Original Article

Internal noise levels in neonatal intensive care unit incubators*

Ruído no interior das incubadoras em unidade de terapia intensiva neonatal

Ruido en el interior de las incubadoras en unidad de Cuidados Intensivos Neonatal

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ABSTRACT

Objectives: To identify levels of sound pressure level (NPS) inside the incubator and the sources of noise in that microenvironment of the Neonatal Intensive Care Unit of a university hospital. **Methods:** Descriptive quantitative study, conducted in incubators for the Neonatal Intensive Care Unit of a university hospital in São Paulo. The records were obtained by NPS dosimeter, totaling 261 hours, 48 hours of records of the sources producing noise. **Results:** There were high NPS inside the incubators. Greater Leq levels were 79.7 dBA in room A, and 74.3 dBA in room B. The main sources of noise were: water circulation fan, maintaining open doors on the incubators during periods of care, equipment alarms, and conversation among professionals close to the incubator. **Conclusions:** The results showed that the NPS inside the incubator are far above those recommended by regulations. Based on these results, we developed a protocol and educational program.
Keywords: Noise; Intensive care units, Neonatal; Neonatal nursing; Humanization of assistance

RESUMO

Objetivos: Identificar níveis de pressão sonora (NPS) no interior das incubadoras e as fontes geradoras de ruído nesse microambiente de Unidade de Terapia Intensiva Neonatal de um hospital universitário. **Métodos**: Pesquisa quantitativa, descritiva, conduzida nas incubadoras de Unidade de Terapia Intensiva Neonatal de um hospital universitário do Município de São Paulo. Os registros de NPS foram obtidos por meio de dosímetro, totalizando 261 horas, 48 horas de registros das fontes produtoras de ruídos. **Resultados**: Constataram-se elevados NPS no interior das incubadoras. Maiores Leq médios foram 79,7 dBA na sala A e 74,3 dBA na B. As principais fontes de ruído foram: barulho da água do ventilador, permanência das portinholas abertas da incubadora, durante os cuidados prestados, alarmes dos equipamentos e conversa entre profissionais próxima à incubadora. **Conclusões**: Os resultados evidenciaram que os NPS no interior das incubadoras estão distantes do recomendado pelos órgãos regulamentadores. Com base nesses resultados, foram desenvolvidos um protocolo e programa educativo.
Descritores: Ruído; Unidades de terapia intensiva neonatal; Enfermagem neonatal; Humanização da assistência

RESUMEN

Objetivos: Identificar niveles de presión sonora (NPS) en el interior de las incubadoras y las fuentes generadoras de ruido en ese micro ambiente de Unidad de Cuidados Intensivos Neonatal de un hospital universitario. **Métodos**: Investigación cuantitativa, descriptiva, conducida en las incubadoras de una Unidad de Cuidados Intensivos Neonatal de un hospital universitario del Municipio de Sao Paulo. Los registros de NPS fueron obtenidos por medio de dosímetro, totalizando 261 horas, 48 horas de registros de las fuentes productoras de ruidos. **Resultados**: Se constataron elevados NPS en el interior de las incubadoras. Mayores Leq medios fueron 79,7 dBA en la sala A y 74,3 dBA en la B. Las principales fuentes de ruido fueron: bulla del agua del ventilador, permanencia de las portezuelas abiertas de la incubadora, durante los cuidados prestados, alarmas de los equipos y conversaciones entre profesionales próximos a la incubadora. **Conclusiones**: Los resultados evidenciaron que los NPS en el interior de las incubadoras están distantes de lo recomendado por los órganos reglamentadores. Con base en esos resultados, fueron desarrollados un protocolo y un programa educativo.
Descriptores: Ruido; Unidades de terapia intensiva neonatal; Enfermería neonatal; Humanización de la atención

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** Study carried out in a University Hospital in the city of São Paulo (SP), Brazil.*

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INTRODUCTION

As of the middle of the 20th century, thanks to the technological development observed, there has been a great amount of equipment in the Neonatal Intensive Care Unit (NICU) to care for hospitalized neonates, whose purpose is to increase survival rates with better quality of life[1]. The use of this technology by the health teams in the NICU leads to several benefits to newborns' (NB) health. However, they can also lead to immediate adverse effects on infants' health and sequelae in the long term[1-4].

