Comparison between noise levels inside and outside neonatal incubators: Implications for neonatal care in India

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ABSTRACT

Background: The neonatal unit equipment generates noise which is detrimental to neonatal physiological homeostasis and development. The incubator is one such essential component of modern neonatal care which, on the one hand, provides a low noise environment and also intrinsically generates noise. **Objectives:** The objectives of the study were to test the hypothesis that the neonatal incubator provided a better acoustic environment with lesser noise levels than the external environment. **Materials and Methods:** A prospective observational study was done in a Level III neonatal unit for 4 months from April 15, 2016, to August 15, 2016. Baseline noise levels of the various equipment inside a working incubator were recorded using a sound level meter. Subsequently, hourly noise levels in the neonatal intensive care unit (NICU) and inside the Giraffe Omnibed Incubator were recorded simultaneously as equivalent Continuous Sound Pressure Level as loudness equivalent. Two digital sound level meters were used. Noise levels inside and outside the incubators were used as a grouping variable. Chi-square test was used for categorical variables and independent t-test for continuous variables. All tests were two tailed and $p<0.05$ was considered statistically significant. **Results:** The noise levels recorded both inside the incubator and the NICU were >58 dbA for most times of the day. The noise levels inside the incubator were significantly less ($p<0.05$) than the outside. **Conclusion:** The statistically significant noise reduction inside the incubator provides a better acoustic environment for neonates.

Key words: *Acoustic, Incubators, Neonates, Noise levels*

Advances in the technology and its application in neonatal intensive care units (NICUs) have been instrumental in the survival of high risk and preterm infants. The sound generated by the equipment and providers results in the unfortunate exposure of these neonates to very high levels of sound. Two decades ago, the American Academy of Pediatrics (AAP) recommended that sound levels should be lower than 45 dBA in the NICU to avoid cochlear damage or disrupt the normal growth and development of a premature infant [1]. AAP recommends that hourly, an NICU loudness equivalent (Leq) should be below 50 dBA, the sound level that is exceeded 10% of the time (L10) should be at or below 55 dBA, and the maximum sound (Lmax) should be below 70 dBA [1]. Transient sounds or Lmax should not exceed 65 Db [2]. An environment with low noise promotes physiologic stability and better neurodevelopmental outcome in the preterm neonate [3].

In spite of these recommendations, the NICU sound levels have been reported to range from 50 to 115 dB [4-6]. The inevitable sound sources in an NICU are the noise generated by conversation by personnel and parents and the technical apparatus such as ventilators, incubators, infusion pumps, and monitors. Incubators provide a stable thermoneutral and a different acoustic environment. There are conflicting data on the noises inside the incubators. The working incubator can generate noise levels 45–70 dB [7]. The sound pollution due to alarms, talking, and other equipment has been found to be lower inside the incubator than the outside [7-9]. Therefore, this study was conducted with the primary aim to test the hypothesis that the incubator provided a better acoustic environment with lesser noise levels than outside.

MATERIALS AND METHODS

This prospective observational study was done in the 16 bedded Level III neonatal unit of a children's hospital in South India from April 15, 2016, to August 15, 2016. The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from either of the parents of the neonates enrolled in the study. All neonates irrespective of gestational age who were admitted to the neonatal unit and nursed in the incubator were included in the study. Neonates who were septic, sick, with open wounds or surgical conditions and whose parental consent was not obtained were excluded from the study.

The NICU comprised two rooms, room 1 with 12 beds and room 2 with 4 beds separated by a floor to ceiling glass partition

and glass door. The study was conducted in room 1 which had the maximum bed occupancy rate and room 2 was used as an isolation room for outborn and septic babies. The nursing station was close to the entrance. The incubators were numbered sequentially 1, 2, 3, and so on starting from the entrance area with the left side incubators as "a" and right side as "b" rows, respectively. The babies were nursed inside the Giraffe Omnibed, GE Healthcare. The sound levels were recorded over 24 h using two digital sound level meters (HTC/SL 1350, range 30–130 dB [A], accuracy 1 dB) which could record equivalent Continuous Sound Pressure Level as Leq.

