

Exploring the Status and Solutions regarding Noises in a Neonatal Intensive Care Unit

Background: The incorporation of technologies for the care of the neonate lead to increasing survival; however, this change neonatal units into very noisy environments. Concerns regarding the environmental noise issue in neonatal units and an interest in developing strategies to reduce this noise have motivated researchers to do a comprehensive qualitative study to provide an opportunity for a better understanding of the situation and help improve the current situation.

Aim: This study aims to explore the status and solutions regarding noises in a neonatal intensive care unit in Turkey.

Method: This was a descriptive exploratory study with a qualitative content analysis approach that was done in 2021. 18 nurses, 4 physicians, 7 staff, and 4 mothers were selected through purposeful sampling. The data were collected through two semi-structured interviews, six focus groups, six observations as well as measuring sound sources frequency by Sound Decibel Meter. Qualitative Content Analysis was used to analyze the data by MAXQDA.

Results: Three main themes and seven major categories emerged through the data analysis. The themes were something like an iceberg, pan negative effects, and holistic modification. All recorded sound levels exceeded the recommended noise level of 45 decibels. 57% of sound sources were between 45-65 dB and 43% were more than 65 dB.

Conclusion: Result showed that the status of NICU regarding noise is like an iceberg that negatively affected all people but only a small portion of this acoustic event is evidence and most of it is neglected. However, this situation must be approach seriously by holistic modification involving environmental modification, behavioral modification, and resources management. Action research would be one possible direction for future research.

Keywords: Intensive Care Units, Neonatal, Noise, Qualitative research

Introduction:

Annually approximately 15 million neonates are born preterm in the world which is more than one in ten births (1). Neonatal intensive care unit (NICU) is a specific department for the caring of severely ill neonates who need specialized continuous treatment due to a wide range of pathophysiological problems. Using different kinds of technologies for the care of the neonates leads to increase survival; however, this turned this department into a noisy environment (2). The amount of noise in this department is related to daily activities, equipment as well as the employed therapeutics such as monitoring alarms, medical equipment mobilization, radios, conversations, ward rounds, shift changes, loudspeakers, and telephones (3). The Environmental Health Committee and the American Academy of Paediatrics established permissible levels of continuous noise during the day at 45 dB and 35 dB for the night, with a transient maximum peak of 65 dB (3). However, many studies have shown intense levels of continuous noise in NICUs (4-6).

A high level of noise exposure is a concern in the NICU since the function of the auditory system in premature neonates is still undeveloped at birth, and the most important stages of it occur during the final weeks of pregnancy (7). The physiological effects of the excessive level of noise contain increased secretions of adrenaline that may lead to variation in heart rhythm, peripheral vasoconstriction, increased blood pressure, increased oxygen consumption, and dilation of the pupils. These changes not also can affect the physiological state of the neonate but also it can affect neurobehavioral states of the neonate such as crying, irritability, agitation, disturbances in sleep patterns, and fatigue (1). Also, noise with the synergic effect of ototoxic drugs may increase the potential of sensorineural hearing loss in premature neonates (8). The prevalence of hearing deficit in neonates is between 0.1% to 0.6%, however, in those discharged from the NICU, this rate will double (2% and 4%) (9). Other long-term devastating effects are abnormal auditory evolution, language problems, altered brain growth, and attention deficit

hyperactivity disorder (8). High noise levels not only can affect neonates but also it can have negative effects on staff. Literature confirmed that high noise levels are correlated with an increased rate of errors and accidents among health care team in NICU which lead to decreased performance and increase the risk of stress-related to the work environment (10) These short and long term complications in neonates and producing problems for health care team makes it essential to identify and explore the factors that produce noise in the NICU environment, which permits modifying towards a favourable department (9).

