to find a suitable location for constructing the hospital and adopt proper strategies for noise reduction (Fallah & Takhsha, 2013).

In ICUs, the level of noise is already higher than in other units due to the use of more medical instruments, like ventilators, monitoring devices with alarms, infusion pumps, etc., so noise has more devastating effects in these units (Khademi, Roudi, Farhat, & Shahabian, 2011). One of the reasons for physical and emotional distress in ICUs is the noise created by different devices (TV, pager and, etc.), speaking and activities of staff, moving equipment around and staff commuting in the ward (Bench & Brown, 2011).

Many studies have shown that the level of noise in ICU is above 80–90 dB (Morton, Fontaine, & Hudak, 2005). The highest recorded noise belonged to the conversations among the staff in the nurses' station (89 dB-A), oxygen mask application (70 dB-A), ventilator alarms (69 dB-A), and monitoring alarms (67 dB- A) (Kol, Demircan, Erdoğan, Gencer, & Erengin, 2015). ICU nurses also reported noise louder than it actually is (White & Zomorodi, 2017).

Unfortunately, hospital noise levels are still rising (as a result of technological developments) (Kamdar, Martin, & Needham, 2017; Otenio et al., 2007), and ongoing interventions have not been able to reduce noise. Therefore, new hospitals need to be redesigned, for example, using soundproof materials in building different parts of the hospital. Furthermore, noise resources should be eliminated or diminished as far as possible, for example, by using ventilator and alarm systems that are less noisy (Kamdar et al., 2017).

A study by Juang, Lee, Yang, and Chang (2010) demonstrated significant correlations about emotional effect, physiological effect, and health care staff's subjective perception of ambient noise. The overall results of this study indicated that noise had direct and indirect destructive effects on the patients, staff, and visitors (Juang et al., 2010).

As the results indicated, identifying, monitoring, and controlling noise sources, as well as educating the hospital staff about the adverse effects of noise on patients' health, can be highly effective in reducing noise pollution (Al-Tarawneh, D'emeh, & Yacoub, 2020; Khademi & Imani, 2015).

Considering the importance of ambient noise in ICUs and its adverse effects on health, it is necessary to evaluate these effects. Since the viewpoint of each person may be the best index for determining the effect of ambient noise on different health aspects, we assessed the viewpoints of the nurses about the sources of noise and its effects on them in ICUs. Evaluating the effects of ambient noise on the staff's health may help authorities to design practical plans for alleviating this noise.

2. Methods

2.1. Design

This was an analytical and cross-sectional study that took place in seven ICUs (general surgery, neurosurgery, burn, gynaecology, ENT, medical, open heart surgery), across all educational hospitals in Rasht (a city in the north of Iran). The data were collected from May 21 to July 19 in 2016.

2.2. Participants and Procedure

All the nurses who met the study criteria were enrolled in the study, after giving informed consent. The inclusion criteria consisted of work experience in the ICU for at least six months and lack of hearing disorders, reported by nurses themselves. The participants whose questionnaire were incomplete or who were unwilling to participate, were excluded from the study. The total number of nurses working in ICUs was 163. The questionnaires were distributed by the researcher to all of them. Before the distribution, the purpose of the study was explained to the participants. Seven nurses were on sick or maternity leave, and eight nurses didn't want to participate. Therefore, only 148 nurses participated in the study.

2.3. Measures

The data collection tool was a three-section questionnaire. The first section was related to personal-occupational characteristics. The second part, which was a researcher designed questionnaire in Persian language based on the Juang study's tool (Juang et al., 2010), evaluated internal (12 questions) and external (10 questions) noise sources with low, moderate, and high ratings from the viewpoint of the nurses. The internal refers to inside the ICUs, and the external refers to the other places inside the hospitals. The third section evaluated the effect of noise on four domains: physiology, emotions, subjective perception of ambient noise, and also work performance, all from the nurses' viewpoint (5 questions in each domain). The effect of noise on their subjective perception was evaluated in the areas of distress, inattention, inability to sleep, fright, and dizziness. The emotional effect of the ambient noise is

