Original Article

Efficacy of a Low Cost Protocol in Reducing Noise Levels in the Neonatal Intensive Care Unit

A. Ramesh, P.N. Suman Rao,[1] G. Sandeep,[1] M. Nagapoornima,[3] V. Srilakshmi, M. Dominic[2] and Swarnarekha

Departments of Otolaryngology, [1]Pediatrics, [2]Community Medicine, [3]Audiology and Speech Pathology, St John's Medical College Hospital, Bangalore, India

ABSTRACT

Objective. To examine the effectiveness and cost of implementing a noise reduction protocol in a level III neonatal intensive care unit (NICU).

Methods. A prospective longitudinal study was done in a level III NICU, wherein a noise reduction protocol that included behavioral and environmental modification was implemented. The noise levels were measured sequentially every hour for 15 days before and after this intervention. The statistical significance of the reduction in noise levels after implementation of the protocol was tested by paired sample student's t-test. Cost was calculated using the generalized cost effectiveness model of the World Health Organisation. The present study has 80 % power with 95 % confidence to measure 2 dB differences between groups for the maximum recommended of 50 dB.

Results. The protocol in the present study reduced noise levels in all the rooms of the NICU to within 60 dB with high statistical significance ($p < 0.001$). The extent of noise reduction in the rooms of the NICU was as follows : ventilator room by 9.58 dB (95 % confidence interval: 6.73 – 12.42, $p < 0.001$) , stable room by 6.54 dB (95 % confidence interval: 2.92 – 4.16 , $p < 0.001$), isolation room by 2.26 dB (95 % confidence interval: 1.21 – 3.30, $p < 0.001$) , pre-term room by 2.37 dB(95 % confidence interval: 1.22 – 3.51, $p < 0.001$)and extreme preterm room by 2.09 dB (95 % confidence interval: 1.14 – 3.02, $p < 0.001$). The intervention was most cost-effective in the ventilator room, requiring Rs. 81.09 to reduce 1 dB and least effective in the extreme pre-term room requiring Rs. 371.61 to reduce 1 dB.

Conclusion. The high efficacy and affordability of noise reduction protocols justify the need for implementation of these measures as a standard of care in neonatal intensive care units. **[Indian J Pediatr 2009; 76 (5) : 475-478]** *E-mail: lavirams @yahoo.com*

Key words : *Noise in NICU; Noise reduction in NICU*

Noise levels in the NICU above the recommended maximum of 50 dB SPL (sound pressure level) is harmful to the development of the neonates.[1,2,3] Reducing the noise levels by even 4 dB have demonstrated a reduced requirement for oxygen support and decreased mean diastolic pressure compared to pre noise reduction values.[4] Studies in India too have shown unacceptable noise levels in the NICU.[5,6] There is no published literature till date available from India that has examined the efficacy of implementing a noise reduction protocol in the NICU. The present study has examined the effectiveness and cost of implementing a noise reduction protocol in a level III NICU in India. This data could be used by professionals involved in the care of newborns in India to adopt similar measures in their NICUs.

Correspondence and Reprint requests : A. Ramesh, Associate Professor, Department of Otolaryngology, Head and Neck Surgery, St John's Medical College Hospital, Bangalore-560034, India. Ph: 9845236298.

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MATERIALS AND METHODS

A prospective study was conducted in a level III NICU from May 26th to June 9th 2007. This is a tertiary level neonatal health care center. The average number of neonates in the NICU at a given point of time is 25 (Range 20 -30).

Noise reduction protocol

The noise reduction protocol consisted of the following measures:

Behavioural modification: All the staff on the NICU

were sensitized about the harmful affects of high noise levels on the neonate. The pre protocol noise levels were presented to the staff, so that they got a sense of the magnitude of noise in the NICU. They were requested to speak in low tones, avoid shouting across a distance, hold discussions during rounds in a separate room, handle the trays and metallic objects gently and put off the FM radio system. Three staff members were appointed as persons who would remind the others, if they talked loudly. Posters with captions requesting for silence, were put up inside and along the outer corridors of the NICU.

Environmental modification: Legs of all the furniture were fitted with rubber shoes. All the metallic files were replaced by plastic files. The volume of all the alarms was tuned using the sound pressure level meter to emit a maximum of 55 dB or changed to visual mode when the option was available .The door of the washing room where metal trays were cleaned, was always kept closed. The volume of the phone ringer was kept at minimum audible volume.

