NeoNoise Project: Preliminary results of sound pressure levels in a neonatal intensive care unit

Joana Santos, Carlos Carvalhais, Mara Nóia, J. Santos Baptista and Manuela Vieira Da Silva
FEUP

Abstract
The noise in the neonatal intensive care units (NICU) is recognized by many researchers as an agent with negative implications on health and well-being of premature infants and health professionals. The present study aimed to evaluate and analyse the sound pressure levels variations in a Portuguese NICU and the noise perception of health professionals and, consequently, propose control actions for noise reduction levels. The measurements of the equivalent continuous A-weighted sound pressure level (L_{Aeq}), took into account the layout of unit and location of the main sources of noise. A questionnaire was applied to assess noise perception of professionals. In general, the results are higher than the limit recommended by international organizations, ranged between 48.3 dB (A) and 82.5 dB (A). Routine activities were identified as potential source of noise levels. Significant differences has been found between the morning and night shift ($p<0.05$). The implementation of quiet time protocol is the first step to noise control in the NICU studied.

Keywords: noise; premature infants; health professionals

1. INTRODUCTION
The literature has suggested that premature infants are exposed to continuous loud noise in neonatal intensive care unit (NICU). According to Philbin & Gray (2002), the sound pressure levels in NICU ranged between 55 to 75 dB A-weighted levels. These results are higher than the limit recommended by international organisations (35 dB (A)-45 dB (A)) and may have been influenced by the equipment (including alarms, monitors, ventilators, infusion pumps, nebulizers) and by health professionals (with tasks and conversation) (Short *et al*., 2011). In general high-intensity noise levels may induce physiological instabilities in newborns, such as apnea, bradycardia and abrupt fluctuations in heart rate, respiratory rate, blood pressure and oxygen saturation an (Philbin & Klass, 2000). Surenthiran et al. (2003) suggest that noise acting in synergy with ototoxic drugs (gentamicin, erythromycin, and fruscmide) and increased risk of sensorineural hearing loss in premature infants. Other negative long-term effects are described in literature, like abnormal auditory development (Chang & Merzenich, 2003), language difficulties and altered brain development (Brown, 2009). Health professionals identified noise like a barrier to work performance (Gurses & Carayon, 2009). Furthermore, this agent may cause extra-auditory effects in professionals like burnout, stress and fatigue, which can result in errors (Mahmood *et al*., 2011).
In Portugal has been a considerable increase in preterm births, which in 2004 had an intermediate value of 6.7% and in 2009 increased to 8.8% (Machado *et al*, 2011). Thus, it is essential to promote a quiet environment to reduce the impact of noise levels on the health and well-being of premature infants and health professionals.
The present study aimed to determine and analyse noise levels in a Portuguese neonatal intensive care unit. In addition, were identified the potential sources of noise and were proposed recommendations to reduce noise exposure.
This work is part of the "*NeoNoise Project*", which is being conducted by the Research Centre on Health and Environment of Allied Health Sciences School of Polytechnic of Porto (CISA/ESTSP-IPP). This project aims to characterise sound pressure levels in neonatal units and to determine the influence of these levels in health and well-being of premature infants and health professionals. The main challenge of the project is to develop guidelines to reduce noise levels that take into account the reality of the Portuguese healthcare services.

2. MATERIALS AND METHODS
2.1. Clinical Settings
All measurements were performed in a NICU of a hospital located in Porto, Portugal. The unit consists of two rooms (A and B), without physical separation between infrastructures. Each room provided care for approximately three and six patients, respectively. Both the preparation of the parenteral nutrition and medication are in room B and, as a result, it had the greatest amount of staff activity.

2.2. Data collection - Noise Measurements and Workers Perception
The measurements were carried out continuously during seven days (room A) and five days (room B) in April 2013.
Noise level measurements were performed using a sound level meter (01 dB, model Solo-Premium). Following the orientations of previous studies (Santos and Miguel, 2012) and (Robertson et al, 1998), measurements were made using the A filter, which is a frequency weighting filter that simulates human hearing. Slow response time averaging (1 second) was also used because is the most appropriate response for the majority of the applications in hospitals and provide stable readings (Philbin & Gray, 2000). To ensure accurate measurement, recording was preceded by calibration of the sound level meter (Kent et al, 2002). In the analysis and interpretation of results were used reference values given by WHO (40 dB (A) for day period and 35 dB (A) for night period) (Berglund et al, 1999).

To analyse the noise perception of workers in their workplaces, it was developed and applied a questionnaire, in order to characterise working conditions, comfort and the main noise sources.

