

# Noise in a Neonatal Intensive Care Unit: measurement and perception of professionals and parents

*Ruído em uma Unidade de Terapia Intensiva Neonatal: mensuração e percepção de profissionais e pais*

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## ABSTRACT

**Objective:** To study the perception about environmental noise of professionals and parents of neonates assisted in a Neonatal Intensive Care Unit (NICU), and to compare the findings with the measured noise levels.

**Methods:** The perception of parents and professionals that work in the NICU in relation to the presence of noise was evaluated by a questionnaire. Sound levels in three rooms and in the corridor of that environment were registered 24 hours/day during 9 days by the Quest Q-400 Noise Dosimeter and analyzed by QuestSuíte<sup>MR</sup> software. Kruskal-Wallis e Mann-Whitney tests were used to compare the noise levels in different places, being significant  $p < 0.05$ .

**Results:** The average noise levels in the intensive, intermediary care, isolation rooms and in the corridor of the unit were 64.8, 62.1, 63.8 and 61.9 dBA, respectively ( $p < 0.001$ ). Health professionals qualified the noise as present and intense, but parents evaluated the noise as moderate. Health professionals judged their own behaviors as noisy, and parents believe that they do not contribute to the existent noise at the place. Health professionals believed that newborns and professionals who work in the NICU may be injured by the noise, but this was not true for parents. All groups considered possible to reduce noise.

**Conclusions:** The opinion about noise intensity differed significantly among health professionals and parents. Health professionals were more coherent about NICU's measured and perceived noise levels.

**Key-words:** noise; infant, newborn; noise measurement; neonatology.

## RESUMO

**Objetivo:** Conhecer a percepção dos profissionais atuantes em Unidade de Terapia Intensiva Neonatal e dos pais dos recém-nascidos internados sobre o ruído existente, além de compará-la aos níveis de ruído mensurados.

**Métodos:** Por meio de questionário, investigou-se a percepção dos profissionais que atuam na unidade, bem como a dos pais dos recém-nascidos internados, quanto ao ruído existente no ambiente. Os níveis sonoros das três salas e do corredor da unidade foram registrados 24 horas/dia, por nove dias em cada local, com dosímetro Quest 400, e analisados pelo *software* QuestSuíte<sup>MR</sup>. Para comparar os níveis de ruído nos diferentes locais, aplicaram-se os testes de Kruskal-Wallis e Mann-Whitney, sendo significante  $p < 0,05$ .

**Resultados:** Nas salas de cuidados intensivos e intermediários, no isolamento e no corredor da unidade foram registrados níveis médios de ruído de 64,8, 62,1, 63,8 e 61,9 dBA, respectivamente, sendo diferentes entre si ( $p < 0,001$ ). Os profissionais da saúde consideraram o ruído presente e intenso e os pais, moderado. Só os primeiros julgaram ruidoso o próprio comportamento. Os profissionais da saúde acreditam que tanto os recém-nascidos quanto as pessoas que trabalham nesse ambiente podem ser prejudicados pelo ruído, enquanto os pais acreditam que não. Todos os grupos julgaram possível reduzir tal ruído.

**Conclusões:** A opinião sobre a intensidade do ruído diferiu entre os profissionais da saúde e os pais dos recém-nascidos. Houve maior concordância entre o nível de ruído mensurado e a percepção do mesmo pelos profissionais da saúde.

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## Introduction

Neonatal intensive care units (NICU) use a large number of technological resources to increase the survival of their newborn (NB) patients by guaranteeing them the best available treatment and the fastest recovery time. However, many of these technologies produce high sound pressure levels (SPL) and make the intensive care environment noisy, contributing to the appearance of physiological and behavioral disorders in people exposed to it.

The most common sources of noise are: mechanical ventilators, heated cots, infusion pumps, monitors, incubators<sup>(1)</sup>, alarms<sup>(1-3)</sup> and air-conditioning<sup>(4-6)</sup>. High noise levels have also been reported as being caused by workers laughing and conversing<sup>(1-4,6,7)</sup>, lack of care opening and closing ICU doors<sup>(2,4,5,8,9)</sup>; moving incubators; dragging chairs<sup>(4)</sup> and carelessness when closing cupboards, drawers and trashcans<sup>(2,5)</sup>.

Exposing NB to high levels of noise does not only risk causing hearing deficiency<sup>(10)</sup>, but can also alter sleeping patterns and cause irritability<sup>(11,12)</sup>, agitation, crying, tiredness, increased oxygen consumption and elevated heart rate<sup>(11)</sup>, with a negative impact on the healing process.