In this regard, Cohn et al in 2015 conducted a systematic review to investigate noise levels in the NICU to see if they comply with the American Academy of Paediatrics proposed standards. Their analysis showed that noise levels in the NICU are overwhelmingly out of compliance with standards. These elevated noise levels in the NICU have the potential to cause permanent hair cell damage and possible noise-induced hearing loss. They concluded that elevated noise levels in the NICUs are a problem that must be addressed as they can cause irreversible damage to the auditory system of infants (5). In Turkey, Beken et al. in 2020 did a study to evaluate the adverse effects of noise on hearing. Their analysis showed that the advised noise levels are usually exceeded and the noise harmed the long-term hearing capacity in their cohort of infants. Hearing tests performed at the sixth month of life were adversely affected in neonates who were hospitalized in NICU (11).

To our knowledge, some studies have been conducted in several countries to address noise problems in NICU (1, 3, 10, 12, 13), however, this phenomenon has not been well studied by a qualitative approach to capture a whole picture from reality. In qualitative research, we can have a deep understanding of the situation by involving all stakeholders who have a rich experience encountering the phenomenon as well as collecting data by different approaches such as observation, interview, and focus groups (14). The first step in modifying and introducing a favourable environment is to improve our understanding of the current condition

and exploring the challenges of NICUs in our health system by qualitative research because the context is different (15). So, concerns regarding the environmental noise issue in neonatal units and an interest in developing strategies to reduce this noise have motivated researchers to do a comprehensive study in Turkey to provide an opportunity for a better understanding of the situation and help improve the current situation. Hence, this study aims to explore the status and solutions regarding noises in a neonatal intensive care unit in Turkey.

Method:

Design

The study was done using a descriptive exploratory qualitative design with a content analysis approach. Content analysis is a method to analyze verbal, visual and written data. It works as a guide and aims to provide an insight from reality to gather a complete and broad picture and description of a phenomenon. In this method, code and categories are derived from data, which help to attain a richer understanding of a phenomenon (16). Another method we used for the analysis was summative content analysis. This method is basically different from the previous one in that instead of analyzing the data as a whole, the text is usually seen as a single word and word frequency is calculated by a computer or manually (15).

Setting and participants

This study was done in the NICU of Necmettin Erbakan University hospital in Konya, Turkey in 2021. This unit consists of four sections: second level and third level NICU, and two isolation rooms. It has the capacity of 43 neonates. A total of 61 personnel including 1 head nurse, 3 physicians, 44 nurses, 5 assistances, 7 caregivers, and 1 cleaning staff works in this unit. Both units are rectangular and there is a nurse station in the middle. The study participants were selected through purposeful sampling. This method is used in qualitative research generally and helps to select information-rich participants (17). The researchers interviewed the nurses, physicians, staff who worked in NICU and had rich experience and information about this unit.

The inclusion criteria of the study were: a) working in this unit for at least 2 months, and b) being willing to participate in the study. Overall, 17 nurses (all female), 4 physicians (1 female and 3 males), 7 staff (5 females and 2 males) were selected. Also, 4 mothers who have been in NICU for about one week participated too.

Data collection

We gathered multiple sources of data such as observations, interviews, focus groups, as well as measuring the frequency of sound sources. Data collection started by observation in different shifts and different hours of the day during one month (6 observations). Observations were semi-structured and non-interventional focusing on the noises. Field notes were written during each observation. In addition, 6 focus group sessions were held with nurses, physicians, staff, and mothers. Three focus sessions with nurses (5-6 nurses in each session), one session for physicians, one session for staff, and one session for mothers. These sessions lasted for approximately 25 minutes, and the participants were informed about the time and place of the sessions in advance. The participants were asked to reflect and talk about noises, their effects, and their recommendation for improvement. Also, two in-depth interviews were conducted with the head nurses and the head of the NICU separately. A guide was prepared for covering key questions with the prompt to encourage responses. The sessions started with general questions and moved to more detailed questions according to each participant's responses. Examples of questions include the following:

1. What are your opinions about the condition of noises in your unit?
2. What are the sound sources in the NICU?
3. What is your opinion about the side effects of this noise on you and the neonates?
4. What are your suggestions for reducing the noise in the NICU?

For gathering more deep information we asked: Can you explain more? Or Can you give an example? All interviews and focus groups were conducted in a quiet location. At the end of the

interviews, the researchers thanked the participants and asked them if they would like to add something. After each session all focus groups and interviews were audiotaped and transcribed verbatim. We continue data collections until we have reached saturation it means that we gained no new information.

