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Noise levels in a neonatal intensive care unit in the Cape metropole

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Introduction. Continuous noise exposure is potentially harmful to infants' auditory systems and wellbeing. Although the effects of noise on infants in a neonatal intensive care unit (NICU) have been well researched overseas, limited studies have been conducted in South Africa.

Aim. To conduct a detailed noise assessment in a state hospital NICU in the Cape metropole.

Study design and setting. Non-experimental descriptive design involving measurement, analysis and description of the noise levels and events in the NICU, Tygerberg Children's Hospital, Western Cape.

Method. Noise levels were measured over two 12-hour periods in both NICU rooms, during which observations were made to identify the sources and frequency of occurrence of NICU noises. Measurements of sound decay were made to determine whether the noise levels were a result of direct noise or reverberant noise from room reinforcements.

Results. Noise levels ranged from 62.3 to 66.7 dBA (LAeq), which exceeds American and British NICU standards (50 - 60 dBA). Staff conversations were the largest single contributor to the number of noise events. The largest single non-human contributor was monitor alarm noise. The NICU was found to be an extremely reverberant environment, suggesting that high noise levels were largely a result of reverberant room reinforcements.

Conclusion. Results highlight the need for noise reduction, which is vital to optimise newborn care, reduce acoustic trauma risks and enhance the infants' wellbeing and physiological stability in the NICU. Moreover, it is especially important to limit NICU noise levels in developing countries as premature infants in the NICU are often at increased risk for developing noise-induced sensorineural hearing loss as a result of NICU noise exposure and/or treatment with ototoxic medication and are often not routinely screened for hearing loss.

Recommendations. Practical suggestions for noise reduction in the NICU are made.

Technological advances and improved understanding of the neonatal condition have reduced infant mortality, and some infants are spending weeks or even months as inpatients in neonatal intensive care units (NICUs).[1] However, improvements in neonatal care have been accompanied by concerns about the impact of the NICU environment on these infants.[2]

The technology-backed environment of a NICU is noisy, and this noise has been found to be a major source of environmental stress for the neonate.[2] Numerous published studies have measured noise levels that would be considered dangerous to adults working in a noisy workplace.[1-5]

The effects of noise on infants in the NICU have been well researched, particularly the cardiovascular and respiratory effects.[6] Studies have documented the effect of noise on the infant's auditory system, such as noise-induced sensorineural hearing impairment (usually mild to moderate in severity).[2] Some research has also suggested that attention-related difficulties and information processing disorders at pre- and school-going ages as well as speech delays, language-related problems and learning difficulties might be due to noise exposure in the NICU.[6]

To date, limited studies relating to noise in the NICU have been conducted in South Africa. A study conducted at a private clinic in Gauteng sought to identify noise sources and measure the noise levels in the NICU in order to provide guidelines for reducing or preventing noise in NICUs.[1]

Research on noise in the NICU and its effects highlights the need for noise reduction. This reduction is vital for optimising newborn patient care, as it improves the neonates' quality of life, contributes to their physiological stability and enhances their growth and health in the NICU.

Aim

The study aimed to provide an index of the existing noise levels and noise sources in a state hospital NICU in the Cape metropole. In addition, it sought to assess whether stricter noise management is required.

Data collection procedure

The study was conducted at Tygerberg Children's Hospital (TCH), which has an active NICU of 2 rooms with a total of 10 open incubators. The data collection procedure is shown in Table I.

TABLE I. DATA COLLECTION PROCEDURE

- Noise level measurement data collected from both rooms in the NICU using the central site method[4]
- Observations of the NICU by the principal researcher to identify the possible noise sources in each room and record the frequency of their occurrence
- Measurements of NICU reverberation time to determine whether the NICU noise levels were a result of direct noise or reverberant noise from room reinforcements
- Feedback of study to and from nursing staff working in the NICU

Noise level measurements

A type 1 sound level meter (SLM) was used to measure the noise levels. All measurements were made according to the relevant South African National Standard (SANS): 10083 (2004). The noise levels in the NICU rooms were expressed in dBA.[7]