Several piece of equipment that support newborns' lives at the NICU, such as breathers, humidifiers, and even the incubators, while working, become a source of noise and can be a powerful stress factor[3-5].

Disorganized sounds in a frequency that is physiologically incompatible with the human ear are considered noises, and can cause physical lesions, psychological, and behavioral changes[6-7].

When exposed to excessive noise, the newborn body can present different responses, such as: hypoxia, release of adrenocorticotropic hormone and adrenaline in the blood stream, increase in heart rate, systemic vasoconstriction, , pupil dilation, increase in blood and intracranial pressure, increase in oxygen consumption and caloric requirements, that can lead to delay in weight gain in the long term. The noise can lead to changes in infants' states of sleep and wakefulness, making them annoyed and whining, hindering their development[3-4,8-9]. Additionally, the excessively noise environment affects infants' ability to interact and can change their behavioral state, leading to "fading" and, thus, affecting in some way the bond between parents and the infant[5]. Hearing loss of newborns admitted to NICU due to prolonged noise exposure is one of the most commonly mentioned problems in the literature[4,10-11].

In high frequencies, noise can lead to hyperstimulation of the hair cells of the organ of Corti in infants, leading to its destruction and thus to progressive hearing loss. It is known that newborns receiving treatment with ototoxic drugs such as aminoglycosides and some diuretic drugs present greater possibility of developing hearing problems when exposed to excessive noise[10]. The literature has also demonstrated that one of the main risk factors for hearing loss in neonates is being exposed to noises in the incubators for more than seven days[12].

Studies on human embryology show that the ear is the first sense organ to develop. On the third week of gestational age, the first differentiated cells that will later form the auditory system start to be formed[13]. There are evidences that the fetus can hear as of the 5th month[14]. Although the main structures of the ear are developed at 25 weeks of pregnancy, they will reach the dimensions of a grown up one year after birth[15].

Thus, premature babies are more vulnerable to hearing lesions in unfavorable sounding environment. Statistical data demonstrate that the prevalence of bilateral sensorineural hearing loss in newborns at NICU is two to four babies in each thousand[16]. Studies show that the exposure of infants to continuous noise is worse than that to intermittent noise because of the continuous stimulation of auditory cells[10].

According to what was mentioned, and considering that neonates tend to stay in the NUCI for longer periods, we asked what are the sound pressure levels (SPL) neonates face inside incubators at the NICU of a university hospital in the city of São Paulo- SP, Brazil and the sources of noise in these microenvironments.

OBJECTIVES

Identify the SPL inside the incubators and the sources of noise in the microenvironment of a university hospital NICU.

METHODS

Quantitative, descriptive study carried out inside incubators of two rooms of the NICU of a university hospital in the city of São Paulo - SP, Brazil.

This unit has four rooms, two are intensive therapy (rooms A and B) and another two (rooms C and D) are for semi-intensive care. Each room has four beds and the approximate area is 23.80 m2, ceiling 3.40 m, vinyl floors, brick walls, concrete roof and glass windows with screens that remained continuously opened, exposing the environment to the noise of the streets. The rooms of the NICU were next to the nursing ward where there is the telephone, the stock of controlled medication, and where employees stay while performing some tasks. Thorough the nursing ward there is a hallway where health professionals, students, and professors pass by and remain during clinical discussions and medical prescriptions.

Overall, shift reporting by the medical and nursing team is performed next to each incubator, as well as the nursing prescriptions.

Newborns' parents can remain in the NICU from 9am to 9 pm in the rooms with their babies, where the information about the clinical development of the babies is frequently conveyed.

The floors of the two rooms are cleaned on Mondays and Tuesdays in the evening, and the floor of the nursery hallway is cleaned on Mondays and Wednesdays in the evening, the nursing ward is cleaned on Fridays at the same time. This process is carried out using an industrial floor polisher.

The model of all neonate incubators is C186T S Fanem? brand. The two rooms do not have air

conditioner.

Before data collection started, the study was approved by the University Research Ethics Committee and authorized by the hospital (Process no 0391/07). An inventory was prepared to identify the sources of noise from the observation of the reality of the institution, and the data documented on the literature[17].