In the first step, the noise levels of the various equipment inside the working incubator in a quiet room were recorded. There were no babies or staff present and a mannequin within the incubator was used to simulate a neonate. These findings formed the baseline of the study. Further, two sound level meters were used in the normally functioning NICU. One sound level meter was fixed in the center of the hall 90 cm from the ceiling and the other was fixed inside the incubator near the head end of the baby. It was planned that five 24 h recordings be obtained from each incubator.

Disposable sterile covers were used to wrap the sound level meter placed inside the incubator and this meter was thoroughly disinfected with chlorhexidine wipes between recordings in different incubators. The hourly noise levels were recorded simultaneously using the two decibel meters by the trained nursing staff over 24 h. The readings were recorded hourly (in the form of Leq). This included the summation of the noises made by the equipment and the human activities. To avoid a behavior change in the NICU medical and nursing staff, desensitization was performed for 2 weeks before the performance of the study. During this period, the sound level meter was suspended from the ceiling and placed inside the incubators.

Statistical analysis was done using R software. A comparison between the noise levels inside and outside the incubator was used as grouping variable. Chi-square test was used for categorical variables and independent t-test for continuous variables. All tests were two tailed and $p<0.05$ was considered statistically significant.

RESULTS

Sound levels were recorded over a total period of 1344 h. A total of 56 consecutive neonates were recruited. There was an average of bed occupancy of 10 neonates/day with an average admission of 2 neonates/day in the NICU during the study period. There were 10 neonates in the 28–32 weeks gestation group, 30 in the 33–36 weeks gestation group, and 16 in the 37–40 weeks gestation group. As per unit protocol, all neonates irrespective of gestational age were initially nursed in an incubator and transitioned to an open care system when they were able to maintain temperature. There were 36 males and 20 females in the enrolled group. A noise generated by a working ventilator with the incubator hood closed generated the maximum noise (Table 1).

Table 1: Noise levels inside a working incubator and the noise generated by equipment

Parameter	Leq (dBA)
Ventilator with hood closed – incubator	68
Ventilator with hood open – open care	58
Continuous positive airway pressure	43
Tap water running	15
Opening/closing of incubator door	23
Two infusion pumps working	16
One multipara monitor on	28
Nasal cannula oxygen on flow	18

Leq: Loudness equivalent

The average noise inside and outside the incubator at various times during 24 h are tabulated in Table 2. The noise levels recorded both inside the incubator and the NICU were >58 dbA for most times of the day. The maximum noise was recorded in the morning and night around the time of nursing and medical shift change, namely, 7–8 am, 1–2 pm, and 7–9 pm. Similar findings were noted after the ward rounds between 11 am and 1 pm and after the afternoon nursing shift change between 2 and 4 pm. Noise levels before the visiting hours between 6 and 7 pm increased. The noise levels inside the incubator were significantly less as compared to that inside the NICU during the times when peak noise levels were recorded ($p<0.05$). The least noise was recorded both inside and outside the incubator (<50 dBA) between midnight and 5 am.

There was no significant difference in the noise levels inside the incubator irrespective of its position from the nursing station. The incubator 1 was the closest and 6 was the farthest from the nursing station (Table 3).

DISCUSSION

Our study which examined noise levels in the NICU and within the incubator recorded high noise levels most of the day both inside the incubator and the NICU, with the maximum noise being recorded during the time of nursing and medical shift change. Moreover, we also found when there were peak noise levels in the NICU, the noise levels inside the incubator were significantly less.

The baseline noise level reported in the working incubator with mannequin in the quiet NICU was similar to that noted by Marik *et al*. [10]. The previous studies have recorded the incubator noise to range from 45 to 70 dBA [7,10]. The maximum sound produced in the baseline for our study was with the ventilator working inside a closed incubator in the quiet room. This reduced by 10 dBA when the hood was opened. Similar results were described by Marik *et al*. who noted that this reduction in noise with the incubator hood open could be due to the reduction in reverberance at low frequencies within the incubator [10].