Finally, we prepared a checklist of sound sources based on our observations and the findings in the interview and focus groups and measured their frequency one by one, and compared them with standards. We used Sound Decibel Meter BENETECH GM1356 to measure the frequency of sound resources.

Data analysis

Conventional content analysis proposed by Graneheim and Lundman was used to analyze the data (18). Focus group sessions, interviews, observation, and field notes were transcribed after each section of data collection. At first, data were approached by being read as a whole repeatedly for a general understanding and after that read word by word to achieve immersion and derive codes. Then, we organized and grouped the codes into meaningful categories. For abstraction, the relationships between categories were clarified, and three major themes were emerged. The researcher again went back to the codes and check whether the themes fit the data. Also, a second researcher read them for further refinement. For calculating the origin of sound sources we used summative content analysis. MAXqda2 software 10.0 R250412 was used for data analysis. Also, we used Mean, standard deviation, and percentage for analyzing the frequency of sound sources and demographic data of participants.

Trustworthiness

The steps that were used to increase trustworthiness of data were: coding and categories were sent back to the participants for any recommendation. A team-based approach was established to analyze data for credibility. We had a good agreement in abstracting proces and some

disagreements were resolved by discussion. Varied experiences, peer checking, and prolonged engagement were some strategies for improving the trustworthiness (14, 19, 20).

Ethical considerations

The ethics committee of the university approved the project. Before each interview, the participants were informed about the aims of the study and that their participation was voluntary. Besides, they were told that they could quit the study at any time. No names were mentioned for confidentiality. On top of that, a consent form was signed by all participants.

Results:

The program included 17 nurses, 4 physicians, 7 staff, and 4 mothers. The nurses' and physicians' mean age was 47.2 ± 3.5 years, with a mean work experience of 16.2 ± 3.8 years.

The participants' characteristics are listed in Table 1.

Coding and analysis of the data generated three themes and seven categories and fourteen subcategories, and 367 primary codes related to this situation that is presented in Table 2. The themes were something like an iceberg, pan negative effects, and holistic modification that explained in the following section.

Something like an iceberg

The first theme that emerged from data included something like an iceberg. The categories were overt sound sources and covert sound sources. Our analysis showed that the sound sources in NICU is like an iceberg that has two dimensions of overt and covert.

Overt sound sources included sound sources that our participants noticed and said as sound sources such as human sound sources (nurses sound, neonates sound) and devices sound sources (alarm sound, ventilator sound). Approximately all of our participants mentioned these sounds as sound resources in the focus sessions and interviews. In this regard, a nurse in the second focus group said: *“Ventilator sounds, aspirator sound, pulse oximeters sound, incubators sound. There are many people in the environment, the voice of the people, the size of the*

environment. We speak loudly and shout from one end to the other. Our staff is elsewhere, we are inside. We shout to make our voices heard to them”.

Covert sound sources included sound sources that none of our participants noticed and no one pointed to these sound sources, maybe due to the normalization process, such as hospital sound sources (sound like pagers or labs elevator) and equipment sound sources (sound produced by a mineral water bottle, trolley, and pen). These sound sources were identified by our researcher's observation and her field notes. Here is an example of her field note:

Observation 4: At 2 p.m., I entered the first department and heard a rough sound of a trolley. I turned my head to the sound source and found that it was the sound of a weight trolley. Suddenly, I heard another sound. Looking and listening carefully, I understand that it was the sound of a mineral water bottle that a doctor tried to open. Just one minute after it, I heard the sound of opening and closing of a pen by a student.

Also, summative content analysis of the field notes showed that 14% of these sound sources originated from human sources, 30% originated from devices, 43% originating from equipment, and 13% originated from hospital sources. So, based on our summative content analysis of the field notes, the covert dimension of this iceberg was more prominent (56% compared to 44%). As a result, we decided to name this theme something like an iceberg.

