ORIGINAL ARTICLE

Identification of the Main Sources of Noise in the NICU of Hospital in Iran and Offering Noise Control Methods

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ABSTRACT

Background: High ambient sounds affect the hearing system of premature infants and cause direct adverse effects in the development of the central nervous system.
Aim: The aim of this research is to identify the main sources of noise generator, which results in the generation of sounds that are more than the prescribed limit.
Method: This study is descriptive-analytic. The NICU's research site in the hospital. Measurement and evaluation of sound were performed by an expert on professional health using a calibrated Sound Meter set of KIMO SDA type. The sound map of various situations was mapped using the Surfer software and compared with the standard exposure limit.
Result: The mean SPL in NICU was 61 dB. The analysis of the data showed that during 24 hours, the morning shift has the highest and the night shift has the lowest noise. The main noise generator factors in the NICU section are ventilated pulse oximeter set and active personnel.
Conclusions: The proposed noise control methods include: Creating a Single-Patient Room, covering NICU's wall, floor, and ceiling, or baby's holding area with sound-absorbing panels to reduce the background noise of the unit, eliminating unnecessary alarms.
Keywords: Neonatal Intensive Care Unit, Hospital, Sound Level, Noise Control

INTRODUCTION

Peripheral noise in hospitals around the world is common to stress and is known not only as a nuisance, but as a serious health hazard[1]. Hospitals have complex sounds that create problems for the health of patients[2]. Premature infants need long-term admission in the Neonatal Intensive Care Unit (NICU)[3]. It is very important to take measures that help improve the neural development of these infants under such conditions. Premature infants are transmitted from the safe environment of the mother's womb to a cold and noisy environment exactly at the sensitive time before the proper development of the hearing system[4]. They often close their eyes to dazzling lights, but they cannot close their ears against loud sounds, and they also have the power to understand and respond to the surrounding sounds, and noise pollution is a major stress for them in the NICU[5]. Normal infants are able to adapt to environmental stress, but premature infants do not have this ability due to the incomplete evolution of the autonomic nervous system and its function[6]. Long, ambient noises are an undesirable phenomenon that not only affects the baby's hearing system but also has direct effects on the development of its central nervous system and can have adverse effects on its future development[7]. Voice actuators can reduce the amount of respiration and reduce arterial blood saturation, increase heart rate, increase blood pressure and increase intracranial pressure, and because of the immaturity of the brain's autonomic regulation system, it indirectly reduces perfusion and oxygenation to the brain and leads to the incidence of agitation, crying, behavioral changes and changes in the electroencephalogram (8). The National Academy of Children of America expressed an optimal level of environmental noise in the NICU below 58 dB, and then the Environmental Health Committee of this Academy, stated the standard level of the sounds to be 45 dB or fewer; the WHO also in an instruction stated that the level of noise pollution at the place where the patients are kept should not exceed 35 dB[9]. However, in various studies, it's shown that noise generation in the infant's intensive care unit was more than 45 dB per day and at night reaches more than 35 dB[10]. The noises in the NICU are generated from three different sources, including background noise of the building and the areas adjacent to the building. The second source is the noise called operational noise caused by the activity of the staff. And the third noise is the facility noise that is caused by the function of electronic equipment[11]. The purpose of this research is to identify the main sources of noise that result in the generation of noises higher than the determined allowed level to as to be a step forward for appropriate corrective actions in the future to help improve the health of premature infants in the hospital's intensive care unit.

