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ORIGINAL ARTICLE

Evaluation of strategies aimed at reducing the level of noise in different areas of neonatal care in a tertiary hospital

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Abstract

Objective: *To determine the noise levels of different areas responsible for newborn care, develop intervention strategies to decrease the noise, and evaluate its effectiveness.* **Methods:** *Prospective, observational and longitudinal study carried out using a sonometer, measuring sound levels for three weeks in the neonatal intensive care unit (NICU), neonatal intermediate care unit (UCIREN), delivery (TOCO QX) and nursery (CUNERO) units. We implemented an intervention program and subsequent measurements were performed under the same initial conditions.* **Results:** *When comparing the decibel levels in different areas during the three weeks, pre- and post-intervention, we found at the neonatal intensive care unit 59.9 ± 4.8 vs. 56.4 ± 4.7 dB (p < 0.001), neonatal intermediate care unit 55.3 ± 3.9 vs. 51.3 ± 4.4 dB (p < 0.001), delivery unit 57.3 ± 4.6 vs. 57.3 ± 5.5 dB (NS), and nursery unit 57.6 ± 5.8 vs. 53.9 ± 5.8 dB (p < 0.001).* **Conclusions:** *There was a significant reduction in noise levels of 3.5 dB at the NICU, 4 dB at UCIREN and 3.7 dB at TOCO QX, so the intervention program was effective in these areas; however, the decibel levels registered continue above those recommended by international standards.* (Gac Med Mex. 2015;151:687-94)

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Introduction

Over the past few years there has been a world-wide increase in the number of premature infants. The incidence of children with very low birth weight (< 1,500 g) ranges from 0.6 to 3% of all births. In Mexico, out of 2,300,000 births occurring by year, 1.46% is estimated to weight less than 1,500 g; therefore, nearly 40,000 infants might require neonatal intensive care[1].

Premature newborns are at higher risk of developing cognitive, motor and behavioral disorders in comparison with full-term newborns. Up to 50% premature infants are likely to show these disorders and between 5 and 15% will exhibit infantile cerebral palsy. In spite of advances that have allowed for survival in this group of neonates to be increased, a proportional reduction in the incidence of disability has not been accomplished and these infants remain at increased neurological and behavioral risk[2].

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The neonatal intensive care unit (NICU) environment is designed to medically sustain the fragile premature child and it is in contrast with the intrauterine environment, thus interfering with the development of the premature infant, his behavioral states and in his capacity to develop adaptive responses[3]. Noise, excessive illumination and frequent manipulation interrupt his sleep states and drive the neonate to use the energy required for growth and development in coping with detrimental stimuli[4]. Early noxious experiences can alter cerebral structures[5].

Prolonged exposure to noise can damage auditory structures and cause a "stress" reaction, altering systemic homeostasis, subcortical structures activation, the autonomous nervous system, the endocrine system and somatic reactions. Levels of noise in the NICU are associated with the employed therapeutics, equipment and daily activities, for example: monitor alarms, medical equipment mobilization, radios, conversations, ward rounds, shift changes, loudspeakers and telephones[5].

International recommendations on NICUs design with regard to the acoustic environment propose favoring softly speaking, with relaxed vocal effort, with acoustic intimacy, comfortable for both personnel and family parents, facilitating physiological sleep of the baby while providing favorable acoustic stimulation to continue with the auditory pathway development without damaging it[6]. The American Academy of Pediatrics (AAP) and the Environmental Health committee established permissible levels of noise at 45 dB (continuous) during the day, with a transient maximum peak of 65 dB, and 35 dB for the night[7].

The purpose of our study is to identify the acoustical environment conditions of healthcare-related areas at the Neonatology Unit of the "Dr. José Eleuterio González" University Hospital in order to develop strategies aimed at improving premature newborns' care and this way counteract noxious effects that compromise their adequate development.

Material and methods

Descriptive, analytical, prospective, observational investigation study conducted at the Neonatology Department of the "Dr. José Eleuterio González" University Hospital of the Faculty of Medicine, Universidad Autónoma de Nuevo León, from November 1 through 22, 2011. The trial was approved by the institutional ethics committee with the folio number NEO11-003. Subsequent continuation of the study was planned with environmental modifications made and new dB measurements in the period comprised from May 1 to 22, 2012.