Pan negative effects

The second theme was a pan negative effect with subcategories of overall negative effects on neonates and overall negative effects on the care team. Overall negative effects on neonates included negative physiologic and psychologic effects on neonates. Observations, as well as participants' quotes, witnessed these effects too. In this regard, a nurse in the third focus group said: *“Babies always wake up, their sleep quality is negatively affected, and developmental delay can occur with the deterioration of the diet. We have 15-20 babies near each other. One of them is crying and the others may awake or startled”.*

Or a mother said: "I am not disturbed by human voice but machines are intolerable. I try to help my baby to sleep but in this environment, it is very hard. When I go home I try to take a shower but I hear the sound of alarms constantly that are ringing in my ear". or another mother said that: "These sounds are very disturbing especially when I try to breastfeed my baby."

Here is an example of a field note:

Observation 3: Now it is 8 a.m., the department is too crowded and the nurses and doctors are busy doing handover. Everyone speaks with each other. I stand near an incubator and looking a neonate. Suddenly, two devices start alarming at the same time. Meanwhile, the neonate suddenly startled and her heart rate starts to increase."

Overall negative effects on the care team included negative physiologic effects and psychologic effects on the care team. The participants strongly believed that the NICU environment affects them negatively and decreases their level of tolerance. The following statement from the participants shows the underpinnings of these subcategories:

A nurse in the third focus group said: "I want to resign from here; I want to leave NICU. When I go home, I cannot sleep for a while due to a headache. This time I can't tolerate babies. These noises annoy me very much. "

A nurse in the fifth focus group said: "I am constantly nervous and have stress. We cannot tolerate other sounds anymore. The most important reason for our intolerance is noises in NICU. For example, our house is close to the main street. Although it is very good and the facilities are good, the only disadvantage is that there is too much mechanical noise and it is unbearable for me. I cannot tolerate any sound. I am always arguing with my husband since my tolerance level decreased".

Holistic modification

The last theme that emerged from data was a holistic modification. The categories were environmental modification, behavioral modification, and resource management.

Our participants recommended environmental modification as a solution with subcategories of changing the architect and renewing or repairing the equipment. Almost all participants highlighted the necessity of environmental changes. The following excerpt from a nurse illustrates environment modification as a solution. A nurse in the second focus group said: *"Rather than us, I think the new-born is very impressed. I think smaller halls, fewer incubators, quieter and less light is more suitable for a new-born. "* or in the second field note written by the observer *"repairing the trollies, wardrobe hinges, and changing the flooring"* were highlighted.

Another solution was behavior modification that consists of teaching the health care team and improving reactivity as subcategories. The participants acknowledge that improving the knowledge and informing the health care team about the disadvantages of noises on neonates can play a substantial role in their reactivity and their reactions. The following narrative statement described this subcategory: A staff in the interview said: *"It can be decreased with teaching, but everyone should take responsibility. I am talking about an education to take responsibility. They may not be aware of the noise. In addition to training, everyone can take responsibility and should warn each other sweetly, we work as a team."*

Improving reactivity was another solution that emerged from our data analysis. The observer's note clearly showed that being encounter with these noises for a long time may normalize this situation for them and decrease their reaction. For example: in observation 6: "It is 3 p.m. a device is alarming, a nurse checked it and then returned to the station. After 30 seconds, it starts alarming. Again and again. But the nurse didn't pay any attention. Alarming and alarming. Another nurse asked the nurse to check it again, but the nurse said that it is ok, I checked it just now, it is normal. But alarming is continuing with annoying sound."

The last solution that our data analysis suggested was resource management. This category has two subcategories of managing human and non-human resources. The data of participants and observations highlighted the importance of management in both sections of human and non-human resources in the NICU. The following field note and interviews confirmed this subcategory as a solution. The head nurse in the interview said: *“I think these devices can be renewed of course. Tomorrow, for example, we will talk to the chief physician about this. Using some ventilator is less noisy, if the central monitor is possible, the central monitor will probably have less noise since everything is seen on the screen, it will be easier to intervene for that baby. ”* or a doctor in the interview said: *“Management of human resources is very important. Increasing the number of personnel or assigning them to each department can be very helpful.”*

The Frequency of sound sources:

The frequency of sound sources and their comparison with the standard is summarized in Table 3. During observations, interviews, and focus group sessions we identified 33 sound sources. Measuring the frequency of these sources showed that the mean frequency of sound sources is 66.09 dB that is more than the standard level (45-65 dB). All recorded sound levels exceeded the recommended noise level of 45 decibels. Also, our analysis showed that 57% of sound sources were between 45-65 dB and 43% were more than 65 dB.