The noise measurement in the two NICU rooms was done using the central site procedure[4] whereby the SLM microphone was suspended from the middle of the ceiling in each of the rooms, with the microphone at a height of 2 m to avoid interfering with staff activities in the NICU. This enabled measurement of the noise levels that the neonates were exposed to in the NICU rooms.[4]

Noise level measurements were taken during two 12-hour periods per room, which assisted in verifying the reliability of the measurements. In each room the measurements were taken from 08h00 to 20h00 during 2 consecutive weekdays. No noise level measurements were taken during the night shift, as it has been reported that there is little difference between noise levels during day and night shifts.[1,4]

The results of the measurements consisted of data relating to LAeq, mean hourly SPL, $MaxL_A$ and $MinL_A$ (see Appendix A, glossary of terms) for each measurement period. Percentile levels for SPL, $MaxL_A$ and $MinL_A$ were also calculated.

Observation and documentation of noise events

Sporadic spot-check observations during the noise measurement periods were carried out by the principal researcher, to observe everyday NICU activity: nursing care procedures, ward rounds and staff handovers, and events associated with various noises. The frequency of occurrance of various noise events were recorded on a checklist, which was developed on the basis of previous research.[8]

Measurements of NICU reverberation time

To determine whether the noise levels in the NICU were a result of direct noise or reverberant noise from NICU room reinforcements, reverberation time estimates using Sabine's mathematical equation,[7] as well as actual reverberation time measurements of an 'empty' ward, were made by the researcher using the same SLM used in the noise level measurements.

Feedback of the results to the staff

Each member of the nursing staff in the NICU received a written summary reporting the main points of the results. The report included a description of the decibel values for various care activities in the NICU and gave everyday examples of sound sources of the same decibel values. It also described the NICU noise levels and their potential effects. The nursing staff were also invited to give written suggestions on how to reduce the noise pollution in the NICU. Completion of the form was voluntary. A total of 9 out of 10 forms distributed to the nursing staff were returned completed to the researcher. Eight of the 9 respondents were nursing staff who worked in the NICU every day, and the 9th was a neonatal mentor at the hospital, with a PhD in developmental care.

Results

The various stages of data collection yielded the following findings:

Noise level measurements

The noise levels found in the present study ranged from 62.3 to 66.7 dBA (LAeq) (Fig. 1).

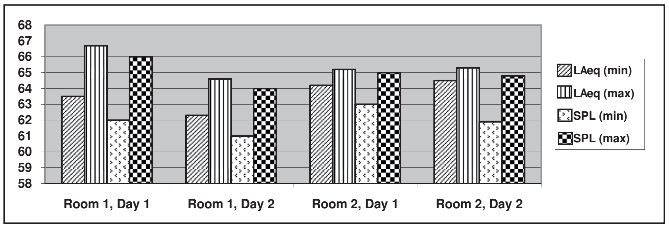

Fig. 1. Decibel (A) value ranges for LAeq and SPL per room per day.

Observation and documentation of noise events

Thirteen categories of noise events were observed (Table II). Staff conversations were always the largest single contributor (27.8 - 36%) to the number of noise events, while the largest single non-human noise contributor was the alarm noise of the monitors (23.7 - 26.1%). An 'unquantifiable' source of noise in each room was a radio in the corner of the room that played constantly throughout the measurement period, at approximately 68 dBA, which was loud enough for the nursing staff to hear above the general noise in the NICU.

Measurements of NICU reverberation time

Reverberation time measurements revealed that the NICU rooms were extremely reverberant environments. It appeared that the level of noise in the NICU was to a significant degree a result of reverberant noise from NICU room reinforcements.

Feedback of the results to the staff

A total of 12 suggestions for NICU noise abatement strategies were made by the nursing staff (see Appendix B). The most frequently suggested strategy was reduction of staff conversation. Most of the suggestions by the nursing staff related to simple noise reduction strategies with minor or no cost implications, such as removing the radio and reducing

