“Noise Factory”: A Qualitative Study Exploring Healthcare Providers’ Perceptions of Noise in the Intensive Care Unit

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Abstract

Objectives: This study aimed to explore healthcare providers’ perceptions of noise in the intensive care unit (ICU).

Design: A qualitative exploratory study was conducted using group interviews.

Setting: The setting comprised a total of 15 participants (five physicians and ten registered nurses) working in an 18-bed medical surgical ICU at a teaching hospital in Istanbul, Turkey. Semi-structured questions were formulated and used in focus group interviews, after which the recorded interviews were transcribed by the researchers. Thematic analysis was used to identify significant statements and initial codes.

Findings: Four themes were identified: the meaning of noise, sources of noise, effects of noise, and prevention and management of noise. It was found that noise was an indispensable feature of the ICU. The most common sources of noise were human-induced noise. It was also determined that device-induced noise such as alarms did not produce a lot of noise however, when staff are too late to respond to the alarms, the sound transforms into noise. Furthermore, it was observed that the precautions to decrease noise level taken by ICU staff had only a momentary effect, and nothing changed in the long-term. Because the whole team

did not implement these initiatives consistently. Majority of nurses stated that they were now becoming insensitive to the noise due to constant exposure to device-induced noise.

Conclusion: The data obtained from this study showed that especially human-induced noise in the ICU threatened healthcare providers' cognitive task functions, concentration, and job performance, impaired communication, and negatively affected patient safety. In addition, it was determined that any precautions taken to reduce noise were not fully effective. A team approach should be used in managing noise in ICUs with better awareness.

Key words: Noise, intensive care, healthcare providers, nursing

Introduction

Intensive care units (ICUs) are complex and noisy environments where large numbers of healthcare providers work and where a variety of highly technological medical devices are used. In recent years, noise levels in ICU environments and the impact of noise on both patients and healthcare providers have become important issues.(Konkani, Oakley, & Penprase, 2014)

Studies have shown that ICUs have higher noise levels than those recommended by scientific institutions (Kim & Van den Berg, 2010; Kinstler et al., 2015). The World Health Organization (WHO) suggests that the background mean noise level in hospitals should not exceed 35 dB and the overall noise profile should be less than 40dB at night (Padmakumar, Bhasin, Wenham, & Bodenham, 2013). In order to protect patients and healthcare providers from the negative effects of noise, the International Noise Council recommends that noise levels in hospitals should not exceed 45 dB during the day and 35 dB during the night.(Kurmann et al., 2011; Liu & Tan, 2000) Studies have stated that the most common sources of noise in the ICU were conversations among staff, management of alarms, and frequent patient rounds and patient admissions (Kol, Aydın, & Dursun, 2015; Konkani et al., 2014; Lawson et al., 2010). One study reported that the mean noise level in the ICU was 57 dB and that the main sources for noise were conversations between staff during patient rounds and the equipment alarms. Another study found that conversations among staff caused a noise level of 84.1 dB and that alarms, such as the IV pump, cardiac monitor, pulse oximeter, and mechanical ventilator, caused noise levels between 75 and 83.2 dB (Kol et al., 2015; Stafford, Haverland, & Bridges, 2014).

In the literature, although there are limited studies investigating the effects of noise on ICU staff, existing studies have emphasized that staff are at risk of hearing loss, anxiety, stress,