Table 1. Demographic Characteristics of the Participants

Groups Variables	Means ± Standard deviation
Nurses	
• Age	28.38±4.17
• Work experiences	6.5±4.77
Physicians	
• Age	37.75±1.25
• Work experiences	11.17±1.42
Staffs	
• Age	37.14±1.09
• Work experiences	6.91±6.13
Mothers	
• Age	26.25±7.36

• Time of stay in NICU (Day)	11.25±6.89
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TABLE 2. Main Theme and Related Subthemes Extracted from the Perspectives of Participants

Main theme	Categories	Subcategories
Something like an iceberg	Overt sound sources	Human sound sources
		Devises sound sources
	Covert sound sources	Hospital sound sources
		Equipment sound sources
Pan negative effect	Overall negative effects on neonates	Negative physiologic effects on neonates
		Negative psychologic effects on neonates
	Overall negative effects on the care team	Negative physiologic effects on the care team
		Negative psychologic effects on the care team
Holistic modification	Environmental modification	Changing the architect
		Changing or repairing the equipment
	Behavioral modification	Teaching health care team
		Improving reactivity
	Recourses management	Managing human resources
		Managing non-human resources

Table 3: Comparison of the frequency of sound resources with standards

Sound Sources	Frequency (dB)	Standard
Alarm one at a moment	64	Between 45-65
Alarms more than one at a moment	72	> 45-65

Opening trash cans	82	> 45-65
Opening doors of cupboards	81	> 45-65
Opening entrance door	62	> 45-65
Mechanical ventilation device of isolated room 1	50	Between 45-65
Sound of wardrobes under the crib	77	> 45-65
Moving weight trolley	66	> 45-65
Moving surgery trolley	62	Between 45-65
Moving cleaning trolley	55	Between 45-65
Wheels of incubators	65	Between 45-65
Punch and paper machines	79	> 45-65
Walking on the wire crossing nursing station entrance	72	> 45-65
Pen of medical students while opening and closing	51	Between 45-65
Personnel slippers	54	Between 45-65
Toilet sink	74	> 45-65
Ringling phone	82	> 45-65
Ringling mobile phones	63	Between 45-65
Drinking water by big plastic mineral water bottles	63	Between 45-65
Sound of printer	63	Between 45-65
Chairs in the nursing station	60	Between 45-65
Mothers' chairs	60	Between 45-65
Wheel of a phototherapy device	58	Between 45-65
Wheel of an ultrasound device,	54	Between 45-65
Wheel of radiology device	64	Between 45-65
Speaker of the hospital	78	> 45-65

Laboratory tube elevator	85	> 45-65
Suction devices	54	Between 45-65
Opening items with plastic cover	63	Between 45-65
Tearing papers and plastic items	75	> 45-65
Sound of people while using mobile	64	Between 45-65
Leoni ventilator	80	> 45-65
Walking on the carpet	49	Between 45-65

Discussion:

To the best of our knowledge, this is the first study that was conducted by requiring both qualitative and quantitative data collection methods and included all stakeholders to determine the current status and find possible solutions for challenges regarding noises in the NICU environment. In general, our result showed that the NICU environment was a noisy environment with different kinds of sound sources. The status was something like an iceberg that some of these sound sources were overt and everyone declared them but most of these sound sources were not overt as if everyone considers them as normal or adopted to them. For example, in our study, the participants pointed out to ventilator and alarm sound. However, none of them implied to some sound sources such as surgery trolleys or weight trolleys. What seems interesting is that these covert sounds were as loud or even loader than overt sound sources and more than standard level (45 dB). One potential mechanism explaining this phenomenon is adaptation process as said by Swati et al. (2014). They explained that noise is not visible and the human ear may get adapted to high sound levels and stops perceiving it as loud but it has its harm (21). This finding could provide useful knowledge that if we want to explore the challenges of an environment and find an effective solution we have to audit the environment by internal and external evaluators. These evaluators can see the environment from