TABLE II. DISTRIBUTION OF NOISE EVENTS OBSERVED IN THE NICU (%)				
	Room 1		Room 2	
Source	Day 1	Day 2	Day 1	Day 2
Staff conversations	27.8	36.0	33.4	34.1
Bumping stainless cart or apparatus	3.5	2.3	2.7	2.3
Opening or closing dustbin lid	7.5	4.0	2.0	3.4
Alarm of monitors	24.3	28.7	23.7	26.1
Caregiving at open incubator	2.6	2.7	1.0	1.1
Multiple sources of noise	5.2	5.3	6.2	5.7
Telephone ringing, intercom, radio	7.0	6.3	7.3	8.1
Moving cart, chair and equipment	3.5	2.7	2.7	4.5
Handling equipment of oxygen supply	4.3	0	1.0	1.1
Cleaning apparatus and containers	3.5	2.7	2.7	2.3
Tearing plastic or paper bag	0.9	2.7	5.5	4.5
Bumping or cleaning the incubator	0.9	1.3	2.7	1.1
Other (infants crying, dropping objects, conversations from family)	8.7	5.3	9.1	5.7
Total	100	100	100	100

staff conversation, especially close to the incubators. A few suggestions made reference to more costly NICU re-construction or renovation of the floor, ceiling and windows, which may not be feasible owing to financial constraints.

Discussion

The noise levels measured in the present study correlate with the noise levels measured in another South African study conducted at a private clinic in Gauteng[1] and similar studies conducted in NICUs in First-World countries.[3,8] In both South African studies, the results exceed all recommendations for NICUs of 50 - 60 dBA.[9-11] Continuous exposure to this high noise level during an infant's stay in the NICU can be potentially harmful to the infant's health and hearing.[12] The measured noise levels may also be detrimental to staff hearing and health.[2,12]

The frequency of occurrence of both human and non-human noise events in this study are in agreement with other published studies,[1,3,8] which showed staff conversation and monitor alarm noise to be the biggest contributors. The radios were on all the time during the measurements and could not be described as 'noise events', but their presence contributed to the noise in the NICU.

The findings from the reverberation time measurements indicated that the hospital building acoustics as well as the room acoustics were poor. It is important to state that NICU wards at TCH were designed as general wards and not as NICUs, so the guidelines and recommendations for NICU design were not followed.[13]

The effects of noise on infant inpatients in the NICU have been well documented. Prematurity places these infants at increased risk for developing noise-induced sensorineural hearing loss as a result of exposure to the intense NICU sounds,[12] because the hearing organ is still developing after birth in premature infants. However, it is difficult to define the degree to which hearing losses observed in preterm infants are the result of NICU noise exposure, as the use of ototoxic drugs in their treatment may mean that they risk ototoxic hearing loss.[12] The majority of the infants at TCH are from lower socio-economic backgrounds, which have been found to be associated with a high incidence of chronic otitis media with conductive hearing loss at follow-up (Professor G F Kirsten and Dr N van Zyl, personal communication, February 2008).

NICU noise exposure may also affect the auditory perceptual development of the preterm infant, because of the underdeveloped nature of their sensory systems.[2] Although when preterm infants reach pre- and school-going age they have a relatively high prevalence of attention-related difficulties, information processing disorders, speech delays, language-related problems and learning difficulties,[2,6] research investigating the links between prematurity and problems of school-age children is scarce. Hypocapnia during ventilation of preterm infants may result in hypoperfusion of the brain that could impact on their hearing and speech development.[14]

Conclusion

This study found high noise levels and poor room acoustics in the NICU and highlighted the need for noise abatement, which is vital to reducing the risk of acoustic trauma, optimising patient care and improving the neonate's quality of life, thus enhancing physiological stability, growth and health. It is suggested that nursing and other staff in the NICU take responsibility for identifying and reducing acoustic stimuli in the NICU in order to facilitate and develop an environment that is acoustically friendly to the neonate.