burnout, fatigue, decreased job concentration and performance, reduced attention, and impaired judgment due to the constant exposure to high levels of noise (Kinstler et al., 2015; Ryherd, Okcu, Ackerman, Zimring, & Persson, 2012). As a result, many medical errors and patient safety concerns have increased within ICUs (Choiniere, 2010; Kol et al., 2015; Konkani et al., 2014; Morrison, Haas, Shaffner, Garrett, & Fackler, 2003). In meta-analysis, it was found that there was a relationship between high rates of burnout among healthcare providers and worsening patient safety (Garside et al., 2018). One study also found that modifiable risk factors in the ICU environment were related to the intention to leave the job (Swamy et al., 2019). Therefore, identifying the sources of noise and preventing noise in the ICU are important in order to increase patient safety, decrease medical errors, and provide a healthy work environment for staff. It was specified that some noise reduction strategies were effective in the short-term only (Garside et al., 2018). Some older literature has discussed environmental noise in the ICU as reported by patients, such as staff activities, medical equipment, air-conditioning, bin lids slamming (Ryherd et al., 2008). Although the noise in hospitals is often a complaint among patients (Baker, 1984; Ryherd et al., 2012) the pool of research on the noise from the healthcare professional's point of view remains limited. Despite the presence of quantitative studies about noise, its effects, and possible solutions, there are none on the perceptions and real-life experiences of ICU staff regarding noise. Detailed information about these experiences will help in developing effective and reliable long-term solutions, improving patient safety concerns, and supporting providers' psychological health. This study provides new insight into the causes and effects of noise and recommendations for preventing noise in ICUs. Therefore, the aim of this study was to explore healthcare providers' perceptions of noise in the intensive care unit (ICU).

METHODS

Study design

This qualitative study considered the Consolidated Criteria for Reporting Qualitative research (COREQ) tool (Tong, Sainsbury, & Craig, 2007). The study used a focus group approach in order to gain a holistic understanding of the perceptions of both nurses and physicians regarding noise in the ICU because they were mostly suffered from noise in the unit. A focus group is a technique involving the use of in-depth group interviews in which participants are selected because they are a purposive, sampling of a specific population, this group being focused on a given topic (Rabiee, 2004). Participants in this type of research are, therefore, selected on the criteria that they would have something to say on the topic, and would be comfortable talking to the interviewer and each other (Richardson and Rabiee, 2001). In this study, subjects are selected because of their knowledge of the study topic (Burrows & Kendall, 1997). One of the distinct features of focus-group interviews is its group dynamics, hence the type and range of data generated through the social interaction of the group are often deeper and richer than those obtained from one-to-one interviews (Thomas et al., 1995). This method creates an informal atmosphere for participants to discuss the topic more freely (Bloor, 2001) and also provides more interaction among participants, unveiling differing opinions and new areas for debate (Reed & Payton, 1997).

Setting and sample

This study collected data from four focus groups in one university hospital in Istanbul, Turkey with an 18-bed medical surgical ICU. The study was conducted from November 2017 through February 2018 in an ICU in which 35 nurses work in 2 shifts. There are eight intensivists working in the ICU. Each shift there are eight nurses and four physicians work in ICU. The intensive care unit consists of 18 separate patient rooms. Each room has automatic glass doors. The doors are generally closed however, patient can call for help via a ring and light signal. Some nurses prefer to keep doors opened in order to hear alarms easily especially in sedated and intubated critically ill patients. When nurses need a help within a patient room,

they can use a ring and light signal. However, if they are outside of the room, they usually seek help by shouting at each other. Monitor technicians follow all patients' monitor and rhythms from the central desk, which is located in the middle of the unit. The nurse: patient ratio is 1:2.

Purposive sampling was used to collect the data. The ICU included in the study was chosen specifically because staff had consistently reported being affected by high levels of noise.

Participants and recruitment

The inclusion criteria were as follows: working as a bedside nurse or physician in the ICU of the hospital. A convenience sample of ten RNs were divided into three focus groups and five MDs in one focus group, for a total of fifteen ICU staff from two different professions. The participants had 2–5 years of experience both in their profession (40%) and in the existing ICU (53.3%) (Table 1). In order to facilitate themes between and across groups, researchers were careful to collect sufficient data from each participant. Because data analysis is commonly conducted across groups of the same participant type (Halcomb, Gholizadeh, DiGiacomo, Phillips, & Davidson, 2007), researchers selected four focus groups. Sampling was provided until the point of data saturation.