Levels of noise were determined for 3 consecutive weeks in all different areas associated with newborn care in our institution: the NICU, the neonatal intermediate care unit (UCIREN), the delivery unit (TOCO QX) and the step-down nursery unit (CUNERO).

These measurements were carried out before and after the implementation of strategies to reduce the levels of noise: Infrastructural modifications (the NICU was physically separated from the pediatric intensive care unit, since, previously, both shared a common area separated by a nursery station). Illumination modifications (separation of switches by areas, with dim emergency lights installed in the NICU periphery with lower light intensity). And staff training (educational talks to the nursery staff, social workers, inhalotherapists, pediatrics and neonatology staff physicians and residents about the strategies, providing relevant information and the protocol to be followed).

Noise average level was defined and the results obtained before and after these modifications were compared with the levels of noise established by the AAP, 45 dB at daytime and 35 dB at nightime[8].

The levels of noise were compared between the different areas (NICU, UCIREN, TOCO QX and CUNERO), between study weeks (1, 2 or 3); with all 3 shifts (morning, 07:00-13:00 h; afternoon, 13:00-21:00 h and night, 21:00-07:00 h) being compared against each area. In addition, a comparative analysis was carried out between the levels of sound recorded in all different areas with the days of the week being analyzed (Monday, Wednesday, Friday and Sunday).

A Radioshack sonometer with 40-120 dB graduation and 0.1 dB resolution was used (Sound Level Meter Cat. No. 33-2055 A), with the equipment being calibrated after each measurement in order to identify the level of noise at different areas and acitivities of the NICU. The obtained measurements were recorded in a case report form.

Statistical method

The obtained results were captured in a database developed with the Microsoft Excel program, with later analysis using the SPSS (Statisticak Package for Social Sciences) software, version 17.

For statistical analysis, quantitative variables were used and central (mean and median) and dispersion (standard deviation) tendency measures were determined.

Table 1. Pre-intervention. Average decibel level of each area as related to the study week

Week	NICU $\bar{x} \pm SD$	UCIREN $\bar{x} \pm SD$	TOCO QX $\bar{x} \pm SD$	CUNERO $\bar{x} \pm SD$	Total $\bar{x} \pm SD$	F*	p
Week 1	58.1 ± 5.1	54.7 ± 3.7	57.3 ± 5.0	58.8 ± 5.7	57.2 ± 5.1	6.5	< 0.001
Week 2	59.8 ± 4.4	55.3 ± 3.9	57.4 ± 4.1	57.2 ± 6.7	57.4 ± 5.1	6.8	< 0.001
Week 3	61.8 ± 4.4	56.1 ± 4.1	57.2 ± 4.6	56.9 ± 4.9	58.0 ± 5.0	15.5	< 0.001
Total	59.9 ± 4.8	55.4 ± 3.9	57.3 ± 4.6	57.7 ± 5.8	–	21.4	< 0.001

NICU: neonatal intensive care unit; UCIREN: neonatal intermediate care unit; TOCO QX: surgical obstetrics unit; CUNERO: step-down nursery.
*analysis of variance.

The hypothesis tests used were the analysis of variance (F-value) and Turkey's post-hoc HSD test.

For the analysis of measurements in different areas, the t paired test was used, whereas to compare the level of noise with different variables, Pearson's correlation test and linear regression were used. An alpha value of 0.001 was used, and the null hypothesis was rejected when the critical value was lower than 0.001.

Results

Pre-intervention

When average level of noise of each area was compared with regard to the study week, we found that, on week 1, the highest level corresponded to the NICU (58.1 ± 5.1) and the lowest to the UCIREN (54.7 ± 3.7) ($p < 0.001$). On week 2, the highest levels were recorded in the NICU (59.8 ± 4.4), and the lowest at the UCIREN (55.3 ± 3.9) ($p < 0.001$). On week 3, we found the same pattern, with the highest level reported at the NICU (61.8 ± 4.4), and the lowest at the UCIREN (56.1 ± 4.1) ($p < 0.001$) (Table 1). When combined or total mean noise was assessed with no separation by weeks, we observed the highest noise at the NICU (59.9 ± 4.8), and the lowest in the UCIREN (55.4 ± 3.9). The analysis of variance detected statistically significant differences ($F = 2.14$ and $p < 0.001$) (Table 1). On the other hand, it is also convenient to describe the results on the other sense, i.e., comparing the level of noise between all 3 weeks, within each determinate area. This way, statistically significant differences ($p < 0.001$) were only found at the NICU, where the highest noise was recorded on week 3, with 61.8 ± 4.3, and the lowest on week 1, with 5.8 ± 5.1 ($F = 7.6$) (Table 1).