evaluated by items like communication problems, scalp tingling (A pins-and-needles sensation on the scalp), ill-temper, irritability, and tension. The items, used to measure the physiological effects of noise comprised tachycardia, tinnitus, headache, fatigue, and loss of appetite. And about the nurses' performance, items like decreased productivity, concentration problem, disobedience, and auditory masking carelessness were measured. All items were scored on a 5-point Likert scale (5: always, 4: often, 3: sometimes, 2: rarely, 1: never). The score of each domain ranged from 5 to 25, and the mean score was used for analysis.

To determine the validity of the questionnaire, it was forwarded to ten faculty members of Rasht School of Nursing and Midwifery (departments of health, internal medicine-surgery, and ICU department). According to their comments and feedback, two items (sounds of footstep and children playing) were deleted, which were rarely sources of noise in Iran's hospitals. Two more common items (Radio sound and TV sound) were added to the questionnaire. The validity of the questionnaire was assessed through Content Validity Ratio (CVR) and Content Validity Index (CVI). CVI was 0.93 and 0.94 and CVR was 0.74 and 1 for external and internal noise sources, respectively. CVI was 0.94 and CVR was 0.92 for all four domains. For the reliability of the questionnaire, the Cronbach's alpha value was calculated and found to be 0.852 in our study.

2.4. Procedure and statistical analysis

The data were analyzed by SPSS version 22, using descriptive and inferential statistics. The Spearman correlation coefficient was applied to investigate the relationship between dependent variables with a non-normal distribution (performance and emotion domain' s scores) and quantitative variables (Age, work experience, work experience in ICU, number of beds in ICU, Bed Occupancy Rate, overtime hours). Pearson correlation coefficient was used to assess the correlation of dependent variables with a normal distribution (subjective perception and physiological domains' scores) and quantitative variables. Moreover, the Mann-Whitney and Kruskal-Wallis tests were used to compare the mean effects of qualitative variables (genders, marital status, education, job title, type of ICU, work shift) on dependent variables with a non-normal distribution, and independent *t*-test and ANOVA were applied to compare the mean effect of qualitative variables on dependent variables with a normal distribution. P values < 0.05 were considered significant.

2.5. Ethical consideration

After this study was approved by the Ethics Committee of Guilan University of Medical Sciences with the code: IR.GUMS.REC.1394.53, the researchers, who were female and had MSC in nursing, started with data collection at the hospitals where they asked the nurses to complete the questionnaire. Prior to the data collection, permission to conduct the study was requested and granted by the Hospital Management, and the participants were assured of the anonymity and confidentiality of the data and their verbal consent was taken.

3. Results

The results showed that 68.2% of participants were aged 22–35 years, and most of them were female (95.3%) and married (64.2%). Furthermore, 91.9% had Bachelor's Degree, 95.3% had a job title as a nurse (not a head nurse), and 83.8% of them worked in rotating shifts. Most of them had 5–14 years of work experience (62.1%) and 5–13 years of work experience in ICU (62.1%). About half of the participants had <50 h of overtime work (58.1%), and the maximum overtime was 120 h. The majority of the beds were related to general surgery, neurosurgery, and open-heart surgery ICU (n = 11). The highest bed occupancy rate was seen in general surgery and neurosurgery ICU (100%) (Table 1).

The results also revealed that the major internal sources of noise (according to participants' viewpoints) were monitoring alarms and ventilators (61.5%), telephone rings (59.5%), and patients' groaning sounds (43.9%). Moreover, the major external noise sources were the hospitals' renovation sounds (41.2%), and new patient admission and patients' groaning sounds (24.3%) (Table 2).

The highest and lowest means ± SD of the nurses' viewpoint about the effect of noise on the study domains were related to the effect of noise on physiology (16.1 ± 4.8) and performance (14.9 ± 5.25), respectively. Furthermore, the means ± SD for two other domains were 16 ± 4.3 for subjective perception and 15.65 ± 4.95 for emotion (Table 3).