MATERIAL AND METHOD

The present study is a descriptive-analytic. The location of the NICU research is in the Alavi Hospital in Ardabil in 2018. The variables studied include noise caused by the function and device alarms, the noise of staff activity, the noise when the section window is open, the noise in different shifts, and the noise on working days and non-working days. Measurement and evaluation of SPL (Sound Pressure Level) were carried out by a calibrated sound

meter KIMO SDA type by trained professional health experts. Environmental measurement and assessment were carried out using a regular network method, in which case the location of the personnel was not considered, but the measurement results are used to determine the distribution of SPL and hazard distributions in the NISU, as well as the determination of the main sources of sound to control the noise. A regular network method was used to prepare a sound map, in which NISU was divided into checkered areas of the same size as the network and center of each box is a measurement station. The methodology is to first classify the NICU into 20 stations and determine the amount of ambient noise level in dB at 1-1.5m height of the ground in the frequency weighing system in 4 different states. Measurement conditions are 1. In the morning, even, and night; 2. Working days and non-working days; 3. When nurses and companions are busy and when they are told not to do anything; 4. When one NICU window is open because of the warmth inside and when all windows are closed. The conditions for shutting down the devices to measure the noise without operating the devices was not feasible because of the health hazards for babies, which is a problem with the implementation of the plan. Using the data obtained from the sound map, different conditions were plotted using the Surfer software. And the results were compared with the standard acceptable exposure levels. At the NICU station, there may be a barrier at some stations that could exclude the possibility of measuring the balance in the station, so that the station was considered as a blind spot. Finally, the data were analyzed by SPSS19 software in different conditions[12]. The statistical tests used are ANOVA One-Way, Post-Hoc Bonferroni, and Independent T-test.

RESULTS

Out of 20 stations, 540 cases were measured in different SPL modes. The lowest measured SPL is 53.10 dB and the highest is 79.50 dB. The data obtained and the survey of the Surfer map indicates that at all stations, and in any case, the SPL is above the permissible limit (45 dB). Analyzing the measured data in the three different shifts by ANOVA One-Way method showed that there is no significant difference between the SPL in the morning, evening, and night shifts (Table 1).

Table 1: Analysis of the data measured in different shifts by ANOVA One-Way test.

Shift	N	$\overline{LP}$	Min.	Max.	P-value
Morning	54	64.33	59.40	71.60	<0.0001
Evening	54	62.81	53.10	79.50	
Night	54	60.27	54.20	64.70	

Table 2: Bonferroni post-hoc test analysis of data measured in different shifts

Shift		Mean Difference	95% Confidence Interval		P-value
Morning	Evening	1.52	-0.48	3.53	0.207
	Night	4.05*	2.04	6.06	<0.0001
Evening	Morning	-1.52	-3.53	0.48	0.207
	Night	2.53*	0.52	4.54	0.008
Night	Morning	-4.05*	-6.06	-2.04	<0.0001
	Evening	-2.53*	-4.54	-0.52	.008

Also Bonferroni test of the morning shift and the night shift and the afternoon shift and night shift, showed a significant difference (Table 2).

As stated above, sound metering was done with the aim of surveying the level of effect of noise of personnel activity. By examining the data and comparing the noise pressure level during the work time of the personnel in each of the three shifts, we find that there is a significant difference between the environment SPL during the time of personnel activity and the inactivity of the personnel (P-value=0.004), which means that the noise of the personnel activity is one of the main generators of noise in this section (Table 3).

Table 3: Analysis of the measured data based on the operation with independent T-test

Item	N	$\overline{LP}$	SD	P-value
Operational noise	54	63.55	2.89	0.004
non-operational noise	54	61.92	2.77	