Data collection

In this study semi-structured questions were used and interviews were conducted with purposively selected sample and analyzed via thematic analysis. One researcher (PG), who was a professor in psychiatric nursing, facilitated the four-focus group face-to-face interviews in the ICU meeting room. In order to create a safe environment for free discussion, the researcher indicated to the participants that the discussion would focus solely on participants' opinions about their experiences and any obstacles they experienced in a noisy environment

as well as their ideas for any possible solutions to decrease noise levels. To acquire a deeper understanding of those experiences, follow-up questions were asked about the topics and themes that the interviewees introduced during the conversation (Kim et al., 2017). Participants were encouraged to speak freely and to respect each other's opinions during the sessions. After providing a brief introduction, another researcher recorded the audio in each session. The duration of each interviews was 45 min. The researchers used existing literature to formulate the five, semi-structured interview questions (Table 2). The number and order of the questions were designed using Hurworth's triangular structure for interviews (Hurworth, 1996). During the interviews, researchers also sought clarification of meaning and further explanation from participants regarding the perceptions of noise in ICU. Interviews were undertaken by one member of the research team with field notes collected to supplement the audio recordings.

Data Analysis

Both researchers had at least five years of ICU experience. They had been working as a faculty in school of nursing. Two researchers participated in the analysis process and transcribed verbatim each of the recorded interviews and translated them from Turkish to English, after which a professional linguist and native speaker of both languages back translated the content to Turkish. Researchers completed the data-coding process using the Corbin and Strauss (2008) thematic analysis approach. Interview recordings were transcribed verbatim. The audio and word files were studied, at times simultaneously whilst making notes, as a means of familiarization and immersion with the data (Borbasi & Jackson, 2008; Casterle et al., 2012). Transcripts were then read in their entirety and relevant phrases were identified and coded. In addition, phrases in the text were reduced and organized into various common headings, allowing us to identify themes. The entire interview text was then read again, with a focus on how the nurses and physicians expressed themselves, as well as the

situations and contexts to which the coded text referred. Logically approximate statements were organized and grouped, enabling the emergence of key themes and transparency. Both authors participated in the analysis process, and the topics that were eventually made visible. Whilst a priori categories from the interview questions were used, the coding was open to capturing new discoveries, using the participants' own words to provide major themes. At the end of the data analysis four themes were identified. Participants did not provide feedback on the findings.

Ethical Considerations

This study was approved by the XXX University Institutional Review Board (2018.334.IRB3.233). The participants were informed about the study in advance and gave their oral and written permission to participate in the study.

Rigor and Trustworthiness

Initial data analysis was undertaken independently by each researcher. As recommended as a way to enhance achieve dependability and credibility (Holloway & Freshwater, 2007) results were then discussed until reaching a consensus on the main themes.

RESULTS

Four themes were identified from the interviews: the meaning of noise, sources of noise, effects of noise, and prevention and management of noise.

Theme 1: Meaning of noise

Some of the participants defined noise as a cacophony of sounds which was unnecessary and at a higher volume than they were accustomed to. They stated that the noise was caused by the combination of sounds from both humans and electronic devices.

“One of my patients asked me, ‘Is this an intensive care unit? This is a noise factory!’ Actually, he said how much he was affected from this confusion of sounds.” (MD-9)

Some participants defined the noise as a high-volume human sound that prevented other sounds needing to be heard. One participant likened the noise to a meaningless sound beam caused by human speech that was unnecessary and loud.

“An ICU is a loud environment. However, the ambient sounds should be minimal, and any unnecessary sounds (human voices) need to be low in order to hear the necessary sounds (device sounds). These unnecessary sounds also cause a perception of noise.” (RN-15)

Some participants stated that noise was an indispensable feature of the ICU.

“Since it is a very busy, crowded, and large environment, noise is indispensable in an ICU.” (RN-3)

“For example, a patient comes with a team of ten people. They all come together for one patient and talk in the same room. This makes noise inevitable.” (RN-1)

Theme 2: Sources of noise

The participants stated that the noise in the ICU was caused by the staff, medical devices, and overall work environment.