Based on the Spearman test, the emotion domain's scores had significant correlations with the number of beds (P = 0.003, r = 0.244) and bed occupancy rate (P = 0.0001, r = 0.379). Additionally, the

Table 1
The demographic and occupational factors.

Demographic-occupational Factors		No. (%)
Age (y)		
	22–35	101(68.2)
	>35	47(31.8)
	Mean ± SD	33.61 ± 6.09
Gender		
	Female	141(95.3)
	Male	7(4.7)
Marital status		
	Single	53(35.8)
	Married	95(64.2)
Education		
	Bachelor	136(91.9)
	Master	12(8.1)
Job title		
	Head nurse	7(4.7)
	Nurse	141(95.3)
Work shift		
	Fixed shift	24(16.2)
	Rotating shift	124(83.8)
Work experience (years)		
	<5	26(17.5)
	5–14	92(62.10)
	15–14	28(19)
	≥25	2(1.4)
	Mean ± SD	9.46(5.72)
Work experience in ICU(years)		
	<5	57(38.50)
	5–13	76(51.4)
	>13	15(10.1)
	Mean ± SD	6.70(4.67)
Overtime hours		
	<50	86(58.1)
	50–100	60(40.5)
	>100	2(1.4)
	Mean ± SD	39.91(32.17)
Kind of ICU Number of Beds (BOR%)		
	General surgery	11(100)
	Neurosurgery	8(100)
	Burn	4(90)
	Gynaecology	3(75)
	ENT	2(50)
	Medical	8(95)
	Open heart	11(60)

Table 2
Major noise sources inside and outside the wards according to the nurses.

Noise Sources			
Inside the wards:	a little	Moderate	a lot
Monitor alarms and ventilators	17 (11.5%)	40 (27.0%)	91 (61.5%)
Phone ringing	10(6.8%)	50 (33.8%)	88 (59.5%)
Patients moaning or crying	13(8.8%)	70 (47.3%)	65 (43.9%)
Conversation between workers	36 (24.3%)	71 (48.0%)	41 (27.7%)
Oxygen or suction apparatuses	27 (18.2%)	82 (55.4%)	39 (26.4%)
Medical equipment	44 (29.7%)	72 (48.6%)	32 (21.6%)
Conversation between visitors or patient's family members 57(38.5%)	65 (42.9%)	26 (17.6%)	
Doors opening or closing	60 (40.5%)	66 (44.6%)	22 (14.9%)
Radio, Television, Tape recorder sound	96 (64.9%)	39 (26.4%)	13(8.8%)
Opening of drawers or clothes chests	69 (46.6%)	67 (45.3%)	12(8.1%)
Cleaning or sweeping	64 (43.2%)	73 (49.3%)	11(7.4%)
Outside the wards:			
Renovation of hospitals	34 (23.0%)	53 (35.8%)	61 (41.2%)
Registration	53 (35.8%)	57 (38.5%)	38 (25.7%)
Patients moaning or crying	47 (31.8%)	65 (43.9%)	36 (24.3%)
Conversation between workers	54 (36.5%)	62 (41.9%)	32 (21.6%)
Conversation between visitors or patient's family members 57(38.5%)	61 (41.2%)	30 (20.3%)	
Rolling of trolley wheels	66 (44.6%)	64 (43.2%)	18 (12.2%)
Doors opening or closing	70 (47.3%)	60 (40.5%)	18 (12.2%)
Cleaning or sweeping	78 (52.7%)	58 (39.2%)	12(8.1%)
Broadcast	95 (64.2%)	43 (29.1%)	10(6.8%)
Radio, Television, Tape recorder sound	102 (68.9%)	36 (24.3%)	10(6.8%)

performance scores also had significant correlations with work experience (P = 0.041, r = 0.168) and bed occupancy rate (P = 0.002, r = 0.250). According to the Pearson correlation test, there were significant correlations between the mental perception scores and the number of beds (P = 0.044, r = 0.166); the subjective perception scores and bed occupancy rate (P = 0.003, r = 0.246); the physiology domain's scores and the number of beds (P = 0.006, r = 0.227); the physiology domain's score and bed occupancy rate (P = 0.0001, r = 0.402) (Table 4).