By looking at the data when the window is open and closed, we find that there is no significant difference between the data (P-value=0.99). So the noise of the adjacent street cannot be the source of the main noise of this section. It should be noted that in this section, which has five windows, only one window is opened, so we also measured the noise when opening and closing the window, and if all the windows were opened, the noise of the adjacent street would probably be effective this section. Analysis of SPL results on working days and non-working days did not show a significant relationship (P-value=0.058). On the day of parents' meeting, which was conducted with the aim of examining the increase of SPL on a non-working day, by reviewing the data, we concluded that in this section, there is no difference between a working day and a non-working one, and this is because, in this section, the meeting is possible in each day for parents and is not limited to a non-working day. In order to investigate the effect of the noise of the ventilator in the unit, we also managed to compare the data when the device was used and when it wasn't. Within the range of the device, on the days when the device was turned on, the average noise was reduced to about 4 dB, compared to the day the device was turned off, which means that this ventilator is one of the main generators of noise in this section. The number of ventilator devices in this section is 9, which on the days we performed the noise meter, 7 of them were on, but only one of them could be examined and there was no possibility to turn off the rest. Another device in the unit was 13 pulse Oximeters, 12 of which were on and alarmed at risk when in danger. On the day that these devices needed repairs and the man responsible for the installations, set the device on sound play mode to repair, so it became possible to check the effect of this device. By checking the data when the device is silent at other times and the repair time, the average noise is different by about 3 dB, so it can be said that this device is also one of the main generators of sound in this section.

DISCUSSION

The noise is more than allowed in all SPL sections. The mean SPL was 61 dB in NICU. The analysis of the data

showed that during 24 hours, the morning shift has the highest and the night shift has the lowest noise. The main noise generator factors in the NICU section are ventilated the pulse oximeter and the personnel activity. Examining the level of noise pollution in the NICU of children's hospital in 2006 by Zonouzi et al[13]. Also, consistent with this study showed that the children in this hospital are exposed to the risk of noise pollution. Also in studies by Hokmabadi & Karimi, similar to the present study, the level of noise pressure in the NICU was declared too high[14,15]. In another study that evaluated the noise pollution in the NICU of Ghaem Hospital in 2014 by Behnam Shafi et al., like the results of this study, it was shown that noise levels in this section of the hospital are more than standard and also the main devices of noise generation are the alarm of monitor, ventilators and the noise of doctors and nurses[16]. Also, the study of noise pollution in the intensive care units of the educational hospitals of Isfahan University of Medical Sciences by Abbasi et al In 2012 showed that the most important causative factors in the ICU environment where people working in the section including nurses, crew, doctors, and equipment used in the ICU environment, including ventilators, monitor alarms, patient-connected oxygen tubes, ICU heating, and cooling equipment in the ICU environment[17]. The results of the present study are also consistent with the results of studies in other countries which will be mentioned. Among these studies are Noise Pollution Levels in Pediatric Intensive Care Unit by Kramer et al. Where it was shown that the average daily noise pressure was 62.9 dB. Parents and staff identified the monitor as a major cause of noise[18]. In another study, Kol et al. Identified the noise sources, including Nursing station, Perfusion alarm, Nebulizer device alarm, Monitor alarm, Staff conversation, ventilator alarm, pulse oximeter alarm, telephone ring, infusion pump alarm, and central air-condition[19].

CONCLUSIONS

As mentioned, the main noise generators in the hospital's NICU include a pulse oximeter, ventilator and talking voice, and activity of the staff of the section and the infant's parents. According to the authorized amount of noise, the noise in the NICU section of hospitals should be about 35 to 45 dB, but the data in this section are in the range of 59-79 dB and is greater than the permissible limit; as a result, the health of newborns is at risk. NICU noise should be reduced as much as possible by engineering technical control methods. The proposed noise control methods are: creating Single-Patient Room, organizing and controlling meeting times, provision of instructions for observing silence by personnel and visitors, interior design and arrangement of the unit with the appropriate distance of noise sources, covering walls, floor, and ceiling of the NICU, or covering baby's location with noise absorbing panel to reduce the noise of the unit. Given that manufacturers of the equipment of NICU produce devices with different noise intensities, it is best to consider the noise of equipment as an effective variable when choosing and purchasing when equipping the NICU. Also, by installing a noise-sensor light signal, it is possible to prevent the creation of higher-alarms and effectively reduce the stress caused by the sudden increase in noise in the infants[20].

Conflicts of Interest: The authors declare no conflict of interest.

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