Staff-induced noise: Most participants stated that the most common sources of noise were from those speaking loudly, laughing, and shouting or from those asking for the help of ICU staff. Other sources included staff not paying attention to the volume of their voice, late responses to silencing device alarms, high numbers of staff within the unit, talking on cellphones, keeping personal cellphone sounds on, setting device alarms at high volumes, and lastly, patient rounds by the entire team.

“We have a lot of communication errors, and we are trying to shout down the corridor. There is a constant need and urgency to request something by shouting.” (RN-2)

“The doctor shouts ‘What are the patient’s vital signs in room number 4?’ Meanwhile, other people are talking, so the doctor does not hear the answer and repeats the question again.” (RN-12)

“The healthcare staff, who come to the unit from outside, can’t adjust their voices, also. Nobody talks like I’m speaking, in a low-level voice.” (MD-9)

“A lot of students from the schools of nursing and medicine are here too. As the number of people increases, the noise increases.” (RN-11)

Device-induced noise: Participants stated that device alarm sounds were inevitable, and that device-induced noise was often caused by alarms that were not turned off or muted. They emphasized that these alarms did not actually produce a lot of noise, therefore, on the contrary, they need to hear them. However, when staff are too late to respond to the alarms, the sound transforms into unnecessary noise. According to the participants, the devices that produced the highest volume of noise were cardiac monitors, mechanical ventilators, IV pumps, perfusors, patient call button, hemofiltration, and dialysis devices, respectively.

“We need to hear alarms anyway. The trouble is when we ignore them. The alarm has to be a disturbing sound, so we can be alerted and respond it.” (MD-4)

“Alarms are meant to be heard. But when alarms continue for a long time, it becomes noise.” (MD-6)

“Alarms warn me about changes in the patient situation. It says, ‘Take action, there is something going wrong.’ So, I should hear these sounds.” (RN-13)

“If we lower the sound of human voices and respond to alarms on time, the devices don’t actually make that much noise.” (RN-1)

Environment-induced noise: Some participants stated that the sound of the care interventions (endotracheal aspiration, etc.), the overcrowded environment, and high patient circulation are the sources of environment-related noise.

“We have at least 3–4 patient admissions within a day. During a new patient admission or discharge, the team unites and talks loudly.” (RN-11)

“Every staff and their work are absolutely necessary. But I think how sufficient our insulation system is has to be questioned first.” (MD-7)

Theme 3: Prevention and management of noise

Participants said they took some precautions to prevent or reduce noise caused by people or devices. They specified that some of these precautions were effective in the moment, while others said they did not work. Some participants indicated that interventions such as silencing alarms before attempting to take an arterial blood gas sample and tracheal aspiration, adjusting the alarm limits according to the patient’ condition, discussing the handing off of a patient outside of the room, did not completely eliminate all noise. However, because the whole team did not implement these initiatives consistently, they were only effective at the moment.

“Setting alarm limits for the patient reduces the noise level by half.” (RN-14)

“We cannot prevent the alarms, but we can decrease their sound.” (MD-4)

“The alarms are signaling to get up and go. You will go and silence it.” (RN-15)

“Sometimes device sounds cannot be prevented. We may respond too late due to high patient circulation.” (RN-3)

ICU staff made suggestions for effectively managing the sounds of these devices. They specified that the staff should increase their awareness in prioritizing the response to alarms, silencing them as soon as possible, and setting alarm limits.

“We cannot eliminate alarms, but we can increase our awareness.” (RN-2)

“We must pay attention to stopping unnecessary alarm sounds. We must first turn them off and then continue.” (RN-1)

“The IV pump’s alarm goes off. The nurse is actually near the patient. However, she is insensitive to the sound or ignores it. Somehow, if staff are warned, sounds will be further reduced.” (RN-3)

Some participants indicated that in cases of human-induced noise, they often warn individuals to lower their volume. However, sometimes it is hard to control this in an overcrowded environment.