When levels of noise at each area were compared analyzing each shift separately, we found the following: in the morning shift, the area with the highest noise was the NICU, with 59.7 ± 5.0, and the dB lowest levels were recorded in the UCIREN, with 56.2 ± 4.4 ($p < 0.01$) (Table 2). In the afternoon shift, the highest noise average corresponded to the NICU, with 59.5 ± 4.3, and the lowest level of noise was recorded at the UCIREN, with 54.6 ± 3.3 ($p < 0.001$) (Table 2). Finally, values analyzed in the night shift showed the highest level of noise in the NICU, with 60.5 ± 5.1, and the lowest levels in the UCIREN, with 55.2 ± 3.8, and in TOCO QX, with 55.4 ± 4.8 ($p < 0.001$) (Table 1). On the other hand, it should be noted that when we compared each shift's noise within a given area, the analysis of variance did not show statistically significant differences between all 3 shifts at each area ($F = 2.0$; $p = 0.130681$), except for TOCO QX, where the highest level of noise was determined during the afternoon shift (58.6 ± 4.5 dB), and the lowest level during the night shift (55.4 ± 4.8 dB; $F = 7.3$; $p < 0.001$) (Table 2).

When the levels of noise of the different areas were compared with regard to the days of the week analyzed in the study, we found: on Monday, the highest level of noise was observed at the NICU, with 61.0 ± 4.2, and the lowest level at the UCIREN (56.2 ± 4.1; $F = 3.8$) ($p < 0.001$) (Table 3). On Wednesday, the highest level was also recorded at the NICU, with 59.3 ± 5.16 dB, in comparison to that recorded in the UCIREN, which was the lowest (55.0 ± 3.9; $F = 4.4$; $p < 0.01$) (Table 3). On Fridays of all 3 analyzed weeks, we detected the highest degree of dB at the NICU (60.7 ± 5.1), and the lowest at the UCIREN (55.3 ± 4.0), ($p < 0.001$ and $F = 8.4$) (Table 3). Sunday showed the same pattern as previous days: the highest level of noise was 58.8 ± 4.5 at the NICU, and the lowest level, 54.9 ± 3.8, at the UCIREN ($F = 4.5$; $p < 0.01$). Again, in this case we also assessed if in a given area the level of sound varied according to the day of the week, but no perceivable differences were observed ($F = 1.5$; $p = 0.2204911$) (Table 3).

Table 2. Pre-intervention. Average decibel level of each area with regard to each assessed shift

Shift	NICU $\bar{x}$ ± SD	UCIREN $\bar{x}$ ± SD	TOCO QX $\bar{x}$ ± SD	CUNERO $\bar{x}$ ± SD	Total $\bar{x}$ ± SD	F*	p
Morning	59.7 ± 5.1	56.2 ± 4.4	58.0 ± 3.8	58.7 ± 6.7	58.1 ± 5.2	3.8	< 0.05
Afternoon	59.5 ± 4.4	54.6 ± 3.3	58.6 ± 4.5	56.8 ± 5.3	57.4 ± 4.8	11.6	< 0.001
Night	60.5 ± 5.1	55.2 ± 3.9	55.4 ± 4.8	57.5 ± 5.1	57.1 ± 5.2	12.8	< 0.001
Total	59.9 ± 4.8	55.4 ± 3.9	57.3 ± 4.6	57.6 ± 5.8	–	21.3	< 0.001

NICU: neonatal intensive care unit; UCIREN: neonatal intermediate care unit; TOCO QX: surgical obstetrics unit; CUNERO: step-down nursery.
*analysis of variance.