Hearing screening: All the neonates in the NICU were screened for hearing impairment within 6 weeks of discharge by a protocol consisting of oto-acoustic emission, auditory brainstem response audiometry (BERA) and behavioral observation audiometry. This is a standard practice for all neonates in the NICU.[7]

Sequential hourly noise level measurements over a 15- day period of before and after the implementation of the protocol

There are 5 rooms in the NICU. The dimensions of the rooms (Length x Breadth x Height in feet) are as follows: ventilator room : 20.6 x 20.6 x 11, stable room : 20.6 x 20.6 x 11, isolation room : 14 x 12.9 x 11, extreme pre-term room : 13.3 x 20.6 x 11and pre-term room : 13.3 x 20.6 x 11. All these rooms are separated by glass and aluminium partitions extending from floor to the roof. Ventilator room is high dependency area occupied by sick and ventilated neonates. Stable room is a low dependency area occupied by term neonates requiring phototherapy and hemodyanamically stable neonates. The maximum numbers of neonates that can be accommodated in these rooms are as follows: ventilator room : 6, stable room : 12, isolation room : 4, extreme pre-term room : 6 and pre-term room : 6. The noise level measurements were carried out by the following method:

1. All the duty nurses in the NICU were trained to use the portable digital sound pressure level meter to measure the sound intensity level.
2. The sound levels were recorded at the center of each of the rooms by the nursing staff on duty.
3. Hourly measurements were performed sequentially over a 15 day period from May 26th to June 9th 2007 consisting of 13 working days and 2 holidays. These levels were compared with the noise levels measured in the same setting before implementing the protocol.[6] The number of neonates and equipments were similar during these two measurement periods.

Calculation of the cost of establishing the protocol

The cost was calculated in Indian rupees using the guidelines outlined in World Health Organisation guide to cost effectiveness analysis.[8] The actual material costs were calculated by adding transport charges to the cost price.

The method for calculating the cost of the 2 hour sensitization sessions was as follows. The cost of the working hours for doctors and nurses was calculated using the shadow wage rate model for scarce labour, where as, those for the paramedical staff, the non-scarce labour model was used. For scarce labour rates, the monthly salary with fringe benefits was divided by the effective working hours for a month. For non-scarce labour the fringe benefits were not included. The final results were calculated as the cost for reducing 1 dB in a room.

Statistical analysis of data

Internal validity: The sound pressure level meter is calibrated using standard sounds. Fast fourier transform algorithms were used for digital signal processing. Noise level measurement from the centre of the room is a standard practice and accurately measures the noise level in the room.[9]

External validity: Geometric mean measurements (dB is a logarithmic scale) along with standard error (SE) was used to summarize the data, as all the data had a symmetric distribution. Noise levels > 50 dB was considered as significant and the mean noise levels measured were compared with this and the statistical significance of the difference was tested using student's t-test. The significance in the difference in noise levels before and after implementation of the noise reduction protocol were tested by paired sample student's t-test. The number of neonates in each room of the NICU during the two 15 day periods of noise measurement was similar to the average occupancy throughout the year. This ensured representative sampling of the target population of neonates in the NICU. p-values less than 0.05 were considered statistically significant. The present study has 80 % power with 95 % confidence to measure 2 dB differences between groups for the maximum recommended of 50 dB. Statistical package for social sciences (SPSS) version 15 was used to perform statistical analysis. Power analysis statistical system (PASS) was used to perform power analysis. Institute ethical review board clearance was taken before conducting the study.

RESULTS

Sequential hourly noise level measurements in the NICU

Table 1 shows the sequential noise level measurements in all the rooms of the NICU, before and after implementation of the protocol. The noise reduction was maximum in the ventilator room by 9.58 dB and least in the extreme preterm room by 2.09 dB. The upper limit of the 95 % confidence intervals was 12.42 dB in the ventilator room with $p < 0.001$, which is highly significant statistically. In all the rooms, the noise levels was reduced to within 60 dB with high statistical significance. In the ventilator room from a very high level of 68.96 dB the noise was reduced to 59.38 dB. The compliance of the behavioral modification was ensured by 3 persons, designated as noise monitors, who were given the duty of regularly reinforcing these measures. The only situation where the protocol was violated, was during an emergency, when the staff had to call aloud across the room which occurred on an average rate of 4 times a day (Range: 2 – 6 times/day). Though the noise levels have reduced in all the rooms, it still is above the maximum recommended of 50 dB in all the rooms.

Cost effectiveness of the protocol

Table 2 shows the cost of various measures implemented to establish the noise reduction protocol. The total cost of the intervention was Rs. 3884. The cost per room in the NICU is Rs. 776.80. The cost effectiveness (Cost per room / dB reduction in the room) is the highest in the ventilator room where it takes Rs. 81.09 to reduce 1 dB. The cost to reduce 1 dB in the stable room , isolation room, extreme pre-term and pre-term rooms were Rs. 118.78, Rs. 343.72, Rs. 371.61 Rs. 327.76 respectively.