Professionals working in the presence of high sound pressure levels can suffer tiredness<sup>(13)</sup>, headaches, reduced ability to concentrate, irritability, hypertension<sup>(14)</sup>, altered cardiac rhythm<sup>(14,15)</sup> hearing loss<sup>(14,16)</sup>, mood swings<sup>(15,17)</sup>, psychiatric disorders (neuroses, psychoses and hysteria)<sup>(17)</sup> and stress<sup>(15,17,18)</sup>.

Parents of patients subjected to high noise levels can suffer physiological and behavioral stress and sensory overload and the noise can also make it difficult for them to interact with their infants<sup>(13)</sup>.

Current standards recommend that daytime noise levels in hospitals be maintained below 45dBA<sup>(10,19-22)</sup> with a  $L_{\max}$  (1 second) of 65dBA<sup>(22)</sup>, while at night the limit is 35dBA<sup>(19)</sup>. However the recommended levels, whether from Brazilian or international standards, are often exceeded.

The objective of this study is to investigate the perceptions of professionals working in the NICU at the *Hospital Universitário de Santa Maria* (HUSM) of the noise levels in the unit and also the perceptions of the unit's patients' parents and to compare these perceptions with actual noise levels measured in the unit.

## Methods

This is a quantitative, non-experimental, descriptive and exploratory study using data collected in the NICU at the HUSM between the 10th of November and the 20th of December of 2007. The project was approved by the research ethics committee at the *Universidade Federal de Santa Maria*. Management at the HUSM and the NICU also gave their consent to the research after analyzing the proposal.

The unit comprises one intensive care ward (six/eight heated cots and incubators); one intermediate care ward (eight standard cots) and one isolation ward (three heated cots).

The study investigated those professionals working at the unit and the parents of its patients who did not have hearing deficiencies considered severe enough to interfere with the study and who agreed to take part. Employees who were on holiday or on leave were not included and neither were parents who did not feel emotionally able to take part because of their children's condition. No sample size calculation was made because the intention was to research the perceptions of those health professionals and parents who were in the unit during the study period. The final study sample comprised 43 (61%) health professionals, six (9%) professionals from other areas and 21 (30%) parents of patients who were in the NICU at the HUSM during the study period. Professionals who were not health professionals (secretarial and general staff) were classified as "other professionals" for analysis.

The lead author administered a questionnaire containing eight open or closed questions on: the respondent's opinion of the acoustic environment in the HUSM NICU; major sources of noise; possible effects on professionals, parents and patients and possibilities for reducing the noise in the unit.

At the same time that the questionnaire data was collected, noise levels in the NICU were measured. Sound levels were measured in all three wards and in the unit's corridor, 24 hours a day for nine days in each location, using a *Quest 400* noise dosimeter calibrated and monitored by an occupational health and safety technician. There was an interval of 1 day between ending measurement in one location and setting up in the next, during which time the data were uploaded to a computer. Therefore, approximately 216 hours (12,960 minutes) of sound level data were collected at each location, making a total of more than 51,800 minutes of measurements for analysis. These noise measurements were planned on the basis of the availability of the noise dosimeter and no sample size calculation was performed.

The dosimeter was positioned in each measurement location, as described below:

- Intensive Care Ward: approximately 1m from the ceiling, on top of a cupboard fixed to one of the side walls of the ward.
- Intermediate Care Ward: approximately 80cm from the ceiling, also on top of a cupboard fixed to one of the side walls of the ward, this time to the left of the door.
- Isolation Ward: 1m 20cm from the ceiling, on top of a rectangular light fitting on the wall to the right of the door – the light fitting did not make any noise that could interfere with measurement.
- Corridor: 15cm from the ceiling on top of a cupboard, very close to the door leading to the intensive care ward.

It was not possible to position the noise dosimeter in the center of the wards or of the corridor, as recommended in the literature, because the flow of people, the unit's routine and the positioning of furniture were all unfavorable.

Fixing the noise dosimeter approximately 1m from the ceiling was also ruled out because the physical conditions were not conducive to this and it was not possible to interrupt the unit's routine or to make loud noises while fitting an appropriate support for the meter.

The meter was programmed to operate from 40 to 140 dB. The exchange rate adopted was the Brazilian standard of  $q=5\text{dB}^{(23)}$ , which means that sound intensity doubles for every 5dB increase. The battery was changed and the meter calibrated every day. The meter was also calibrated before starting measurements at each new measurement location.