Table 3. Pre-intervention. Average decibel level of each area with regard to the studied day of the week

Day	NICU $\bar{x}$ ± SD	UCIREN $\bar{x}$ ± SD	TOCO QX $\bar{x}$ ± SD	CUNERO $\bar{x}$ ± SD	Total $\bar{x}$ ± SD	F*	p
Monday	61.0 ± 4.2	56.2 ± 4.1	57.6 ± 4.7	57.6 ± 5.7	58.1 ± 5.0	6.6	< 0.001
Wednesday	59.3 ± 5.2	55.0 ± 3.9	58.2 ± 5.1	57.3 ± 6.3	57.4 ± 5.4	4.4	< 0.01
Friday	60.7 ± 5.1	55.3 ± 4.0	56.6 ± 4.0	58.5 ± 5.9	57.8 ± 5.2	8.4	< 0.001
Sunday	58.8 ± 4.5	54.9 ± 3.8	56.8 ± 4.4	57.1 ± 5.4	56.9 ± 4.7	4.5	< 0.01
Total	59.9 ± 4.8	55.4 ± 3.9	57.3 ± 4.6	57.6 ± 5.8	–	21.7	< 0.001

NICU: neonatal intensive care unit; UCIREN: neonatal intermediate care unit; TOCO QX: surgical obstetrics unit; CUNERO: step-down nursery.
*analysis of variance.

Post-intervention

When average noise level of each area was compared with regard to the study week we found the following: on week 1, the highest noise average coresponded to the NICU, with 58.1 ± 4.8 dB, and the lowest, to the UCIREN, with 52.4 ± 4.7 dB and F = 10.9 (p <0.001) (Table 4). On week 2, the recorded levels of noise were also higher in the NICU, with 55.1 ± 4.1 dB, and the lowest, at the UCIREN, with 51.1 ± 4.5 dB, with F = 1.28 and p < 0.001. On week 3, we could observe that the highest level of noise was in TOCO QX, with 57.9 ± 4.9 dB, and the lowest level at the UCIREN, with 50.5 ± 3.8 dB. When mean total noise was assessed without separation by weeks, but only by assessed areas, we found the highest measurement for TOCO QX, with 57.3 ± 5.5 dB, and the lowest for UCIREN, with 51.3 ± 4.4 dB (p < 0.001) (Table 4). However, it is also convenient to describe the results in the opposite direction, i.e., within a given area,

Table 4. Post-intervention. Comparison of each area's decibel level with regard to the study week

Week	NICU $\bar{x}$ ± SD	UCIREN $\bar{x}$ ± SD	TOCO QX $\bar{x}$ ± SD	CUNERO $\bar{x}$ ± SD	Total $\bar{x}$ ± SD	F*	P
Week 1	58.1 ± 4.8	52.4 ± 4.7	57.8 ± 5.7	55.8 ± 6.6	56.0 ± 5.9	10.9	< 0.001
Week 2	55.1 ± 4.1	51.1 ± 4.5	56.3 ± 5.9	51.8 ± 4.9	53.6 ± 5.1	12.8	< 0.001
Week 3	56.1 ± 4.6	50.5 ± 3.8	57.9 ± 4.9	54.1 ± 5.0	54.7 ± 5.3	22.4	< 0.001
Total	56.4 ± 4.7	51.3 ± 4.4	57.3 ± 5.5	53.9 ± 5.7	–	40.0	< 0.001

NICU: neonatal intensive care unit; UCIREN: neonatal intermediate care unit; TOCO QX: surgical obstetrics unit; CUNERO: step-down nursery.
*analysis of variance.

Table 5. Post-intervention. Comparison of each area's decibel levels with regard to assessed shift

Shift	NICU x̄ ± SD	UCIREN x̄ ± SD	TOCO QX x̄ ± SD	CUNERO x̄ ± SD	Total x̄ ± SD	F*	P
Morning	57.5 ± 4.6	53.4 ± 4.9	57.6 ± 4.6	53.5 ± 5.6	55.5 ± 5.4	11.	< 0.001
Afternoon	58.1 ± 4.4	51.9 ± 3.3	59.4 ± 4.6	57.2 ± 5.6	56.7 ± 5.4	25	< 0.001
Night	53.7 ± 3.7	48.7 ± 3.1	54.9 ± 6.3	51.1 ± 4.2	52.1 ± 5.1	18	< 0.001
Total	56.4 ± 4.7	51.3 ± 4.4	57.3 ± 5.5	53.9 ± 5.8	–	40	< 0.001