The Mann-Whitney and Kruskal-Wallis tests showed a significant relationship between the emotion domain's scores and the type of ICU (P = 0.0001); the performance domain's scores and the type of work shifts (P = 0.024). The noise had the greatest effect in the general surgery ICU and the lowest effect in the ENT ICU, respectively (Table 5).

Independent *t*-test and ANOVA were used to evaluate the relationship between the score of the subjective perception and the type of ICU; the physiology domain's scores and the type of ICU, both of which were significant (P < 0.05). The greatest effect was seen in general surgery, and neurosurgery ICU and the lowest was seen in ENT ICU (Table 5).

4. Discussion

Ambient noise is a bothersome factor in all occupational environments, which in the long term can lead to physical and psychological

Table 3
The mean scores of nurses' viewpoints about the effects of noise on health domains.

Area	Mean	S.D
Subjective perception Distress Inattention Inability to sleep Fright Dizziness	16	4.3
Emotion Communication problems Scalp tingling Ill temper Irritability Tension	15.65	4.95
Physiology Tachycardia Tinnitus Headache Fatigue Loss of appetite	16.1	4.8
Performance Decreased productivity Concentration problem Disobedience Carelessness Auditory masking	14.9	5.25

Table 4
The relationship between mean scores of four health domains and the quantitative variables (individual and clinical).

	r*	P
1) Emotion		
Age	0.001	0.995
Work experience	0.035	0.671
Work experience in ICU	0.149	0.071
Number of Bed	0.244	0.003
Bed occupancy rate	0.379	0.0001
Overtime hours	−0.092	0.268
2) Performance		
Age	0.049	0.558
Work experience	0.104	0.207
Work experience in ICU	0.168	0.041
Number of Bed	0.153	0.064
Bed occupancy rate	0.250	0.002
Overtime hours	− 0.011	0.899
	r**	P
3) Subjective perception		
Age	−0.045	0.584
Work experience	−0.041	0.622
Work experience in ICU	0.042	0.615
Number of Bed	0.166	0.044
Bed occupancy rate	0.246	0.003
Overtime hours	−0.011	0.898
4) Physiology		
Age	−0.024	0.775
Work experience	−0.017	0.833
Work experience in ICU	0.128	0.121
Number of Bed	0.227	0.006
Bed occupancy rate	0.402	0.0001
Overtime hours	−0.091	0.271

* Parameters Spearman correlation.
** Parameters Pearson correlation.

Table 5
The relationship between mean scores of four health domains and the qualitative variables (individual and clinical).