“If nurse or doctor is chatting and listening to music from the phone, my warning works.” (RN-11)

“I say to the doctors to use sign language because they won’t understand me in a crowded environment anyway. I can understand by sign. I think that although everyone experiences this, it is not known who really adjusts their voice level and how while speaking.” (RN-1)

Some of the participants stated that their attempts to prevent noise were useless and ineffective. For the prevention of device-induced noise, when the number of patients is high and the team is new, encouraging a colleague to silence alarms or adjust the alarm limit according to the patient’s condition did not work. Furthermore, they specified that performing these interventions by just a few staff also had no effect since the whole team did not act

consistently. Particularly, if one of the patients needed attention, they could not turn off another patient's alarms immediately because nurse to patient ratio was not 1:1.

For the prevention of human-induced noise, participants stated they could use a separate room (instead of the common area) if the team members needed to discuss patients or talk on the telephone. However, these interventions had only a momentary effect, and nothing changed in the long-term.

"We say, 'Do not wait a long time when the alarm goes off, turn it off immediately.' But it has only a slight effect." (RN-15)

"If the origin of the noise is human, we warn, but this does not always work. In the long run, there is absolutely nothing we can do, it just effective for an instant." (RN-12)

"I may warn my friend. And the moment that I lower his voice, the door opens and a team from a different branch or cafeteria worker comes into the ICU." (RN-14)

"There are things that can be done for the sounds of both the devices and people. We do them, but they don't work." (RN-1)

Some participants stated that all ICU staff should make more efforts to prevent noise and that everyone should behave consistently, otherwise noise could not be controlled. Some of them indicated there was nothing they could do to prevent noise.

"Everyone should be in the same mind and act similarly. If an alarm is ringing in the next room, they won't solve the problem, because they think that the patient is not under their responsibility." (RN-9)

"Reducing the number of people is never a solution because we need all of them. People need to speak with a little more control." (MD-4)

“The area is very large and we often need to call for help by shouting to others. Maybe we can warn ourselves more as a team, and maybe we can handle this work without needing that person to warn us.” (RN-3)

“I have never tried to do anything as a radical solution for noise other than warning people and getting away from it.” (MD-7)

It is seen that the participants’ suggestions for the prevention of both human- and device-induced noise in the ICU are the effective management of device alarms, behavioral changes, and increased awareness of ICU staff and development of regulations. Physicians and nurses also stated that the following behavioral changes and precautions could be taken to contribute to the reduction of noise: muting all cellphones (with the exception of DECT phones for blue codes), moving closer together to talk instead of shouting from a distance, consistently warning those speaking loudly, keeping staff in the patient room, directing any care team to a separate area, and conducting patient visits efficiently within specified time periods. In addition, they also indicated that environmental installations, such as sound insulation, could help prevent bothersome noises.

“Five doctors should be prevented from informing and speaking to the patient and relatives all at the same time.” (RN-15)

“Fifteen people come in with one patient. We could select only those who will take care of the patient directly and remove the others from the room.” (RN-1)

Theme 4: Effects of noise

Regarding the effects of the noise, both the nurses and doctors stated that noise caused serious distractions and prevented them from focusing on their work. Especially physicians indicated that when they needed to make decisions about the patient, noise negatively affected their ability to think clearly and made decision-making difficult.

“I feel I have lost my ability to think. After entering an empty room, closing the door, standing there calmly for a moment, or after reducing the sound by warning people in the environment, I can then think about what I should do for the patient.” (MD-7)

“I get tired because I spend a lot of energy concentrating.” (MD-5)

“I want to eliminate the noise as soon as possible. I can’t do what I want to, so the sound makes me restless.” (RN-9)

The participants stated that noise increased the probability of making mistakes, made it difficult to focus on their responsibilities properly, and caused forgetfulness and difficulties in doing or completing what they had intended.