NICU: neonatal intensive care unit; UCIREN: neonatal intermediate care unit; TOCO QX: surgical obstetrics unit; CUNERO: step-down nursery.
*analysis of variance.

comparing the level of sound between weeks; this way, we found statistically significant differences for the UCIN, where the highest noise was recorded on week 1 (58.1 ± 4.8 dB), and the lowest on week 2 (55.1 ± 4.1 dB). For CUNERO, the highest noise was during week 1 (55.8 ± 6.6 dB), and the lowest on week 2 (51.8 ± 4.9 dB). For UCIREN and TOCO QX, the noise was similar during all 3 study weeks, with no significant differences being appreciated (Table 4).

When each area's levels of noise were compared analyzing each turn individually we found the following: in the morninh shift, the area with the highest noise was TOCO QX (57.6 ± 4.6), and the least noisy area was the UCIREN (53.4 ± 4.9 dB). In the afternoon shift, the highest average was also recorded by TOCO QX (59.4 ± 4.6 dB), and the lowest, by the UCIREN (51.9 ± 3.3 dB). For the night shift, the behavior was similar, with higher level of noise for TOCO QX (54.9 ± 6.3 dB) and lower for UCIREN (48.7 ± 3.1 dB); with regard to the shift, in all 3 areas there was significant difference demonstrated between the groups with the highest and lowest levels, with a p-value < 0.001 (Table 5). Again, it is convenient to describe the results comparing the noise between shifts wthin a given area; in this case, the highest level for the NICU was recorded in the afternoon shift, with 58.1 ± 4.4 dB, and the lowest, in the night shift, with 53.7 ± 3.7 dB. At the UCIREN, the morning shift recorded the highest level of noise (53.4 ± 4.9 dB), and the night shift, the lowest (48.7 ± 3.1 dB): For the TOCO QX area, the afternoon shift recorded the highest level of noise (59.4 ± 4.6 dB), and the night shift, the lowest (51.1 ± 4.3 dB). In the CUNERO area, the noisiest was the afternoon shift, with 57.2 ± 5.6 dB, and the least noisy, the night shift, with 51.1 ± 4.3 dB. Overall, without making any difference between areas, the afternoon shift was the one that recorded the highest number of dB (56.7 ± 5.4), in comparison with the night shift (52.1 ± 5.1 dB); the analysis of variance revealed statistically significant differences (F = 38.6 and p < 0.001) (Table 5).

When the levels of noise of the different areas were compared with regard to the days of the week analyzed in the study, we found the following: on Monday, the highest level was recorded in TOCO QX, with 55.9 ± 5.3 dB, and the lowest level was for CUNERO, with 51.6 ± 3.9. On Wednesday, the highest level was recorded in TOCO QX (55.2 ± 5.9 dB), and the lowest by UCIREN (50.4 ± 4.1 dB). On Friday, the area with the highest noise was TOCO QX (60.7 ± 4.7 dB), and the area with the lowest noise, the UCIREN (50.3 ± 5.1 dB). On Sunday, measurements were very similar, with the highest level for TOCO QX, with 57.5 ± 4.5 dB, and the lowest, for UCIREN, with 51.3 ± 4.4 dB, with statistically significant differences existing in all measurements conducted, with a p-value < 0.001. From another perspective, analyzing the level of noise according to the days and in specific areas, we found that the highest level recorded at the NICU was on Friday (56.9 ± 4.7 dB), and the lowest on Wednesday (55.1 ± 5.2 dB). In the UCIREN, the level of noise was maintained stable and there were no statistically significant differences between days of the week. In TOCO QX statistically significant differences (p < 0.001) did exist: the highest level was recorded on Friday (60.7 ± 4.7 dB), and the lowest on Wednesday (55.2 ± 5.9 dB). Additionally, in CUNERO we also found significant difference (p < 0.001), with the highest level for Friday (56.6 ± 6.1 dB), and the lowest for Wednesday (53.8 ± dB), with an F-value of 6.09 (Table 6).