*Estatística* 7.0 was used to analyze data from the questionnaire and, wherever possible (closed questions), the chi-square test and the difference between two independent proportions were used, to a significance level of 5.

The SPL measurements were analyzed by TST using *QuestSuite*<sup>MR</sup> software.

Noise levels at different measurement locations were compared using the Kruskal Wallis nonparametric test and the Mann-Whitney U test, both to a significance level of 5%.

Wherever possible, the questionnaire results were related to the noise level measurements.

## Results

Table 1 shows the results for the parents of patients and the professionals' perceptions of whether the unit was noisy and, if so, of the intensity of the noise. There was only a statistically significant difference between the health professionals' and the parents' perceptions. When asked about the sources of noise in the unit, 98% of the health professionals and 67% of the other professionals said they thought the noise was primarily generated by equipment. A large proportion of the parents (48%) believed that equipment was primarily responsible for creating the noise, followed by 29% who believed that the professionals were the primary cause of the noise in the NICU. There were statistically significant differences between the health professionals' opinions and the opinions of the other professionals ( $p=0.003$ ), and also between the opinions of the health professionals and the parents' opinions ( $p<0.001$ ).

Table 2 shows the perceptions of the professionals working in the NICU and of the parents of the unit's patients about their own behavior in the unit. The health professionals' opinions differed statistically from the other two groups. The noisy behaviors mentioned with greatest frequency were unavoidable handling and movements and conversation.

Table 3 lists the groups' opinions on whether the noise in the NICU could be harmful to professionals, patients or parents. There were statistically significant differences between the opinions of the health professionals and the opinions of the other two groups on whether the noise in the NICU could harm the neonates ( $p<0.001$ ). The health professionals' opinion on whether exposure to the noise in the NICU could be harmful to professionals was also different to the other two groups.

**Table 1** – Perceived level of noise in a neonatal ICU according to professionals and parents of patients

	Noise			Total n
	Absent n (%)	Moderate n (%)	Intense n (%)	
Health professionals	0	17 (39.5)	26 (60.5)	43
Other professionals	1 (16.7)	2 (33.3)	3 (50.0)	6
Parents of patients	4 (19.0)	14 (66.7)	3 (14.3)	21
Total	5 (7.1)	33 (47.1)	32 (45.7)	70

Health professionals *versus* parents of patients,  $p<0.001$ .

When asked about the possibility of effects harmful to the parents, the majority of respondents did not believe that they would be affected by the noise in the HUSM NICU because they did not spend long enough in the NICU. No statistically significant differences were detected between the three groups.

When asked whether it would be possible to reduce the noise in the unit, the majority of the health professionals (98%), the other professionals (67%) and the parents (57%) believed it would be possible, with a statistically significant difference between the proportion of health professionals and the proportion of other professionals ( $p=0.003$ ) and between the proportion of health professionals and the proportion of parents who believed it would be possible to reduce noise ( $p<0.001$ ).

Chart 1 illustrates the opinions of the different groups on the sources of noise in the HUSM NICU, the possibility of harmful effects to infants and professionals and on the measures that could be taken to reduce the noise in the unit studied.

Fifteen of the professionals investigated worked on the morning shift, 10 during the afternoon, 16 on the night

shift, and 2 during the morning and afternoon. Taking just those professionals who worked on the morning shift, 53% thought the noise level was moderate and 47% thought it was intense. All mentioned that the noise is primarily caused by equipment and the majority (73%) thought they contributed to the noise level. All believed that both patients and professionals exposed to these noise levels could suffer harmful effects, but the majority (60%) believed that patients' parents would not be affected. All stated that it would be possible to reduce the noise in the unit.

Of those working in the afternoon, 80% classified the noise as intense, 90% of them believed that the noise in the unit is primarily caused by equipment and 80% thought they contributed to the noise on their shift. All mentioned that the noise in the unit could be harmful to both patients and professionals, but half believed that patients' parents would not be affected. Almost all (90%) stated that it would be possible to reduce the noise in the unit.

Among those working on the night shift, 69% classed the noise as intense and 31% as moderate; all thought that the noise is primarily caused by equipment and more than 55% thought they contributed to the noise level in the unit.