Considering the possibility that professional working in the NICU could change their behavior because of the presence of researchers and the machine, we carried out desensitization for two weeks, during which, the microphone of the dosimeter remained positioned inside the incubator, and the researchers observed all the procedures that would be carried out during the final data collection. Thus, we simulated change in batteries, Leq records and recalibration of the dosimeter at the end of each shift. At the time, pre-test of the inventories and training of the observers was carried out. Training was considered satisfactory when 85% coincidence was reached in researchers' records[18].

Data collection was carried out using a dosimeter brand Quest 400 from January 12 to 25, 2009. The device, that cold record the SPL every minute was set in the following way: slow response, measuring in decibel (dB) the noise pressure level, using A-weighted sound pressure levels dB(A)[19]. The dBA scale is the filtering method that mimics the receiving features of the human ear and it is indicated to apprehend continuous noise (Leq). The device was programmed to operate in SPL intervals between 40 and 140 dB(A)[20]. Thus, each noise level measured had its duration precisely recorded and stored, providing researchers a set of data for statistical treatment and analysis.

The microphone of the dosimeter was introduced inside the incubator selected for the study, about 20 cm away from the infant's ear[21]. In the data collection strategy, the plan was to have one device on for 24 hours, in a total of 336 hours, for two consecutive weeks, in each room. Of the total, the sample resulted in 261 hours of SPL records, 33 hours were lost because of technical measuring problems of the dosimeter, the need to stop data collection because the infant had to leave nursery to undergo procedures, or infant leaving to another type of bed. Additionally, before carrying out data analysis, the first 30 minutes of the SPL records of the dosimeter were discarded in the beginning and end of each shift, considering the possibility of making noise when handling the device to calibrate it, and thus influencing the Leq of the period. Therefore, 42 hours of records were discarded in total.

Batteries were changed daily, Leq was recorded and the dosimeter was calibrated with a QC10 calibrator at the end of each shift. Leq records were obtained when the dosimeter was turned off, at the end of the shift, and restarted at the beginning of the other shift, on all days of the week.

To decide in which incubator the microphone would be put in, we identified among newborns of each unit, that who presented the greatest value of the Score for Neonatal Acute Physiology Version II, which indicates greater risk for neonatal mortality[22]. During data collection, the dosimeter was transferred to another incubator three times due to the infant's need to leave the NICU.

We obtained 48 hours of records of sources of noise, 24 hours in each room, encompassing all days of the week and work shifts, as demonstrated in data from Picture 1 to apprehend the sources of noise in the changes of the existing daily activities.

All data of A-weighted sound pressure levels, recorded every minute by the dosimeter inside the incubators were transferred to the program Quest Suite for Windows. From these data, continuous and equivalent SPL (Leq) and their maximum (Leqmax) and minimal (Leqmin) values were calculated for each incubator of the two rooms, in the different shifts and days of the week.

RESULTS

As for room A, we have observed that during data collection, there was predominance of high mean Leq values, even during the night shifts.

In the incubators of room A of the NICU, the highest mean Leq recorded was 79.7 dBA on the afternoon shift on Thursday, and the lowest was 53.6 dBA on the night shift on Saturday (Picture 1). Thus, the difference between the highest and lowest Leq in the incubators of this room was 26.1 dBA. The maximum and minimal Leq recorded in the incubators in room A were: 100.8 dBA in the afternoon shift on Thursday and 46.4 dBA on Tuesday morning, respectively.

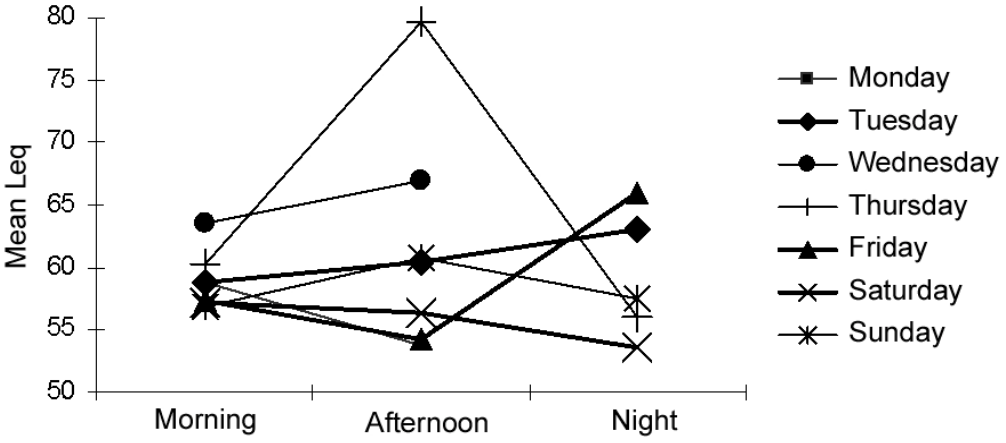
In the incubators in room B of the NICU, we have also found high mean Leq values. During the period SPL was measured inside the incubator of this room, the highest mean Leq found was 74.3 dBA, and the lowest was 55.1 dBA, both on Tuesday and Monday night, respectively. The variation was 19.2 dBA (Picture 2).