When the results were analyzed comparing total average levels of noise in different neonatal care areas before and after the intervention we found that, in the NICU, pre-intervention levels were 59.9 ± 4.8 dB vs. 56.4 ± 4.7 dB post-intervention (Fig. 1). The comparative

Table 6. Post-intervention. Decibel average of each day with regard to the assessed area

Day	NICU $\bar{x} \pm$ SD	UCIREN $\bar{x} \pm$ SD	TOCO QX $\bar{x} \pm$ SD	CUNERO $\bar{x} \pm$ SD	Total $\bar{x} \pm$ SD	F*	P
Monday	55.7 ± 3.4	52.4 ± 3.5	55.9 ± 5.3	51.6 ± 3.9	54.1 ± 4.7	8.2	< 0.001
Wednesday	55.1 ± 5.2	50.4 ± 4.1	55.2 ± 5.9	52.9 ± 6.5	53.8 ± 5.5	3.3	< 0.05
Friday	58.1 ± 4.7	50.3 ± 5.1	60.7 ± 4.7	56.8 ± 5.9	56.6 ± 6.1	24.2	< 0.001
Sunday	56.9 ± 4.7	52.2 ± 4.3	57.5 ± 4.5	54.4 ± 5.2	55.3 ± 5.1	9.5	< 0.001
Total	56.4 ± 4.7	51.3 ± 4.4	57.3 ± 5.5	53.9 ± 5.7	–	32.0	< 0.001

NICU: neonatal intensive care unit; UCIREN: neonatal intermediate care unit; TOCO QX: surgical obstetrics unit; CUNERO: step-down nursery.
*analysis of variance.

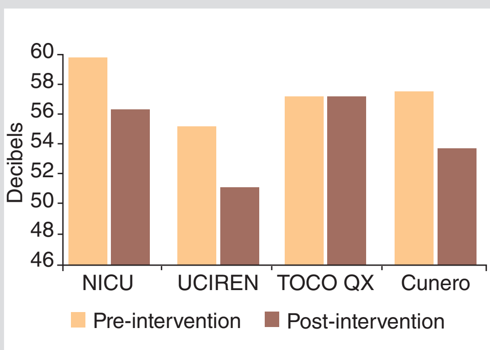

Figure 1. *Level of noise (decibels) prior to the intervention and after the intervention in all different areas. NICU: neonatal intensive care unit; UCIREN: neonatal intermediate care unit; TOCO QX: surgical obstetrics unit; CUNERO: step-down nursery.*

analysis with Student's t-test indicated that these differences were statistically significant ($p < 0.001$) (Table 7), with an attenuation average of 3.5 dB. In the UCIREN, pre-intervention levels were 55.4 ± 3.9 vs. 51.3 ± 4.4 dB, with these being significantly lower after the intervention ($p < 0.001$), with an attenuation of 4 dB. In the TOCO QX area we did not demonstrate statistically significant differences before and after the intervention (57.3 ± 4.6 vs. 57.3 ± 5.5 dBl (Table 7). Finally, for CUNERO, we recorded pre-intervention levels of noise of 57.6 ± 5.8 vs. 53.9 ± 5.7 dB post-intervention, with statistically significant differences ($p < 0.001$) with a 3.7 dB attenuation (Table 7).

Discussion

There are growing concerns in different publications on the implication of noise in the generation of neonatal stress, and continuous exposure of a vulnerable and immature individual will lead to general health status deterioration as well as to long-term neurodevelopmental disorders and neurosensory hypoacusis of variable degrees[8,9]; therefore, numerous studies refer different strategies to reduce the noise, especially in the NICU, since this place is the main

Table 7. Comparison between total mean values at different areas of neonatal care before and after interventional strategies to reduce the noise

Areas	Pre-intervention ± SD	Post-intervention ± SD	p*
NICU	59.9 ± 4.8	56.4 ± 4.7	< 0.001
UCIREN	55.3 ± 3.9	51.3 ± 4.4	< 0.001
TOCO QX	57.3 ± 4.6	57.3 ± 5.5	NS
CUNERO	57.6 ± 5.8	53.9 ± 5.8	< 0.001

NICU: neonatal intensive care unit; UCIREN: neonatal intermediate care unit; TOCO QX: surgical obstetrics unit; CUNERO: step-down nursery.
*Student's t-test.

noise generator, without forgetting the neonatal intermediate care units[6,10-14]. It should be mentioned that, unlike reports published in the literature, measurements were made in all areas involved with the care of newborns in this study; unlike current reports, where only the NICU and the neonatal intermediate care unit (UCIREN) are referred to, the surgical obstetrics unit (TOCO QX) and the step-down nursery (CUNERO) were also included.