“It affects me negatively, I am very distracted, I cannot concentrate and complete my work... maybe it can cause us to make mistakes.” (MD, 7)

More than half of the nurses stated that because they were constantly exposed to the device-induced noise, they were now becoming insensitive and accustomed to the noise, which poses a great danger to patient safety. On the other hand, the nurses working in ICUs for more than 5 years years stated that their sensitivity to device sounds increased and that they were more aware of the alarms.

“I have been working here for six months. The first three months were very noisy. Because I started working in the environment for the first time, the sounds disturbed me much more. Now my level of tolerance has increased, and I got used to the noise over the last 3 months. Even if my phone rings, I don’t hear it at all.” (RN-13)

“The development of an insensitivity in ICU staff to noise is a huge risk for the patient.” (RN-14)

Apart from the doctors, nurses stated that the noise in the environment caused irritability and that they often experienced burnout, restlessness, emotional depression, and a great deal of fatigue.

“I feel emotionally drained. I have severe headaches. I can’t sleep at night and feel really tired. I’m stressed out.” (RN-10)

“Noises echo in my brain, and I personally cannot tolerate device noise. It affects me badly and irritates me.” (RN-2)

Some nurses stated that they did not realize the effects noise had on their psychology and that they intended to change departments or retire early because of the negative psychological effects.

“Noise is an undetected reason for requiring an early retirement or department change.” (RN-9)

“After realizing the effects of the noise on me, I can’t really work in this unit anymore ... but also I think about retirement at a young age. Why is there no payment for frazzlement in our profession?” (RN-14)

Participants stated they preferred to move away from the noisy environment, go to a quiet and calm environment, not talk to the people around them, and rush even when talking on the phone in order to cope with the negative effects of noise. Some participants also said that they tried to cope with similar practices outside the hospital.

“I don’t want to talk with my family on the phone after work. I keep my phone on a low volume, speak shortly, and keep it away if possible.” (RN-15)

“I don’t prefer to go to crowded and closed areas after work. I always choose more open and quiet places. We do not turn on the television at home as I want to relax.” (MD-7)

“When I go home after work, even though I have a plan to go out, I do not want to leave the house when I see the calm environment. I give up from my plan and try to relax.” (RN-14)

DISCUSSION

The therapeutic environment of the ICU is often disturbed by human- and device-induced noise (Watson et al., 2015). In this study, four themes illustrated the perceptions and experiences of healthcare staff regarding noise, which are key to helping reduce noise and creating permanent solutions.

Noise can be defined as any undesired sound or combination of sounds, which can have negative psychological and physiological effects (Choiniere, 2010). In this study, both nurses and physicians defined noise as sound confusion that was unnecessary and at high volumes and often blocked out important sounds, like alarms. On the other hand, participants stated that noise was a natural and indispensable part of the ICU environment due to the continuous patient circulation and the busy environment.

In ICUs, over 50% of noise is generated by speech and human activities (Akansel & Kaymakçi, 2008) and the main source are the conversations and raised voices of staff (Darbyshire, Müller-Trapet, Cheer, Fazi, & Young, 2019; Fillary et al., 2015; Garside et al., 2018; Kol et al., 2015; Stafford et al., 2014). Furthermore, general care practices, patient monitorization, patient mobilization, overhead pagers, telephones, trolleys, doors, traffic in corridors, and footsteps contribute to the environmental noise level and are associated with high noise levels (Honan et al., 2015; Kol et al., 2015; Waye, Elmenhorst, Croy, & Pedersen, 2013; Yoder, Staisiunas, Meltzer, Knutson, & Arora, 2012). Participants highlighted that alarms would always be heard due to the nature of the ICU and that these kind of sounds did not cause the perception of noise. However, if the alarm were not silenced by the nurse or doctor and continued, it became noise. The alarms stimulate the ICU team in order to provide

necessary intervention for the patient on time. Some studies determined that the response time to alarms increased as the frequency of alarms increased (Bonafide et al., 2015; Funk, Clark, Bauld, Ott, & Coss, 2014; Honan et al., 2015). While staff hear the alarms, the response to them may be prolonged, which brings up the issue of patient safety. Therefore, effective alarm management, which is accepted as a patient safety goal by the Joint Commission (JCI) (2019), is not only important for noise reduction but also essential for patient safety. JCI also recommends that staff behaviors be evaluated, and staff be provided with alarm management strategies in order to prevent medical errors and provide patient safety. It is seen that the most important factor in the occurrence of both human- and device-based noise is the ICU staff itself. Thus, constant noise reduction strategies adopted by the whole ICU team are needed.