The highest Leqmax value in this environment was 89.0 dBA on Thursday morning, and the Leqman was 42.7 dBA on Sunday morning.

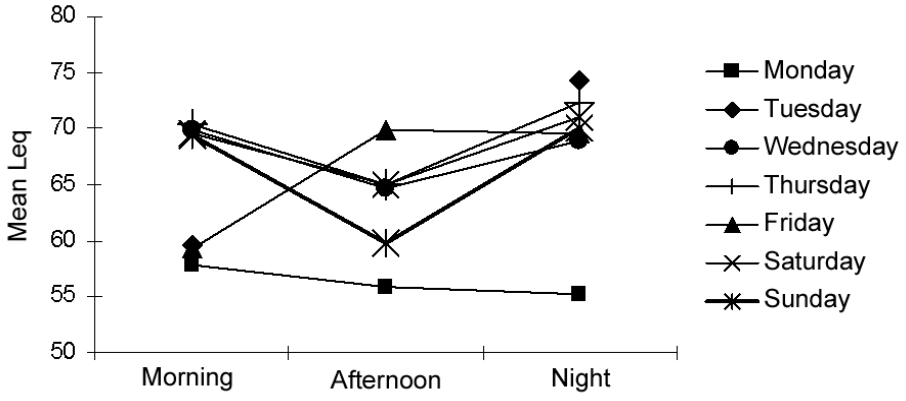
The main sources of noise in the incubators of room A of the NICU were: the noise of water in the circuit of the fan used by the infant (20.0%), incubator porthole remaining open to provide care to newborns (18.6%), alarms of the devices used in infants (9.3%), talks among professionals near the incubator (7.8%), placing objects on tops of incubator (3.3%), performing physical examination in the NB (1.8%) and closing the incubator

Picture 1 – Times of structures observation of the noise sources inside the incubators in rooms A and B of a university hospital NICU – São Paulo – SP, 01/12 to 25/2009

Days of the week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Times noise sources were observed	7:00 – 7:59 h	8:00 – 8:59 h	9:00 – 9:59 h	10:00 – 10:59 h	11:00 – 11:59 h	12:00 – 12:59h	13:00 – 13:59 h
	14:00 – 14:59h	15:00 – 15:59h	16:00 – 16:59h	17:00 – 17:59h	18:00 – 18:59h	19:00 – 19:59h	20:00 – 20:59h
	21:00 – 21:59h	22:00 – 22:59	23:00 – 23:59h	00:00 – 00:59h	01:00 – 02:59h	03:00 – 04:59h	05:00 – 06:59h



Picture 1 – Mean Leq values (dBA) within incubators by shifts and days of the week in room A of the NICU at a university hospital. São Paulo- SP, January 12 to 25, 2009.



Picture 2 – Mean Leq values (dBA) within incubators per shift and days of the week in room B of the NICU of a University hospital. São Paulo- SP, January 12 to 25, 2009

porthole (1.8%) among others.

In the incubators from room B of the NICU, the following sources were more frequently responsible for producing noise: baby crying (17.8%), incubator porthole remaining open to provide newborn care (15.1%), alarms of the devices used in the NB being observed (12.5%), noise of the water in the fan circuit used by neonate (7.1%), placing objects on tops of incubator (3.1%), talks among professionals near the incubator (2.9%), parents or employees talking to the baby (2.3%) and opening the cabinet drawer of the studied incubator (2.1%), among others.