Variables	Emotion		Performance		Subjective perception		Physiological	
	mean ± SD	P	mean ± SD	P	mean ± SD	P	mean ± SD	P
Gender								
Female	15.57 ± 4.96	0.368*	14.84 ± 5.19	0.874*	15.59 ± 4.31	0.277***	16.05 ± 4.08	0.611***
Male	17.29 ± 4.50		16.14 ± 6.69		17.71 ± 4.27		17.00 ± 5.13	
Marital status								
Single	15.79 ± 4.90	0.677*	15.32 ± 4.50	0.324*	16.02 ± 4.02	0.935***	15.58 ± 4.35	0.336***
Married	15.57 ± 4.99		14.67 ± 5.64		15.96 ± 4.49		16.38 ± 5.03	
Education								
Bachelor	15.51 ± 4.88	0.311*	14.75 ± 5.19	0.150*	15.90 ± 3.28	0.476***	16.08 ± 4.78	0.907***
Master	17.25 ± 5.58		16.67 ± 5.90		16.83 ± 4.80		16.25 ± 5.24	
Job title								
Head nurse	13 ± 3.32	0.141*	14.86 ± 2.79	0.782*	12.57 ± 2.23	0.032***	12.71 ± 3.45	0.056***
Nurse	15.78 ± 4.98		14.91 ± 5.35		16.15 ± 4.32		16.26 ± 4.80	
Work shift								
Fixed shift	16.25 ± 4.40	0.451*	17.04 ± 5.19	0.024*	16.13 ± 4.06	0.858***	17.04 ± 4.67	0.292***
Rotating shift	15.53 ± 5.05		14.49 ± 5.18		15.95 ± 4.37		15.91 ± 4.82	
Kind of ICU								
General surgery	18.23 ± 5.34	0.0001**	17.42 ± 6.66	0.024**	17.68 ± 5.08	0.030****	18.52 ± 5.10	0.0001****
Neurosurgery	16.76 ± 5.31		15.00 ± 5.87		15.96 ± 5.27		18.08 ± 4.66	
Burn	13.13 ± 4.08		13.50 ± 5.16		15.31 ± 3.48		14.88 ± 4.18	
Gynaecology	13.15 ± 4.47		13.00 ± 2.61		15.85 ± 2.88		14.15 ± 4.45	
ENT	11.5 ± 3.66		12.13 ± 2.90		12.00 ± 2.78		11.25 ± 4.03	
Medical	17.12 ± 4.02		15.80 ± 4.43		16.64 ± 3.07		16.64 ± 4.10	
Open heart	14.37 ± 3.83		13.80 ± 4.13		15.17 ± 4.06		14.27 ± 3.79	

* Mann-Whitney.
** Kruskal-Wallis.
*** Independent *t*-test.
**** ANOVA.

symptoms. It is very important to pay attention to this issue in hospitals and especially in ICUs. In the present study, we evaluated the adverse effects of noise on four aspects of the nurses' health from their viewpoints. The result showed that noise has more negative effects on physiology, subjective perception, emotion, and performance, respectively.

Moreover, we assess the sources of noise according to their viewpoints. There are differences in internal and external sources of noise between our study and other studies. Ventilators and staff were reported as the major noise sources in studies conducted at Mashhad and Qom hospitals(Heydari et al., 2014). According to another study, ventilators, infusion pumps, and cardiac monitoring devices were the major sources of noise (Khademi et al., 2011); however, Juang et al. (2010) reported the staff, trollies, and visitors as the primary external sources(Juang et al., 2010). Otenia et al., (2007) almost have the same findings as Juang that much of the noise in ICUs are from the equipment and conversation between hospital staff (Otenio et al., 2007). A systematic review of 29 studies about ICU noise indicated that different activities done in ICU (such as hand washing and using different equipment), closing doors, and falling objects are other major sources of noise. Briefly, hospital noise can be either structural (derived from different devices) or operational (created by the staff) (Kol et al., 2015).

This difference in the major noise sources between our study and others could be due to non-standard ward structure, for example, lack of one-bed cabins, waiting room for patients' families, and admission room. Another reason for the difference may be that the previous studies measured the noise level in different wards, but we only measured it in ICU.

The score of the nurses' viewpoint about the effect of noise on different study domains indicated that the highest and lowest mean scores were related to the effect on the physiology domain and the nurses' performance, respectively. This is similar to Juang's (2010) study, which indicated that the noise could affect physiological and emotional aspects of health, subjective perception, and staff performance (Juang et al., 2010). Jafari et al., (2013) evaluated the effect of low-frequency noise on mental performance, and they reported that it caused a significant reduction in concentration (Jafari & Kazempour, 2013). Some studies have shown that loud noise in the hospitals, in addition to physiological and psychological effects, increases the error rate in the staff, especially the nurses (Hodge & Thompson, 1990; Murthy, Malhotra, Bala, & Raghunathan, 1995). It can be concluded that unlike previous studies, in our study the effect of noise on the nurses' performance was found to be the lowest. To explain this difference, it could be stated that the physiological effects of the noise are revealed with shorter exposure to the noise, but when the noise persists for a long time, it may affect the performance, resulting in lower performance quality.