In the analysis we made of pre-intervention noise behavior in the different areas of neonatal care, all measurements were above the international recommendations, with a mean of 59.9 dB, similar to figures reported by other authors; however, we did not find statistically significant differences between the 3 consecutive weeks of study, work shifts and assessed days of the week, unlike other authors who have documented a noise decrease as study weeks advance, with the predominating shift being the morning shift, and of the days, Monday being the noisiest[14-17]. The NICU was the area with the highest noise and the UCIREN was the one with the lowest noise, as reported by other authors, since there is more personnel working and larger amount of electrimedical equipment (monitors, ventilators, suction, etc.); however, the dB levels recorded in all measurements are well above the ranges recommended by international standards prior to the implementation of strategies intended to reduce the noise as reported[15-20].

In the post-intervention analysis, the levels of noise decreased with regard to those previously recorded at the NICU, UCIREN and CUNERO, thus being the Neonatology Department-dependent areas that were most susceptible to change, unlike TOCO QX, where the personnel is in constant rotation and does not adapt to noise-control strategies. With regard to these findings, most authors report a noise decrease following the implementation of specific programs, with differences lying in adherence to behaviors and close surveillance[11,21-23]. The afternoon shift recorded the highest levels of noise, and the night shift, the lowest, at all areas of neonatal care, with this being atributted to the fact that in the morning there is more compliance with interventional strategies and at night there is less personnel present and, in general, less activity than in other shifts, with the afternoon shift being the noisiest; most studies refer the morning shift as being the noisiest[20,24] and a Brazilian study refers to the afternoon shift, as in the present trial[25].

With the implemented strategies we managed to attenuate the noise by 3.5 dB for the NICU, 4 dB for the UCIREN and 3.7 dB for CUNERO, with this difference being statistically significant. Other authors report highly variable attenuation ranges from 4 to up to 10 dB, with the difference lying on adherence to behaviors and long-term follow-up of these; hence, the obtained attenuation range is consistent with previous reports by other authors[21-23,26,27].

In spite of the strategies employed to modulate the acoustic environment in the different areas for the care of neonates, such as the NICU, UCIREN and CUNERO, the recorded dB levels continue above the international recommendations[8], as previously documented by other authors, and this is owing to difficulties to adhere to interventional programs by the personnel working in these areas and periodical surveillance of compliance, lack of knowledge and attitude towards change, large quantities of older generation, highly noisy electromedical equipment and hospital open-unit design, since, currently, everything suggests that units with individual rooms are less noisy[24]; with these new designs, in addition to individual noise and light attenuation, a more individualized care can also be provided to the patient and promote more closeness to his/her family, since separation from the parents is also considered a preponderant factor in the generation of neonatal stress[6,10,13].

We could continue enumerating difficulties in the compliance with programs focused on noise decrease; however, it is essential that once we know our deficiencies, to recognize areas of opportunity to carry out this program – as important as all other activities – in intensive care, and not to decline in the face of negative attitudes by the personnel, to adopt already proven noise reduction protocols according to our infrastructure and purchasing power and, if necessary, even regulate this as a right for the patients and an obligation for the Hospital.

References

1. Galván BE, Villa GM, Villanueva GD, et al.; Neosano's Group. Very low birth weight (VLBW): Risk factors for incidence and mortality at eight different hospitals in Mexico. A regional experience. Pediatr Acad Soc Meet. 2005;57:308.
2. Perlman JM. Neurobehavioral deficits in premature graduates of intensive care-potential medical and neonatal environmental risk factors. Pediatrics. 2001;108: 1339-48.
3. Als H. A synactive model of neonatal behavioral organization. Phys Occup Ther Pediatr. 1986;6:35-55.
4. Als H. NIDCAP Federation International. An Education and Training Program for Health Care professional, 1986. [actualizado marzo 2009].
5. Als H, Duffy FH, McAnulty GB, et al. Early experience alters brain function and structure. Pediatrics. 2004;113:846-57.
6. Als H, Gilkerson L. The role of relationship-based developmentally supportive newborn intensive care in strengthening outcomes of preterm infants. Semin Perinatol. 1997;21:178-89.