2.4. Statistical Analysis

The processing and data analysis involved descriptive statistics, with analysis of L_{Aeq} values. For the comparison of L_{Aeq} values between shifts it was used initially the Kruskal-Wallis test, and then the Mann-Whitney test. To compare the L_{Aeq} according to occupancy rates nonparametric Mann-Whitney test for independent samples and Wilcoxon for paired samples were used. The software IBM SPSS™ (Statistical Package for the Social Sciences) 20th version and MS Excel® were used for these analysis.

3. RESULTS AND DISCUSSION

Figure 1 shows the results obtained for the mean, minimum and maximum values of L_{Aeq} dB (A) in the two rooms of NICU.

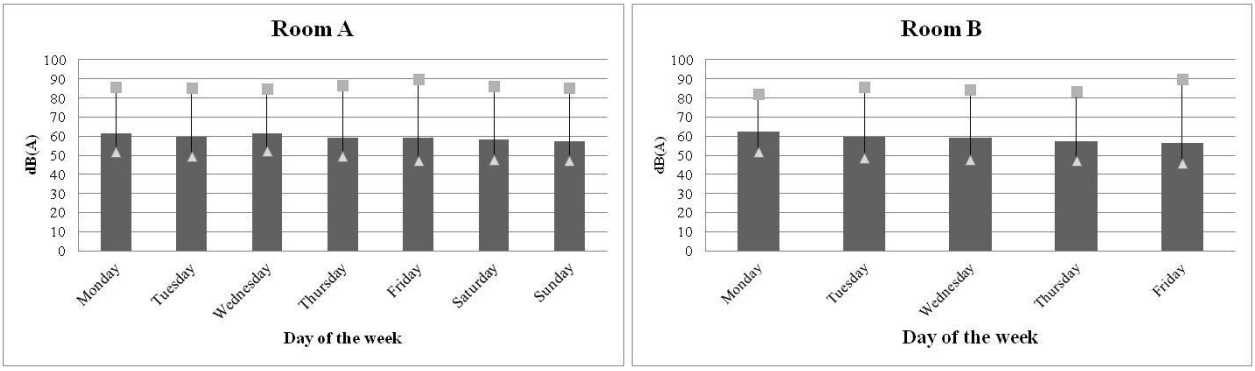

Figure 1 – Results in Rooms A and B per day.

During the week, the mean values of L_{Aeq} dB (A) obtained in room A ranged from 49,6 dB(A) and 82,5 dB(A) and maximum values ranged between 50,1dB(A) and 90 dB(A). The results demonstrated that Monday L_{Aeq} dB (A) values were higher than the others days of the week, ranging between 52 and 86 dB(A). In room B, mean values of L_{Aeq} dB (A) obtained ranged between 48,3dB(A) and 74,7dB(A) and the results followed the same pattern than room A. Monday was the day with high sound pressure levels (mean 61,2 dB (A)). These results are above those recommended by WHO and were similar to those obtained by Berg et al. (2010). Furthermore, sound pressure levels were significantly higher on weekdays than on weekend days ($p < 0,05$). These findings are consistent with Matook et al. (2010). Table 1 shows the sound pressure levels in the three shifts of the NICU studied.

Table 1 - Noise levels per shift.

Shift	Room	L_{Aeq} (dB) Mean (min-max)
Morning (8 a.m. to 2:29 p.m.)	A	60,1 (50,5-82,2)
	B	59,4 (49,9-71,5)
Afternoon (2:30 p.m. to 10p.m.)	A	60,8 (52,2-78,5)
	B	58,5 (49,6-70,9)
Night (10 p.m. to 7:59 a.m)	A	58,1 (49,6-82,5)
	B	57,6 (48,3-74,7)

In general, mean values of L_{Aeq} were lower in night shift; such was already reported for other authors (Bremmer et al., 2003; Philbin & Gray, 2002). Night period is characterised by fewer visitors and health professionals and low lighting, which might reduce conversation. Significant differences has been found between the morning and night shift ($p<0,05$) and between the afternoon and night shift ($p<0,05$). On the other hand, no significant differences has been found between the morning and afternoon shift ($p=0,369$). Patient care activities and conversation between staff and visitors were identified as an important source of noise. The present study included 36 valid questionnaires which responded mostly women (92%). The questionnaire was answered by seventeen nurses, nine doctors and ten operating assistants. The responses of the relevant questions of the questionnaire are given by Table 2.

Table 2 – Percentage of workers responses.