The findings show direct relationships between emotional effect of the noise and the number of beds in each ward, as well as the emotional effect of the noise and bed occupancy rates. In other words, the higher the number of active beds and the patients are in ICU, the higher level of noise exist due to the more use of devices and higher number of staff required. Also, a correlation was found between the performance domain's scores and work experience in ICU; and the performance domain's scores and bed occupancy rate. In fact, noise has more effects on the performance of more experienced ICU nurses and also the nurses who work in ICUs with more beds. The study of Kooshanfar et al. (2016) showed a relationship between the average sound and bed occupancy rates (Kooshanfar et al., 2016). Juang et al. (2010) showed that noise has more effect on the emotion domain and the performance of the

personnel with more than five years of experience (Juang et al., 2010). Therefore, it could be concluded that ICU is one of the demanding units to work in; and longer work experience in these noisy wards may affect on the staff's performance.

The present study indicates a correlation between subjective perception and physiological effects of noise with the number of beds and also with bed occupancy rate. It seems that higher occupancy rates and number of hospitalized patients result in much more noise in the ward, affecting the nurses' health (subjective perception and physiology). The reason for this finding may be that our study was conducted in ICU where the bed occupancy rate is high, and staff shortage is compensated by overtime working. The studies previously mentioned are not found to evaluate these correlations.

Our findings show a correlation between the scores of emotion domain and the type of ICU, and also between the scores of performance domain and the type of work shift. In other words, the greatest and lowest effect of noise was seen in fixed and rotating shifts, respectively. Khademi et al. (2011) also reported that internal ICU was the noisiest ward (Khademi et al., 2011), indicating that the staff working in crowded wards, full of terminally ill and multiple trauma patients, are emotionally more vulnerable to noise and their performance is more influenced, causing more errors in their tasks. Moreover, noise has more adverse effects on the performance of the staff who had fixed shifts. Since most staff on fixed shifts work in the morning and the noise level is higher at that time, it may be stated that the effect of noise is more noticeable among this particular group of staff.

Our findings demonstrate a relationship between the score of subjective perception and the type of ICU and between the score of subjective perception and job title; in other words, noise had greater effects on subjective perception nurses compared to head nurses. Furthermore, there was an association between the physiology domain score and the type of ICU.

5. Conclusions

Our study shows that noise in the workplaces such as ICU not only has adverse effects on the staff's performance but also on their physiology, emotion and subjective perception. Due to these adverse effects, we believe that appropriate strategies should be designed to reduce noise levels (through using intact or proper equipment, silent ventilation systems, sound insulators in walls, etc.). Also, new sections should be considered in hospital construction guidelines and standards for controlling noise in ICUs. In addition, educational workshops are required to enhance the staff's knowledge of noise control and management. Furthermore, due to the importance of noise management by authorities, their performance in this regard should be evaluated in future studies.

6. Limitations

One limitation of this study is that determining the effect of noise on the physiological domain of nurses' health could not be evaluated by a questionnaire precisely. So it's better this effect be assessed by some biological index of the human body, showing physiological distress, in future studies. Since this study was only conducted on the nursing staff, it is suggested that the effect of noise on the patients be evaluated in other studies. The bias in our study was information bias, where the nurses might answer the questions in a way that was acceptable for the researchers.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This paper is the result of MSc thesis, approved by the Ethics Committee of GUMS, Rasht, Iran (ethics code: IR.GUMS.REC.1394.53). The authors would like to thank the Research and Treatment Vice Chancellors of Guilan University of Medical Sciences, School of Health, Social Determinants of Health Research Center of Rasht Shahid Beheshti School of Nursing and Midwifery, head nurses, educational supervisors, nurses, and ICU staff of all above hospitals for their sincere cooperation.