**Table 2 – Perceived effect of own behavior on Neonatal ICU noise according to professionals and parents of patients**

	Own behavior does not contribute to noise n (%)	Own behavior does contribute to noise n (%)	Total n
Health professionals	14 (32.6)	29 (67.4)	43
Other professionals	5 (83.3)	1 (16.7)	6
Parents of patients	19 (90.7)	2 (9.5)	21
Total	38 (54.3)	32 (45.7)	70

Health professionals versus other professionals:  $p=0.023$ ; health professionals versus parents of patients:  $p<0.001$ ; other professionals versus parents of patients:  $p>0.005$ .

**Table 3 – Opinions of professionals and parents of patients on whether people exposed to the noise in the NICU could suffer harmful effects**

	Group affected	The noise is not harmful n (%)	The noise could be harmful n (%)	Don't know n (%)	Total n
Health professionals	Neonates	1 (2.3)	42 (97.7)	0	43
Other professionals		2 (33.3)	3 (50.0)	1 (16.7)	6
Parents of patients		9 (42.9)	8 (38.1)	4 (19.0)	21
Health professionals	Professionals	1 (2.3)	42 (97.7)	0	43
Other professionals		2 (33.3)	4 (66.7)	0	6
Parents of patients		12 (57.1)	5 (23.8)	4 (19.0)	21
Health professionals	Parents	29 (67.4)	12 (27.9)	2 (4.6)	43
Other professionals		3 (50.0)	2 (33.3)	1 (16.7)	6
Parents of patients		14 (66.7)	6 (28.6)	1 (4.8)	21

Harmful to newborn infants: health professionals versus other groups,  $p<0.001$ ;

Harmful to professionals: health professionals versus other professionals,  $p=0.003$ ; health professionals versus parents,  $p<0.001$ .

**Chart 1** – Opinions of the three groups on sources of noise in the HUSM NICU, possible effects on newborn infants and professionals, and measures to be taken to reduce the noise in the unit.

	Sources of noise (n) <sup>1</sup>	Possible effects on newborn infants (n) <sup>2</sup>	Possible effects on professionals (n) <sup>3</sup>	Measures to reduce noise (n) <sup>4</sup>
Health professionals	air-conditioning (34) behavior of professionals (24) vacuum cleaners (24) ventilators(21) monitors (15) alarms/beeps(14)	hearing problems (22) sleep disturbances (21) behavioral disorders(20) stress (16) irritability (14)	stress (27) irritability (19) hearing problems (14) headaches (8) tiredness (8)	change and/or service air-conditioners (32) change and/or service life support machines (29) raising professionals' awareness (17)
Other professionals	air-conditioning (3) behavior of professionals (2) flow of people (2)	behavioral disorders (2) hearing problems (1)	stress (3) irritability (2) hearing problems (2)	change and/or service air-conditioners (3) change and/or service life support machines (2)
Parents of patients	behavior of professionals (11) life support machines in general (10)	behavioral disorders (5) sleep disturbances (3)	headaches (2) tiredness (2) attention disorders(2)	raising professionals' awareness (6)

<sup>1</sup> opinions of people who thought that the HUSM NICU was noisy (moderate or intense noise); <sup>2</sup> opinions of people who thought that patients could be affected by the noise in the HUSM NICU; <sup>3</sup> opinions of people who thought that the professionals could be affected by the noise in the HUSM NICU; <sup>4</sup> opinions of people who thought that it was possible to reduce the noise in the HUSM NICU.

Behavioral disorders: agitation, fright, abnormal breathing, crying.

All believed that both patients and professionals exposed to this environment could suffer harmful effects, but the majority (87%) mentioned that patients' parents would not be affected, probably as a result of the short exposure time. All stated that it would be possible to reduce the noise in the unit.

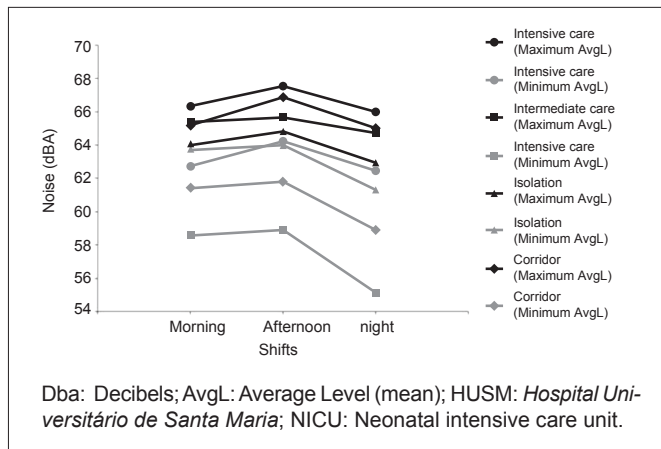
The mean noise levels recorded in the intensive and intermediate care wards, the isolation ward and the corridor were 64.8dBA, 62.1dBA, 63.8dBA and 61.9dBA respectively. Figure 1 illustrates the maximum and minimum average levels (AvgL) by shift and by measurement location. It was observed that in all four measurement locations the highest maximum and minimum AvgL both occurred during the afternoon shift. It was also observed that higher noise levels were recorded in the intensive care and isolation wards and the greatest variability was recorded in the intermediate care ward.