References

1. Nzama NPB, Nolte AGW, Dörfling CS. Noise in a neonatal unit: guidelines for the reduction or prevention of noise. *Curationis* 1995; 18(2): 16-21.
2. Blackburn S. Environmental impact of the NICU on developmental outcomes. *J Pediatr Nurs* 1998; 13(5): 279-289.
3. Kent WDT, Tan AKW, Clarke MC, Bardell T. Excessive noise levels in the neonatal ICU: potential effects on auditory system development. *J Otolaryngol* 2002; 31(6): 355-360.
4. Robertson A, Kohn J, Vos P, Cooper-Peel C. Establishing a noise measurement protocol for Neonatal Intensive Care Units. *J Perinatol* 1998: 18(2): 126-130.
5. Strauch C, Brandt S, Edwards-Beckett J. Implementation of a quiet hour: effect on noise levels and infants sleep states. *Neonatal Netw* 1993; 12(2): 31-35.
6. Graven SN. Sound and the developing infant in the NICU: conclusions and recommendations for care. *J Perinatol* 2000; 20(8s): S88-S93.
7. Everest FA. *Master Handbook of Acoustics*. 4th ed. New York: McGraw-Hill, 2001: 159-162.
8. Chang YJ, Lin CH, Lin LH. Noise and related events in a neonatal intensive care unit. *Acta Paediatr Taiwan* 2001; 42(4): 212-217.
9. Levy GD, Woolston DJ, Browne JV. Mean noise amounts in level II vs. level III neonatal intensive care units. *Neonatal Netw* 2003; 22(2): 33-38.

10. Philbin MK, Robertson A, Hall J. Recommended permissible noise criteria for occupied, newly constructed or renovated hospital nurseries. *J Perinatol* 1999; 19(8, Part 1): 559-563.

11. Third Consensus Conference on Newborn ICU Design. Recommended standards for newborn ICU design 1996. http://www.nd.edu/~kkolberg/DesignStandards.htm (accessed 2 July 2003).

12. American Academy of Pediatrics. Committee on Environmental Health. Noise: a hazard for the fetus and newborn. *Pediatrics* 1997; 100(4): 724-727.

13. Fifth Consensus Conference on Newborn ICU Design. Recommended standards for newborn ICU design 2002. http://www.nd.edu/~kkolberg/DesignStandards.htm (accessed 2 July 2003).

14. Laffey JG, Kavanagh BP. Hypocapnia. *N Engl J Med* 2002; 347: 43-53.

15. Brüel & Kjær. *User Manual: Integrating Sound Level Meter Type 2239A*. Denmark: Brüel & Kjær, 2001: 25-26.

Appendix A. Glossary of terms

LAeq: Equivalent continuous sound level (using A-weighted sound level) over the elapsed measurement time. This is the most useful parameter for giving an impression of the average sound pressure level.[15]

MaxL: Maximum sound pressure level (SPL) over the elapsed measurement time.[15]

MinL: Minimum sound pressure level (SPL) over the elapsed measurement time.[15]

Reverberation time: The time required for a sound that is very loud to decrease to inaudibility.[7]

SPL: The maximum sound pressure level within the last one-second interval. This parameter is different from the peak value because SPL is an RMS (root mean square) measurement.[15]

Appendix B. Practical noise reduction strategies

On the basis of present and previous research it is important to reduce noise levels within the NICU. Some practical noise reduction strategies are listed below.

1. Reduce staff-generated noise by increasing awareness of noise levels and the damaging effect that it has on patients through staff training and through 'quiet' signage posted at strategic positions within the NICU.
2. Conversations should not be held over the patient in the radiant warmer, incubator or bed.
3. Introduce a 'quiet time' or 'quiet hour'[5] during the last hour of each traditional 8-hour shift, consisting of:
   - A sign hung at the door of the NICU indicating 'quiet hour in progress'
   - Talking in a whisper at the bedside
   - Allowing no large equipment into the unit
   - Making an effort not to slam doors, drawers or incubator doors or to drag chairs
   - Permitting no physician rounds
   - Responding rapidly to alarms or crying infants
   - Forwarding all calls to the front desk
   - Rearranging caregiving activities to minimise infant disturbances.
4. Turning off and *removing* the radio from the unit or only playing soft music.
5. Turning down alarm volumes and responding to alarms immediately and silencing before attending to the infant.
6. Fitting blinds or curtaining to increase absorption of noise (although these may increase the risk of infection).
7. Turning off the constant pulse sound on the oxygen saturation monitors.
8. Reducing the ringing volume of the telephones.
9. Replacing metal dustbins with plastic or 'noiseless' ones
10. Fitting door frames with foam edging to stop doors from banging and reduce the noise when closing the doors.
11. If finances are available, introducing acoustic-reducing building material such as acoustic ceiling and wall tiles.
12. Funds allowing, installing dB monitors with set limits to increase awareness of unacceptable noise levels.