different perspectives and complete each other. For example, in this study, some sound sources were identified and expressed by the health care team and some of them were identified by our observations. These views gave us a holistic perspective that can help us in future intervention to consider all sound sources. In this regard, Galindo et al. (2017) conducted a study to evaluate the level and sources of noise in the NICU unit. They found sign monitor and telephone as the source with levels between 16.8-63.3 (dB). The mean level was 64.00 ± 3.62 (dB), with a maximum of 76.04 ± 5.73 and minimum of 54.84 ± 2.61 (22).

Also, our result showed that these sounds had a profound negative effect on everyone such as neonate and their mothers as well as the health care team in the NICU which is consistent with the result of previous studies. Rodarte et al. in 2019 conducted a study to evaluate preterm exposure and reactions to high noise in incubator. They found that sudden, high noises can affect neonatal behavior and causes facial manifestations, reflexive and bodily responses, and changes in their sleep condition (23). Furthermore, Smith et al in 2018 conducted a study to explore the rates, types, and levels of sound events in the NICU and their effects on state. Their result showed that all measured sound levels exceeded the standard noise level (45 decibels). They highly recommended reducing sound sources that disrupt neonate condition to improve neurodevelopmental results (24). One important point that declared by Smit et al. (2018) is that it may not be cost-effective to collect data regarding the effect of noises on neonate. The reason is that neonates experience extreme physiologic variation and their medical situation is really fragile that may lead to clouds any association between neonate physiologic state and noises (24). Thus, qualitative research can help us in this regard as we explore the live experience of people encountering this phenomenon and understand about the effect of noises on neonate by asking their direct caregivers.

Also, our result confirmed the effect of these sounds on the health care team. Approximately all participants stated that these sounds can have negative physiologic and psychological effects

on them. Similarly, Daniele et al. (2012) assessed the perception and knowledge of professionals in a NICU regarding noise. They noticed the effects of noise in their work shift and after that (67.4%) and they used strategies to reduce these noises (25).

Evidence from prior research highlighted the importance of human sound sources. For example, Smith et al. (2018) explained that all sound sources are not negative and some human sounds such as mothers' sounds can help neonatal sleep and recovery. Also, they implied that lack of exposure to sound sources in NICU may limit exposure to speech and delay language development in the future (24). However, our analysis showed that only 13% of these sound sources originated from human sources. So, this finding supported that some sound such as mothers sound or the sound of health care team for communicating with each other to provide safe care is very important and valuable and may decrease errors. A previous study by Shellhaas et al. 2019 also supported this fact. They evaluated if the NICU environment affects neonatal sleep and whether exposure to the mother's voice can moderate this impact. Their result showed that exposure to the mother's voice during sleep may protect neonates from awakening due to environmental noise (26). Thus, as Smith et al. (2018) suggested future research can focus on the methods of decreasing non-human sound sources that can negatively affect the neonates, on the other hand look for stimulation that will produce a suitable tranquil, developmentally supportive acoustic environment (24).

Another aim of this study was to explore possible solutions. Our analysis showed that holistic modification that included environmental modification, behavior modification, and resource management is necessary to decrease these challenges. Regarding environmental modification, Szymczak et al. (2014) compared the frequency of sound in a single department with an open department and they found that single department have equal sound frequency and noise level compared with open department. Due to reducing language exposure in the single department, they didn't recommend it (13). So, based on our result doing some small architectural changes