Question/Statement	Answer	%
1- How do you classify noise levels in your work environment?	Clearly acceptable	8,1
	Acceptable	67,6
	Unacceptable	24,3
	Clearly unacceptable	0,0
2 - What are the main noise sources in NICU?	Equipments	75,7
	Team conversation	43,2
	Visits	13,5
	Healthcare procedures	5,4
3 - Concerning to noise, this environment is…	Comfortable	18,9
	Slightly uncomfortable	64,9
	Uncomfortable	8,1
	Very uncomfortable	8,1
	Extremely uncomfortable	0,0
4 - In what shift you think the noise is most annoying?	Morning	81,1
	Afternoon	10,8
	Night	24,3

As the table 3 shows, for the question 1, 8,1% of respondents rated the noise as "Clearly Acceptable" on their workplace, 67,6% as "Acceptable" and 24,3% as "Unacceptable". Concerning to question 2, 75,7% of health professionals reported that "equipments" are one of the most annoying noise sources. The "Team conversation" was reported by 43,2% of professionals, "visits" by 13,5% and “healthcare procedures” by 5,4%. The perception of comfort in relation to the work environment was assessed using the statement 3. The results shows that, in general, 18,9% of health professionals considered the work environment "Comfortable", 64,9% “Slightly uncomfortable”, 8,1% "Uncomfortable" and 8,1% “Very uncomfortable”. In fact, noise is identified by professionals as a disturbing agent and had a negative impact on the environment. Similar data was found by Gurses & Carayon (2009) and Santos & Miguel (2012) in their studies. 81,1% of respondents considered the morning shift as the most uncomfortable.

4. CONCLUSIONS

The NICU studied presented higher sound pressure levels than recommended by international organisations. Thus, routine activities of healthcare professionals has been identified as a potential source of noise, it is important to refer that this study did not consider the effects of the physical space (baseline sound level of unit) on noise levels. The first step to improve a quiet environment is necessary to develop and implement a quiet time protocol with the collaboration of healthcare professionals. Training the staff in order to implement quiet work behaviours is essential. However, changing physical elements of space can result in great noise reduction.

5. REFERENCES

Berg, A. L., Chavez, C. T., & Serpanos, Y. C. (2010). Monitoring noise levels in a tertiary neonatal intensive care unit. *Contemporary issues in communication science & disorders, 37*, 69-72.

Brown, G. (2009). NICU noise and the preterm infant. *Neonatal Network*: NN, 28(3), 165-**173.**

Bremmer, P., Byers, J. F., & Kiehl, E. (2003). Noise and the premature infant: physiological effects and practice implications. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 32*(4), 447-454.

Berglund, B., T. Lindvall, D. H. Schwelaand, and T.K. Goh. (1999). Guidelines for community noise. In Protection of the human environment. Geneva, Switzerland: World Health Organization

Edward F. Chang, Michael M. Merzenich (2003) Environmental Noise Retards Auditory Cortical Development. *Science*. 300 (5618), 498-502.

Gurses, A. P.,Carayon, P. (2009). Exploring performance obstacles of intensive care nurses. *Appl. Ergon.*, 40, 509-518.

Kent, W. D. T., Tan, A. K. W., Clarke, M. C., & Bardell, T. (2002). Excessive noise levels in the neonatal ICU: potential effects on auditory system development. *The Journal Of Otolaryngology*, 31(6), 355-360.

Machado, M.C., Alves, M. I., Couceiro, M. L. (2011). Saúde Infantil e Juvenil em Portugal: indicadores do Plano Nacional de Saúde. *Acta Pediatr Port*, 42(5):195-204.

Mahmood, A., Chaudhury, H., Valente, M. (2011). Nurses' perceptions of how physical environment affects medication errors in acute care settings. *Applied Nursing Research*, 24, 229-237.

Matook, S. A., Sullivan, M. C., Salisbury, A., Miller, R. J., & Lester, B. M. (2010). Variations of NICU sound by location and time of day. *Neonatal Network: NN, 29*(2), 87-95.

Philbin, M. K., & Gray, L. (2002). Changing Levels of Quiet in an Intensive Care Nursery. *J. of Perinatology, 22*(6).

Philbin, M. K., & Klaas, P (2000). Evaluating studies of the behavioral eftects of sound on newborns. Journal of Perinatology, 20(8 Pt. 2), S61-S67.

Robertson, A., Kohn, J., Vos, P., & Cooper-Peel, C. (1998). Establishing a noise measurement protocol for neonatal intensive care units. *Journal of perinatology*, 18(2), 126-130.

Santos, J., & Miguel, A. S. (2012). *Noise Levels in Hospital Environment - The Case of Intensive Care Units*. Paper presented at the Sho 2012: International Symposium on Occupational Safety and Hygiene.

Short, A., E., Short, K., T., Holdgate, A., Ahern, N., Morris, J. (2011). Noise levels in an Australian emergency department. *Australasian Emergency Nursing Journal*. 14, 26-31.

Surenthiran,S..S., Wilhraham, K., May, J., Chant,T, Emmerson, A. J. B., & Newton, V. E. (2003). Noise levels within the ear and post-nasal space in neonates in intensive care. *Archives of Disease in Childhood. Fetal and Neonatal Edition*, 88, F3I5-F318.