DISCUSSION

Most of the time SPL was monitored inside the incubators of rooms A and B of the NICU, they were above the values recommended both by national and

international agencies. The Brazilian Association of Technical Norms establishes Leq values below 60.0 dBA inside incubators; the American Academy of Pediatrics recommends values below 58.0 dBA, as the maximum level allowed for these devices[23-24]. Authors from a study verified the SPL in 16 incubators, and found Leq values between 58.9 and 67.2 dBA[2]. A Brazilian study carried out in the incubators with and without babies in three public hospitals in the Southeast of Brazil, identified SPL from 59.0 to 79.0 dBA in the incubators with babies[10]. A PhD thesis recorded SPL between 47.6 and 88.7 dBA in the incubators of a teaching hospital[25]. Another study that assessed noise exposure of high risk newborns in NICU found SPL in incubators ranging from 56.0 to 60.0 dBA[26]. High noise levels, from 59.1 to 113 dBA, have been also found inside the incubators of a school-hospital[27].

Regarding the sources of noise in this device, studies highlight: conversations in the unit, vocalizations, and infants' crying, opening and closing porthole, oxygen flow, equipment alarm, handling the counter, among others[2, 25-27].

In the present study it was also seen that conversation in the unit was one of the most important sources of noise. These outcomes may be because this NICU is from a university hospital with a greater presence of professionals and students. On Thursday afternoon where the mean Leq recorded was 79.7dBA, there were up to 16 people in the room, because of the admission of a critically ill neonate which required several interventions such as placement of mechanic pulmonary ventilation, intravenous catheter passage and other procedures.

The records in the present study showed a significant increase in the SPL, while the porthole remained opened. In this situation external noise gets into the incubator and it loses its function of being a sound barrier. On the other hand, it has been identified that closing the porthole was a source of noise.

A study showed that the average of the maximum level of noise due to non-continuous impact generated by handling incubator portholes was 96.2 dB(A) while opening, and 107.0 dB(A) while closing it[2].

In the present study, SPL verified inside the incubator ranged from 58.3 to 68.7, in the absence of any records of the sources of noise, either inside the devices or in the environment of the NICU studied. Assuming that the incubator hood is a barrier to the spread of noise from the outside to the inside, we may say it prevents the passage to outside of the noise generated inside. Thus, while sources of noise were being apprehended, we saw that the baby was contorting with pain, it may have moaned, whose sound could not be heard by the observer. In the records of the sources, it was also seen that infants' cry alone reached very high levels of sound pressure, reaching up to 84.6 dBA. This indicates the need to handle pain properly and for immediately responding to infants' pain and agitation, since behavioral changes can trigger alarms, increasing even more the exposure to noise. Infants' behavioral state is one of the important SPL determinants within the incubator[5].

On the other hand, outcomes from several studies indicate that a project to minimize SPL within incubators should encompass architectural aspects, a preventive maintenance program for the equipment, and awareness raising among professionals, since these three pillars have a great influence on the noise within incubators[2,4-5,10,25-27]. Thus, after assessing the results, based on the literature, a guideline was prepared with recommendations on these aspects. An educational program was also introduced to reduce noise in the NICU mentioned. A new measurement of the SPL and the record of the sources of noise inside the NICU will be carried out after the educational program is applied.

CONCLUSION

The present study showed the high SPL to which neonates are exposed within incubators at the referred NICU. In the incubators of room A of the NICU, the highest mean Leq recorded was 79.7 dBA, and the lowest was 53.6 dBA; in those in room B, the highest mean Leq was 74.3 dBA, and the lowest was 55.1 dBA. The main sources of noise were: water noise in the fan circuit, opened portholes, talks among professionals, infants' crying, and equipment alarm, among others.

These outcomes may show the daily sound ecology within incubators of the NICU studied, as the sample encompassed the three shifts of all days of the week for 14 days, we can conclude that the variables that formed the SPL obtained are not random. Since a great part of the noise is caused by infants' crying and professionals' activities, and that the sources of noise are related to care for infants and their families, environmental management that leads to SPL decrease is difficult. It is necessary to introduce strategies for noise reduction in NICU and inside the incubators and to implement routines for its systematic assessment, in order to make all people involved in infants' care and well being aware and committed.

However, we should highlight some limitations of the present study regarding the identification of the SPL values of the sources of noise separately to be able to determine priorities in the interventions for noise reduction.

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