for easing the communication of the health care team and renewing and repairing the equipment may seem more cost-effective. Looking closely at table 3, we can conclude that small modifications of the environment and management of human and non-human resources may lead to decreasing many of these sound sources. Similar to our study some studies highlighted the importance of behavior modification such as teaching health care teams and improving reactivity. For example, Biabanakigoortani et al. (2016) conducted a study to evaluate the effect of peer education on staff in the NICU. Their result showed that peer education decreased generating unnecessary noises by the staff (27). This result is consistent with our result, as one of our participant suggested the importance peer education and creating the sense of responsibility in all staff. Furthermore, Swati et al. (2014) provided a model to explain the process of behavior modification regarding noises in staff in NICU. They sustain a culture of silence by ongoing notification to existing staff and new staff to adhere to the department rules related to noises (21). Existing studies attempt to prescribe a special solution for different NICU environments. Although different studies suggested different approaches for decreasing the noises in NICU, however, our finding represents an important and unique contribution to the literature understanding that each NICU department is unique with a different context that needs a special modification for itself and we cannot write one prescription for every environment. Thus, for acquiring more desired result each environment has to do a comprehensive situational analysis by involving all stakeholders and then choose the most cost-effective approaches between the recommended possible solutions. Action research would be one possible direction for future research to solve clinical problems. In this approach, all stakeholders and beneficiaries participate in designing the project, collecting, analysing and evaluating data, and finally disseminating and reflecting in an organization (28).

Strength and limitation:

This study has a limitation because the finding of this study cannot be generalized to other contexts attributed to the nature of qualitative research. Notwithstanding its limitation, this study used different kinds of qualitative and quantitative approaches for data collection and involve all stakeholders. Also, this study may offer some insight into the important role of involving an external qualitative observer in the audit process.

Conclusion: The result of this study showed that the status of NICU regarding noises is like an iceberg that negatively affected all people but only a small portion of this is evidence and most of it is neglected but it must be taken seriously. Also, this study revealed the importance of holistic modification involving environmental modification, behavioral modification, and resources management as a solution for decreasing noises in the NICU environment, however, it highlighted that each environment is unique which need to be carefully evaluated by qualitative and quantitative approaches to find a suitable and cost-effective solution for it. Action research would be one possible direction for future research.

References:

1. Jordão MM, Costa R, Santos SV, Locks MOH, Assuiti LFC, de Lima MM. NOISE IN THE NEONATAL UNIT: IDENTIFYING THE PROBLEM AND PROPOSING SOLUTIONS. *Cogitare Enferm.* 2017;22(4):e51137.
2. Cardoso SM, Kozłowski Lde C, Lacerda AB, Marques JM, Ribas A. Newborn physiological responses to noise in the neonatal unit. *Brazilian journal of otorhinolaryngology.* 2015;81(6):583-8.
3. Nieto-Sanjuanero A, Quero-Jiménez J, Cantú-Moreno D, Rodríguez-Balderrama I, Montes-Tapia F, Rubio-Pérez N, et al. [Evaluation of strategies aimed at reducing the level of noise in different areas of neonatal care in a tertiary hospital]. *Gaceta medica de Mexico.* 2015;151(6):741-8.
4. Valizadeh S, Bagher Hosseini M, Alavi N, Asadollahi M, Kashefimehr S. Assessment of sound levels in a neonatal intensive care unit in tabriz, iran. *Journal of caring sciences.* 2013;2(1):19-26.
5. Cohn E. Noise levels in the Neonatal Intensive Care Unit: A systematic review. 2018.
6. Garrido Galindo AP, Camargo Caicedo Y, Vélez-Pereira AM. Noise level in intensive care units of a public university hospital in Santa Marta (Colombia). *Medicina intensiva.* 2016;40(7):403-10.
7. Lahav A, Skoe E. An acoustic gap between the NICU and womb: a potential risk for compromised neuroplasticity of the auditory system in preterm infants. *Frontiers in neuroscience.* 2014;8:381.
8. Carvalhais C, Santos J, da Silva MV, Xavier A. Is There Sufficient Training of Health Care Staff on Noise Reduction in Neonatal Intensive Care Units? a Pilot Study From Neonnoise Project. *Journal of toxicology and environmental health Part A.* 2015;78(13-14):897-903.