However, our study reported that noise levels in an operational NICU were higher outside the incubator, suggesting that the incubator might actually be protective and helpful in reducing the transmission of external noises normally occurring in functional

Table 2: Average hourly noise levels inside and outside incubator

Time points (h)	Noise (Leq outside incubator	Noise inside incubator (Leq)	Difference	t-value	p value
0–100	49.34±4.3	49.13±4.07	0.209	0.884	0.38
100–200	49.57±4.16	48.79±4.97	0.777	3.107	0.003
200–300	50.74±3.52	50.52±3.63	0.227	1.199	0.236
300–400	49.08±3.4	49.01±3.73	0.066	0.246	0.806
400–500	51.93±3.15	51.66±3.91	0.27	1.068	0.290
500–600	55.93±2.74	55.57±3.19	0.354	0.918	0.347
600–700	54.46±5.49	54.64±5.15	-0.177	-0.382	0.704
700–800	62.53±1.59	60.83±2.15	1.698	5.124	<0.001
800–900	59.81±3.14	58.83±2.59	0.986	3.07	0.003
900–1000	57.01±3.00	57.11±3.09	-0.167	-0.261	0.795
1000–1100	59.19±3.63	58.53±3.65	0.654	2.041	0.046
1100–1200	61.69±2.87	60.18±2.89	1.509	4.819	<0.001
1200–1300	60.61±3.45	59.96±3.31	0.654	1.660	0.001
1300–1400	61.42±3.01	60.06±3.13	1.357	4.436	<0.001
1400–1500	60.72±2.91	59.69±2.34	1.034	3.378	0.103
1500–1600	60.76±2.52	59.38±2.71	1.382	4.646	<0.001
1600–1700	59.23±2.33	58.72±3.04	0.509	1.470	0.147
1700–1800	58.81±3.77	58.64±3.25	0.171	0.505	0.616
1800–1900	61.25±2.46	60.11±3.09	1.139	2.574	0.013
1900–2000	61.45±3.36	60.17±2.97	1.280	2.802	0.007
2000–2100	61.44±2.81	59.51±3.42	1.93	4.384	<0.001
2100–2200	59.43±3.65	59.15±3.29	0.279	0.831	0.41
2200–2300	59.66±2.71	58.39±3.07	1.273	3.499	0.001
2300–2400	57.02±2.97	56.68±2.89	0.334	1.185	0.241

Leq.: Loudness equivalent

Table 3: Noise levels inside incubator in relation to incubator position from the nursing station

Incubator position	Average inside (Leq)	Average during peak hours (Leq)	Average during quiet hours (Leq)
1	57.0	64.4	43.3
2	60.1	63.6	43.0
3	53.8	63.8	43.1
4	58.3	64.9	44.4
5	57.2	63.3	44.0
6	52.4	61.5	40.8

Leq: Loudness equivalent

NICUs. This finding is in accordance with the findings of Wubben *et al*. who found higher noise levels outside and noise attenuation of up to 12 dBA inside the incubator [11] but not consistent with the study by Parra *et al*. who reported higher measured noise within incubator, suggesting that machine characteristics may also influence noise levels [12].

In the study from Iran, the lowest noise was detected around 10 pm. The highest noise recorded in most studies was during the time of nursing and medical shift change as in our study [13,14]. The noise levels in our NICU were above the AAP recommendations apart from 2 h after midnight when it was statistically less. This is similar to the findings in other studies, from India and around the world, in which sound levels ranged from 56 to 104 dBA [8,13-16]. A more recent study by Smith *et al*. has proposed that the noise level recommendations need to be modified, as the recommended 45 dBA is practically unattainable in an NICU [17].

The lack of difference in the average noise levels inside the incubator in our study irrespective of its position from the nursing station could have been because documentation and handover were done at the bedside and not at the nursing station. Hence, all the babies were exposed to the same intensity of noise. Our findings have public health importance as it reinforces the need to sensitize NICU nurses, doctors to reduce conversational noise, and the alarm volumes of monitors and equipment. The visiting families also need to be encouraged to adhere to noise reduction measures.

The strengths of the study include a large number of neonates of all gestational ages on various respiratory supports with multiple recordings, from a large tertiary neonatal unit. Despite this, the study has its limitations. It did not examine the physiological parameters reflecting the impact of noise levels on the neonates.

CONCLUSION

The incubator in the normally functioning NICU provides a better acoustic environment for the neonate. NICU nurses and doctors should be sensitized to reduce conversational noise and the alarm volumes of monitors and equipment. These along with modifications in biomedical equipment design may be helpful to reduce the noise level in NICU.

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