Hearing screening of the neonates in the NICU

None of the neonates admitted in the NICU during this period had hearing impairment.

DISCUSSION

The noise reduction protocol has reduced noise in all the rooms of the NICU. The effectiveness is maximum in the ventilator room, because the noise levels were the highest here. The differential reduction in the rooms could be due to the noise cascading effect. Noise cascading effect is explained as the tendency of personel in the environment to talk louder, if the ambient noise level is high. With behavioral modification and other measures, the ambient noise gets reduced which causes the personal to speak softly. As the ambient noise was highest in the ventilator room before the protocol, reducing it has caused the maximum reduction in terms of absolute measures. In India, there are no studies in this area, so there is no data to compare and discuss. Studies done in other countries have shown that conversations during rounds have been shown to contribute significantly to the excess noise levels with considerable reduction in noise levels after activity modification .[10,11,12] The alarms in visual mode was a cause for anxiety in the nursing personnel as they had to repeatedly look at the monitors.

The environmental modification measures have

Table 2. Cost of Materials and Labour Used for Modifying the Environment in the NICU*

Item	Cost in Indian national rupee (On January 1, 2008) (Rs.)
Rubber shoes for the legs of furniture	100
Posters requesting personnel to be quiet	200
Replacing metal files with plastic files	450
Training session for the personnel (2 hours)	3134
Total	3884

*Inclusive of cost for transportation and overheads which includes electricity , room charges and audio visual aid charges

Table 1. Average Noise Levels in all the Rooms of the NICU Before and After Implementation of the Noise Reduction Protocol

Room	Mean noise level before in dB (S.E*)	Mean noise level after in dB (S.E*)	Difference in the mean noise levels in dB (SE*)	95% confidence interval of the difference with p value
Ventilator	68.96 (0.94)	59.38 (0.56)	9.58 (0.95)	6.73 – 12.42 ($p < .001$)
Stable	61.22 (0.76)	54.71 (0.47)	6.54 (0.54)	2.92 – 4.16 ($p < 0.001$)
Isolation	56.58 (0.37)	54.32 (0.51)	2.26 (0.34)	1.21 – 3.30 ($p < 0.001$)
Extreme-preterm	54.30 (0.40)	52.21 (0.41)	2.09 (0.31)	1.14 – 3.02 ($p < 0.001$)
Preterm	56.66 (0.46)	54.29 (0.22)	2.37 (0.38)	1.22 – 3.51 ($p< 0.001$)

* Standard error of the mean (SE)

reduced transient surges in the noise levels. Similar observations has been made by other studies.[10] Though a considerable reduction in noise levels has been achieved in all the rooms, nevertheless noise levels continue to be above the maximum recommended of 50 dB. The factors that were contributing to the excess noise in the present study setting and the remedial measures we are intending to implement are as follows:

(1) A double glass partition is to be put to reduce noise from the encased hospital generator room that is adjacent to the NICU. (2) Any noise generated in the NICU gets reflected and re-reflected till it losses its energy which is called reverberation. This phenomenon adds to the already existing noise levels. Acoustic tiles on the roof and veneer flooring reduce reverberations. Acoustic foam is not ideal for NICU, as it accumulates dust and is difficult to clean frequently. (3) Low frequency noise is generated by the motors and compressors of ventilators . Active noise control by antinoise would be required to reduce this noise. Antinoise is noise opposite in phase but of same amplitude to the ambient noise. Piezoelectric smart panels could be installed which convert sound energy to electrical energy.[13]

These measures require investment in infrastructure modification and active noise control technology. As they incur excess expenditure, it would be prudent for hospitals establishing a NICU to plan for noise control measures at the outset so that the high expenses could be minimized.

The cost effectiveness of the noise reduction was highest in the ventilator and stable room. This is explained by the high noise levels in this room. So if, resources are limited, it should be focused on these rooms.

CONCLUSION

Noise in all the rooms of a level three NICU can be reduced considerably by incorporating affordable behavioral and environmental modifications. The noise reduction protocol was most cost effectiveness in the rooms with relatively higher noise levels that is the ventilator and stable room. So if resources are limited, they could be first utilized for rooms with the highest noise levels. These findings justify the need for noise reduction protocols to be a standard of care in neonatal intensive units.

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Contributions: A Ramesh and Sandeep G, measured the noise levels. Dr Suman and Dr Swarnarekha ensured the protocol being followed in the NICU. Ms Nagapoornima and Srilaxmi did the analysis of the noise data. Dr Dominic performed the statistical analysis.

Conflict of Interest: None

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