9. Hernández-Salazar AD, Gallegos-Martínez J, Reyes-Hernández J. Level and Noise Sources in the Neonatal Intensive Care Unit of a Reference Hospital. *Investigacion y educacion en enfermeria*. 2020;38(3).
10. Almadhoob A, Ohlsson A. Sound reduction management in the neonatal intensive care unit for preterm or very low birth weight infants. *The Cochrane database of systematic reviews*. 2020;1(1):Cd010333.
11. Beken S, Önal E, Gündüz B, Çakir U, Karagöz İ, Kemaloğlu YK. Negative Effects of Noise on NICU Graduates' Cochlear Functions. *Fetal and pediatric pathology*. 2020:1-10.
12. de Araújo Silva AC, Zamberlan-Amorim NE, Mara L, Fonseca M, Fujinaga CI, Benutti DP, et al. Perception of the multidisciplinary team about noise in neonatal intermediate care units. *Acta Paul Enferm*. 2012;25(1):74-9.
13. Szymczak SE, Shellhaas RA. Impact of NICU design on environmental noise. *Journal of neonatal nursing : JNN*. 2014;20(2):77-81.
14. Streubert Speziale H, Streubert JH, Carpenter DR. *Qualitative Research in Nursing: Advancing the Humanistic Imperative*. Fifth ed. China: Lippincott Williams & Wilkins; 2011. 470 p.
15. Sabet Sarvestani R, Moattari M, Nasrabadi AN, Momennasab M, Yektatalab S. Challenges of nursing handover: a qualitative study. *Clinical nursing research*. 2015;24(3):234-52.
16. Elo S, Kyngäs H. The qualitative content analysis process. *Journal of advanced nursing*. 2008;62(1):107-15.
17. Suri H. Purposeful sampling in qualitative research synthesis. *Qualitative research journal*. 2011.
18. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qualitative health research*. 2005;15(9):1277-88.
19. Kyngäs H, Kääriäinen M, Elo S. The trustworthiness of content analysis. *The application of content analysis in nursing science research*: Springer; 2020. p. 41-8.
20. Elo S, Kääriäinen M, Kanste O, Pölkki T, Utriainen K, Kyngäs H. Qualitative content analysis: A focus on trustworthiness. *SAGE open*. 2014;4(1):2158244014522633.
21. Swathi S, Ramesh A, Nagapoornima M, Fernandes LM, Jisina C, Rao PN, et al. Sustaining a "culture of silence" in the neonatal intensive care unit during nonemergency situations: a grounded theory on ensuring adherence to behavioral modification to reduce noise levels. *International journal of qualitative studies on health and well-being*. 2014;9:22523.
22. Garrido Galindo AP, Camargo Caicedo Y, Velez-Pereira AM. Noise level in a neonatal intensive care unit in Santa Marta - Colombia. *Colombia medica (Cali, Colombia)*. 2017;48(3):120-5.
23. Rodarte MDO, Fujinaga CI, Leite AM, Salla CM, Silva CGD, Scochi CGS. Exposure and reactivity of the preterm infant to noise in the incubator. *CoDAS*. 2019;31(5):e20170233.
24. Smith SW, Ortmann AJ, Clark WW. Noise in the neonatal intensive care unit: a new approach to examining acoustic events. *Noise & health*. 2018;20(95):121-30.
25. Daniele D, Pinheiro EM, Kakehashi TY, Balieiro MM. [Workers' knowledge and perception regarding noise in the neonatal unit]. *Revista da Escola de Enfermagem da U S P*. 2012;46(5):1041-8.
26. Shellhaas RA, Burns JW, Barks JDE, Hassan F, Chervin RD. Maternal Voice and Infant Sleep in the Neonatal Intensive Care Unit. *Pediatrics*. 2019;144(3).
27. Biabanakigoortani A, Namnabati M, Abdeyazdan Z, Badii Z. Effect of peer education on the noise management in Iranian neonatal intensive care unit. *Iranian journal of nursing and midwifery research*. 2016;21(3):317-21.
28. Sarvestani RS, Moattari M, Nasrabadi AN, Momennasab M, Yektatalab S, Jafari A. Empowering nurses through action research for developing a new nursing handover program in a pediatric ward in Iran. *Action Research*. 2017;15(2):214-35.