Taking the entire dataset, the noise level variability was also greatest in the intermediate care ward and the difference when compared to the other locations was statistically significant ( $p < 0.001$ ), but the other locations did not differ significantly from each other ( $p = 0.26$ ).

When the measurement results were compared with the respondents' perceptions of noise levels, the health professionals had closest agreement with recorded levels, particularly those who worked on the afternoon shift. Furthermore, the noise variability recorded supports the respondents' perceptions about sources of the noise (air-conditioning and professionals).

## Discussion

It was found that the mean noise at all four measurement locations exceeded 45dBA for the majority of the



**Figure 1** – Minimum and maximum AvgL, by shift and measurement location.

measurement period. This finding suggests that this is an environment with elevated sound pressure levels and is in agreement with the perceptions of the great majority of the people in the sample, who considered the NICU to be a noisy environment. The health professionals' perceptions most clearly illustrate the presence of excessive sound levels, which do not meet the recommendations of Brazilian or international standards for neonatal and hospital environments<sup>(10,19-22)</sup>.

On the subject of the sources of noise, all three groups' opinions agree with a study by Scochi *et al*<sup>(1)</sup> which found that the principal cause of noise in NICUs is the equipment. These findings also support the results of a recent study<sup>(24)</sup>, which found that a large proportion of the nursing professionals in a NICU at a medium-size hospital in the state of São Paulo believed that the noise in their unit was primarily caused by equipment.

When asked to specify noise sources, a large proportion of respondents mentioned air-conditioning systems, in common with many other studies of NICUs<sup>(4-6,25,26)</sup>, which have observed a significant increase in noise in front of running air-conditioners. Studies conducted by Oliveira *et al*<sup>(26)</sup> and Zamberlan<sup>(5)</sup> detected increases of 17dBA to 3.5dBA in the background noise levels in NICUs when air-conditioners were switched on.

The professional team's activities was the second most mentioned source of noise, in agreement with research by Chen and Chang<sup>(27)</sup>, Diniz *et al*<sup>(6)</sup> and Carvalho *et al*<sup>(9)</sup> with conversation<sup>(1-4,6,7)</sup> being one of the most often mentioned activities. In agreement with these studies, the present study found that, after equipment noise, conversations were the second ranked cause of noise in the NICU<sup>(24)</sup>.

The health professionals' perceptions of what behaviors increase this noise were similar to those listed in other studies that have identified elevated SPL in the environments studied as being caused by conversation<sup>(1-4,6,7)</sup>, emergency procedures and treatment processes<sup>(8,28)</sup>.

With reference to the possible harmful effects on newborn infants exposed to the SPL in the HUSM NICU, the health professionals mentioned hearing deficiency, which agrees with a document published by the American Academy of Pediatrics<sup>(10)</sup>, which warns that exposure to the noise levels in PICUs can cause cochlear damage, because immature auditory structures may be more susceptible to lesions from a combination of noise and other risk factors.

Other harmful effects mentioned by these respondents were similar to the findings of other studies that have listed sleep disturbances, irritability<sup>(11,12)</sup>, behavioral disorders<sup>(11)</sup> and stress<sup>(12)</sup> as possible harmful effects to neonates exposed to high sound levels.

With reference to the harmful effects of the noise in the HUSM NICU on the professionals working in the unit, the effect most often mentioned by health professionals was stress, similar to what was observed by Morrison, Haas, Shaffner *et al*<sup>(15)</sup>, the World Health Organization<sup>(17)</sup> and Topf<sup>(18)</sup>. The next most common were irritability<sup>(14)</sup>, hearing problems<sup>(14,16)</sup>, headaches<sup>(14)</sup>, and tiredness<sup>(13)</sup>, all of which have been mentioned in other studies. Also agreeing with the literature, the other professionals mentioned stress<sup>(15,17,18)</sup>, irritability<sup>(14)</sup> and hearing problems<sup>(14,16)</sup> as possible harmful effects.