References

Al-Tarawneh, O. M., D'emeh, W. M., & Yacoub, M. I. (2020). An assessment of nurses' knowledge regarding noise in intensive care units in Jordan. *International Journal of Africa Nursing Sciences, 12*, Article 100183.

Andrade, K. P., Oliveira, L. L. A.d., Souza, R.d. P., & Matos, I. M. D. (2016). Noise level measurement and its effects on hospital employees based on complaint reports. *Revista CEFAC, 18*(6), 1379–1388.

Basner, M., Babisch, W., Davis, A., Brink, M., Clark, C., Janssen, S., & Stansfeld, S. (2014). Auditory and non-auditory effects of noise on health. *The Lancet, 383*(9925), 1325–1332.

Bench, S., & Brown, K. (2011). *Critical care nursing: Learning from practice*. John Wiley & Sons.

Busch-Vishniac, I. J., West, J. E., Barnhill, C., Hunter, T., Orellana, D., & Chivukula, R. (2005). Noise levels in Johns Hopkins hospital. *The Journal of the Acoustical Society of America, 118*(6), 3629–3645.

Clark, C., & Paunovic, K. (2018). WHO Environmental noise guidelines for the European Region: A systematic review on environmental noise and quality of life, wellbeing and mental health. *International Journal of Environmental Research and Public Health, 15*(11), 2400.

Cunha, M., & Silva, N. (2015). Hospital noise and patients' wellbeing. *Procedia-Social and Behavioral Sciences, 171*, 246–251.

Darbyshire, J. L. (2016). Excessive noise in intensive care units: British Medical Journal Publishing. *Group*.

Darbyshire, J. (2019). Noise in the intensive care unit: Where does it come from and what can you do about it? *ICU Management & Practice, 19*(2).

Delaney, L., Litton, E., & Van Haren, F. (2019). The effectiveness of noise interventions in the ICU. (1473-6500 (Electronic)).

Fallah, H., & Takhsha, N. (2013). Evaluation of noise pollution in intensive care units and emergency in hospitals of North Khorasan University of Medical Sciences. *Journal of North Khorasan University of medical sciences, 5*(2), 331–337.

Heydari, H. R., Mohebi, S., Paidari, N., Ramouz, P., Nayebi, T., Omrani, D., & Rahimifard, H. (2014). Noise exposure assessment among nurses in Qom Educational Hospitals in 2012. *Iran. QOM UNIVERSITY OF MEDICAL SCIENCES JOURNAL, 7*(6), 46–53.

Hodge, B., & Thompson, J. (1990). Noise pollution in the operating theatre. *The Lancet, 335*(8694), 891–894.

Horsten, S., Reinke, L., Absalom, A., & Tulleken, J. (2018). Systematic review of the effects of intensive-care-unit noise on sleep of healthy subjects and the critically ill. *British Journal of Anaesthesia, 120*(3), 443–452.

Jafari, M., & Kazempour, M. (2013). Review of Low Frequency Noise Effects on Mental Performance. *Journal of Health, 3*(4), 52–62.

Juang, D., Lee, C., Yang, T., & Chang, M. (2010). Noise pollution and its effects on medical care workers and patients in hospitals. *International Journal of Environmental Science & Technology, 7*(4), 705–716.

Kamdar, B. B., Martin, J. L., & Needham, D. M. (2017). Noise and light pollution in the hospital: A call for action. *Journal of Hospital Medicine, 12*(10), 861.

Khademi, G., & Imani, B. (2015). Noise pollution in intensive care units: A systematic review article. *Reviews in Clinical Medicine, 2*(2), 58–64.

Khademi, G., Roudi, M., Farhat, A. S., & Shahabian, M. (2011). Noise pollution in intensive care units and emergency wards. *Iranian Journal of Otorhinolaryngology, 23*(65), 141.