This study observed that verbal warnings to prevent human-based noise did not work in cases when employees were speaking loudly, shouting to others, or talking on the telephone within the unit. In order to prevent noise caused by devices, it was found that some staff silenced the alarm at the source as soon as possible or before any patient interventions or reset the alarm limits according to the patient's status. A few participants stated that in the case of prolonged alarm noise, they gave warning to the responsible nurse to respond. However, it is seen that any individual prevention strategies taken by ICU staff for both human- and device-induced noise were only temporarily successful or ineffective in the long-term, and sometimes even not effective at all. In addition, when the number of patients was high or the majority of team members were new, interventions did not work. Furthermore, a short-staffed and busy environment did not allow staff to notice and respond to multiple patient alarms.

In the literature, some strategies, such as training programs for behavioral modification and noise awareness, quiet-time protocols, and environmental modifications, have been recommended to reduce human-induced noise (Garside et al., 2018; Gathecha et al., 2016; Murphy, Bernardo, & Dalton, 2013; Wilson, Whiteman, Stephens, Swanson-Biearman, &

LaBarba, 2017). As in previous studies, we advise similar strategies and also other human-induced noise reduction strategies, such as switching telephone ringers to quiet settings, speaking softly, avoiding loud conversations close to patients, designating specific rooms or spaces in the ICU for clinical discussions, and minimizing the number of caregivers at the bedside.

For device-induced noise, participants stated that they actually wanted to hear the alarms as this is very important for the patient's care and safety. However, if the alarms are not managed consistently by all team members, the alarms turn into noise and may go unnoticed. Previous studies have mentioned that all interventions employees try to implement to prevent device-induced noise are those suggested in previous studies (Sendelbach, Wahl, Anthony, & Shotts, 2015; Whalen et al., 2014). It is clear that strategies for the effective management of alarms will be effective in preventing noise, as well. However, not responding to alarms or not setting alarm limits in a consistent manner by all team members as well as a lack of behavioral and organizational regulations increase noise in the environment (Cvach, 2012; Li & Gretzinger, 2015). Behavioral and organizational protocols for alarm management prevents employees from becoming insensitive due to repetitive alarms without compromising patient safety and provides more effective management of unnecessary alarm noise. Alarms should be heard within a reasonable range and should be determined by the nurse at the bedside according to the patient's condition. Controlling alarms (learning how to respond and turn them off properly) should be explicitly addressed in organizational protocols. Furthermore, nursing protocols for responding to alarms should be developed to be congruent with the nurses' experiences (Varpio, Kuziemy, Macdonald, & King, 2012). It was specified that modifying alarm limits positively affected the care providers' experience and satisfaction and provided better patient care (Shanmugham, Strawderman, Babski-Reeves, & Bian, 2018). One study found that administrative controls were able to reduce the number of physiologic

monitor alarms in a medical progressive care unit by 43% without compromising patient safety (Graham & Cvach, 2010).