7. Altuncu E, Akman I, Kulekci S, et al. Noise levels in neonatal intensive care unit and use of sound absorbing panel in the isolette. Int J Pediatr Otorhinolaryngol. 2009;73:951-3.
8. American Academy of Pediatrics, Committee on Environmental Health. Noise: a hazard for the fetus and newborn. Pediatrics. 1997;100:724-7.
9. Gallegos J, Reyes J, Fernández V, et al. Índice de ruido en la unidad neonatal. Su impacto en recién nacidos. Acta Pediatr Mex. 2011;32:5-14.
10. Forsythe P. New practices in the transitional care center improve outcomes for babies and their families. J Perinatol. 1998;18:S13-7.
11. Laudert S, Liu WF, Blackington S, et al.; NIC/Q 2005 Physical Environment Exploratory Group. Implementing potentially better practices to support the neurodevelopment of infants in the NICU. J Perinatol. 2007;27:S75-93.
12. McKlindon D, Barnsteiner JH. Therapeutic relationships: Evolution of the Children's Hospital of Philadelphia model. MCN Am J Matern Child Nurs. 1999;24:237-43.
13. Meyer EC, Coll CT, Lester BM, et al. Family-based intervention improves maternal psychological well being and feeding interaction of preterm infants. Pediatrics. 1994;93:241-6.
14. O'Brien M, Dale D. Family-centered services in the neonatal intensive care unit: a review of research. J Early Interv. 1994;18:78-90.
15. Philbin MK, Robertson A, Hall JW 3rd. Recommended permissible noise criteria for occupied, newly constructed or renovated hospital nurseries. The Sound Study Group of the National Resource. J Perinatol. 1999;19:559-63.
16. Szczepanski M, Kamianowska M. Evaluation of noise in the neonatal intensive care unit. Archs Perinatal Med. 2008;14:37-40.
17. Centeno Marmanillo DV, Apac Ascaño AL, Sánchez Tonohuye JC, et al. Niveles de ruido y fuentes asociadas en una unidad de cuidado intensivo neonatal. Rev Peruana Pediatr. 2005;58:12-4.
18. Fajardo L. Niveles de ruido en la Unidad de Cuidado Intensivo Neonatal «CIRENA» del Hospital Universitario del Valle, Cali, Colombia. Colomb Med. 2007;38:S64-71.
19. Matook SA, Sullivan MC, Salisbury A, et al. Variations of NICU sound by location and time of day. Neonatal Netw. 2010;29:87-95.
20. Darcy AE, Hancock LE, Ware EJ. A descriptive study of noise in the neonatal intensive care unit. Ambient levels and perceptions of contributing factors. Adv Neonatal Care. 2008;8:165-75.
21. Ramesh A, Suman Rao PN, Sandeep G, et al. Efficacy of a low cost protocol in reducing noise levels in the neonatal intensive care unit. Indian J Pediatr. 2009;76:475-8.
22. Philbin MK, Gray L. Changing levels of quiet in an intensive care nursery. J Perinatol. 2002;22:455-60.
23. Krueger C, Schue S, Parker L. Neonatal intensive care unit sound levels before and after structural reconstruction. MCN Am J Matern Child Nurs. 2007;32:358-62.
24. Krueger C, Wall S, Parker L, et al. Elevated sound levels within a busy NICU. Neonatal Netw. 2005;24:33-7.
25. Aurelio FS, Tochetto TM. Noise in a neonatal intensive care unit: measurement and perception of professionals and parents. Rev Paul Pediatr. 2010;28:162-9.
26. Wang Y, Zhang W, Li XQ, et al. Noise exposure in level III NICU environment in Beijing region and effects of intervention measures. Zhonghua Er Ke Za Zhi. 2008;46:120-3.
27. Zamberlan-Amorim NE, Fujinaga CI, Hass VJ, et al. Impact of a participatory program to reduce noise in a neonatal unit. Rev Lat Am Enfermagem. 2012;20:109-16.
28. Ramesh A, Denzil SB, Linda R, et al. Maintaining reduced noise levels in a resource-constrained neonatal intensive care unit by operant conditioning. Indian Pediatr. 2013;50:279-82.