Kol, E., Demircan, A., Erdoğan, A., Gencer, Z., & Erengin, H. (2015). The effectiveness of measures aimed at noise reduction in an intensive care unit. *Workplace Health & Safety, 63*(12), 539–545.

Kooshanfar, Z., Khaleghdoost Mohammadi, T., Paryad, E., Kazemnezhad, E., & Golhosseini, S. (2016). Noise Pollution Level in Rasht Hospital's Intensive Care Units. *Journal of Guilan University of Medical Sciences, 25*(99), 10–16.

Mardomi, K., Bagheri, M., & Hasanpoor Rahimabad, K. (2012). Notice of architecture designing in decrease of noise pollution of therapeutic environments in 2003. *Mohitshenacy, 38*(4), 141–154.

Mehran, E., Sahra, V., Mohammad Asghari, J., & Akbar, G. (2017). NOISE POLLUTION AS A PUBLIC HEALTH CONCERN IN PEDIATRIC HOSPITALS: A CASE STUDY IN TABRIZ, IRAN. *Journal of Air Pollution and Health, 2*(2).

P.G. Morton D.K. Fontaine C. Hudak B. Gallo Critical care nursing: a holistic approach (Vol. 1): 2005 Lippincott Williams & Wilkins Philadelphia.

Morton, P. G., Fontaine, D., Hudak, C., & Gallo, B. (2013). *Critical care nursing: a holistic approach.10th Ed*: Lippincott Williams & Wilkins.

Murthy, V., Malhotra, S., Bala, I., & Raghunathan, M. (1995). Detrimental effects of noise on anaesthetists. *Canadian Journal of Anaesthesia, 42*(7), 608.

Otenio, M. H., Cremer, E., & Claro, E. M. T. (2007). Noise level in a 222 bed hospital in the 18th health region-PR. *Revista brasileira de otorrinolaringologia, 73*(2), 245–250.

Potter, P. A., Perry, A. G., Stockert, P., Hall, A., Astle, B. J., & Duggleby, W. (2018). *Canadian Fundamentals of Nursing-E-Book*: Elsevier Health Sciences.

Pugh, R. J., Jones, C., & Griffiths, R. (2007). *The impact of noise in the intensive care unit Intensive Care Medicine* (pp. 942–949). Springer.

Rabiyan, M., & Gharib, M. (2004). Noise pollution in the oprating rooms and intensive care units. *Quartery Teb Va Tazkieh, 51*, 50–56.

T. Sahoo M. Joshi S. Madathil A. Verma M. Sankar A. Thukral Quality improvement initiative for reduction of false alarms from multiparameter monitors in neonatal intensive care unit Journal of Education and Health Promotion 8 1 2019 203 203 10.4103/jehp.jehp_226_19.

Salandin, A., Arnold J Fau – Kornadt, O., & Kornadt, O. (2011). Noise in an intensive care unit. (1520-8524 (Electronic)).

Simons, K. S., Verweij, E., Lemmens, P. M., Jelfs, S., Park, M., Spronk, P. E., & Kohlrausch, A. G. (2018). Noise in the intensive care unit and its influence on sleep quality: A multicenter observational study in Dutch intensive care units. *Critical Care, 22*(1), 250.

Tirgar, A., Koohpaei, A., Allahyari, T., & Alimohammadi, I. (2007). *Occupational health. AndisheRafe Publisher, 125*, 102.

Tsara, V., Nena, E., Serasli, E., Vasileiadis, V., Matamis, D., & Christaki, P. (2008). Noise levels in Greek hospitals. *Noise and Health, 10*(41), 110.

White, B. L., & Zomorodi, M. (2017). Perceived and actual noise levels in critical care units. *Intensive and Critical Care Nursing, 38*, 18–23.

Yarar, O., Temizsoy, E., & Günay, O. (2019). Noise pollution level in a pediatric hospital. *International Journal of Environmental Science and Technology, 16*(9), 5107–5112. https://doi.org/10.1007/s13762-018-1831-7