A large proportion of the parents of NICU patients believed that the professionals were unaffected by the noise, in common with reports published by Morrison, Haas, Shaffner *et al*<sup>(15)</sup>, the World Health Organization<sup>(17)</sup> and Topf<sup>(18)</sup>.

Asked about the possibility of harmful effects on parents exposed to the NICU noise levels, all three groups were in agreement that parents would not be affected since they spent so little time in the unit.

With reference to measures needed to reduce sound levels, in common with Diniz *et al*<sup>(6)</sup>, our sample stated that the air-conditioners needed replacing. Reeducation of the professional team was also suggested by health professionals and parents, similar to the literature<sup>(3,6,9,25,29)</sup>. Both health professionals and other professionals also mentioned the need to replace equipment for quieter models, which was also suggested by Lichtig and Maki<sup>(25)</sup>. Reducing the volume of equipment and its sensitivity, suggested by the other professionals, has also been mentioned in a number of

other studies<sup>(9,30)</sup>. In addition to these measures, the parents mentioned taking more care not to drag chairs and to open and close trashcan lids more quietly, which agrees with a study by Holsbach *et al*<sup>(4)</sup>.

The most intense sound pressure levels were recorded in the intensive care ward and the isolation ward, which have more life-support equipment. It is believed that the sound levels are intensified by the alarms on machines which, due to the conversations that take place in these wards and the distance between incubators and monitoring points, are set to maximum volume, as was found by Holsbach *et al*<sup>(4)</sup>. It was expected that the SPL would be lower in the intermediate care ward, which has a smaller number of these machines.

When the mean noise levels were analyzed by shift, it was observed that in all measurement locations the noise levels were at their most intense during the afternoon shift and at their lowest during the night shift, in common with results published by Ichisato<sup>(2)</sup> and Corrêa<sup>(31)</sup>. However, even during the night the noise levels exceeded the recommendations<sup>(19)</sup>.

When the measured noise levels were compared with the health professionals' perceptions, the greatest degree of agreement was observed with the afternoon shift, since 80% of them considered the noise level in the NICU to be intense, while workers on the other two shifts were split between those who thought noise was moderate and those who thought it was intense. Furthermore, more professionals on the afternoon shift believed that their own behavior contributed to the noise, indicating their awareness that their shift had elevated SPL.

Noise level variability was greatest in the intermediate care ward, with periods of silence contrasting with periods of intense noise, possibly caused by the professionals or by air-conditioning turning on, since the ward has no life-support machines.

One limitation of this study was the failure to fix the dosimeter in the center of each measurement location, one meter from the floor or one meter from the ceiling. This may have affected the results since it prevents equal capture of the sound pressure levels originating from all points within the location. Furthermore, the low number of

professionals who were not health professionals prevented extrapolation of the results of this group. Notwithstanding, it was still considered important to present their perceptions and to compare them with those of the health professionals.

In conclusion, the predominant perception among the health professionals was that the HUSM NICU has intense noise levels. They thought that they contribute to increasing the noise and that both newborn infants and professionals exposed to the noise could be affected by it. Half of the other professionals considered the noise in the NICU to be moderate and believed that these levels could be harmful to both patients and professionals. The majority of them did not think their own behavior was noisy. The parents thought the noise in this NICU was moderate and that they did not contribute to the noise. They believed that these levels would not affect the professionals. Opinions were divided on whether the neonates would suffer harmful effects, with a majority thinking they would not. All groups thought it would be possible to reduce the noise. The health professionals' perceptions exhibited the greatest degree of agreement with actual measured noise levels.

The findings of this study validate those of other studies conducted in neonatal units, finding excessive sound levels that do not meet Brazilian or international standards and recommendations for hospital and neonatal environments.

It was observed that the health professionals questioned considered the NICU studied to be noisy, that they demonstrated knowledge of the effects of that noise on newborn infants and professionals and that they believed that they themselves contributed to the noise levels, in contrast with the other two groups. These findings indicate a need to implement noise reduction programs in order to avoid the unit's patients suffering from physiological, psychological and behavioral disorders, thereby aiding their development and promoting the recovery process, in addition to improving the physiological and psychological wellbeing of the professional team. It is to be hoped that the fact that the health professionals are aware of their contribution to production of these excessive noise levels will facilitate implementation of the necessary programs.

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