A wide variety of interventions was used across studies, precluding the comparison of the effectiveness of different types of interventions. Researches emphasized that such initiatives as training for behavior modification in ICUs could be effective in reducing noise levels (Connor & Ortiz, 2009; Dennis, Lee, Woodard, Szalaj, & Walker, 2010; Dube et al., 2008; Ramesh et al., 2009). However, one systematic review concluded that among all noise reduction strategies, there was no single method tested nor effectiveness proven (Garside et al., 2018). Another study found that behavior modification programs reduced noise level; however, the reduction was still not enough for noise levels in ICUs. Therefore, technological interventions and other environmental modifications should be implemented simultaneously in order to provide a quieter environment (Garside et al., 2018; Konkani et al., 2014). We suggest developing alarm management protocols specific to each unit and the development of the educational programs regarding alarm response and management, alarm threshold values, and priority levels for ICU staff in order to provide the same approach within the unit. Additionally, regular trainings for staff and the evaluation of behaviors towards device-induced noise management will be effective in the success of the interventions.

This study concludes that common causes of human-, device-, and environment-based noise is related to human activity and that the biggest obstacle in preventing noise is that all staff do not exhibit similar management behaviors. Therefore, it is obvious that individual initiatives are not effective and that all team members need to increase their awareness about noise and demonstrate the same approach by changing behaviors. Improvements in the work environment have also been shown to improve mental health, well-being, resilience, and coping strategies of healthcare professionals (Schreuder et al., 2012).

In ICUs, strong leadership and clear communication are necessary to provide quality, multi-disciplinary care to the patient. However, high noise levels may impair communication, cognitive task functions, and altruistic behaviors of ICU staff.(Cordova et al., 2013; Patterson & Schrader, 2006) Noise is also a potential cause of stress as it increases work pressures, irritability, fatigue, emotional exhaustion and burnout, alters concentration, impairs work performance and caregiving abilities, and leads to mistakes (Morrison et al., 2003; Ryherd et al., 2012). More than 40 dB of noise raises patient safety concerns due to anxiety, staff stress, poor judgement, and a decrease in job performance and concentration in ICU staff (Choiniere, 2010; Kol et al., 2015; Konkani & Oakley, 2012; Morrison et al., 2003). Furthermore, the physical and psychological overload of staff and ineffective teamwork can also compromise patient safety and increases medication errors (García-Salido, la Calle, & González, 2019; Wang et al., 2013). Burnout and moral distress experienced by ICU nurses, affects the quality of care and leads to turnover (Whittaker, Gillum, & Kelly, 2018).

High levels of noise may make staff less sensitive to alarms and may cause them to cope improperly with significant alarms that can directly affect patients' safety (Bell, 2010). Several studies specified that ICU nurses perceived alarm sounds like ambient noise after a certain period of time; then, they became normalized and desensitized to the sound (Bach, Berglund, & Turk, 2018; Cho, Kim, Lee, & Cho, 2016; Drew et al., 2014; Ergezen & Kol, 2019). In this study, only the ICU nurses stated desensitization. The statement of the nurse with six-month of experience in the ICU regarding desensitization was quite remarkable, showing that one can be desensitized to the sounds in a short time. Actually, it is an expected result because nurses provide 7/24 patient care alongside the patient; therefore, they are mostly exposed to device-based noise. The literature highlighted that excessive alarm sounds may also cause nurses to experience alarm fatigue (Christensen, Dodds, Sauer, & Watts, 2014; Cvach, 2012; Schreuder et al., 2012). Since desensitization and fatigue related with

alarm sounds are directly linked to patient safety, efforts to manage alarms effectively can prevent potential hazardous events (Cho et al., 2016). Therefore, the well-being of both nurses and patients and high turnover of staff should be targeted with organizational interventions (Swamy et al., 2019). Interventions to reduce the long-term exposure to noise in ICUs and to prevent the desensitization experienced by healthcare staff are necessary.

Limitations

The study has some limitations. There may have been potential bias towards socially acceptable answers because the collected data were self-reported. However, we included staff from different levels, and this strategy provided valuable insight.

Conclusion

This study found that noise in the ICU threatens healthcare providers' cognitive task functions, concentration, and job performance, impairs proper communication, and negatively affects patient safety. The experiences and perceptions of ICU staff should be taken into account while developing effective noise reduction strategies in the long-term. This could also improve the mental health, well-being, resilience, and coping strategies of healthcare professionals working in ICUs.

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