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ANALYSIS OF A NOISE LOAD IN DIFFERENT TYPES OF INFANTS' INCUBATORS

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ABSTRACT
Present study evaluated the noise levels inside the various types of incubators, identified its sources and investigated the real noise load of infants during 24-hour periods. It is higher in average by 15 dB(A) than the average noise levels in empty incubators and than the average noise load of infants in open crib. In 29 % cases it was even higher than the WHO limit for the 8-hour work time in workplace.

1 - INTRODUCTION

Advances in medical technology have led to major technological developments in the field of neonatal care. Over the past three decades there has been increasing concern about noise levels in neonatal intensive care units, especially in incubators. Incubator noise is certainly an important cause of stress to infants and a source of serious and dangerous changes in their behavioral and physiologic states [1].
Noise recorded inside the incubators has several components. The first one is background noise from the incubator motors, the second components are: life supporting therapeutic and monitoring equipment, nursing staff (opening and closing incubator doors, contact with incubator wall, etc.) and the infant itself.

2 - MATERIAL AND METHOD

Noise levels inside incubators have been measured by Brüel-Kjaer precision integrating sound level meter 2230 with 1/1 and 1/ 3 octave filter set 1625. The microphone was placed at a point where the infant's head lied.
Noise analysis of 6 various types of incubators (4 older and 2 new types, n = 81) was done. Noise levels were measured:

- inside empty incubators;
- inside incubators during other therapeutic and monitoring equipment service (alarm, perfusor, assisted respiratory devices, oxygen therapy, etc.);
- noise produced by manipulation with infants (opening and closing the doors, striking the wall of incubator either by putting something on, etc.);
- noise produced by infant itself (crying).

The real noise load of infant in incubator was performed by the long-term (24-hour period) recording of the noise inside the incubator during taking care of infant (n = 38). Simultaneously the level analysis in 2-dB(A) intervals was recorded through microprocessor (occurrence of noise levels was recorded 1045-times /sec.).

3 - RESULTS AND DISCUSSION

Average noise levels of incubator motors (inside empty incubators) were 64.2 − 79.7 dB SPL; 50.9 − 60.7 dB(A) (Table 1) according to type with maximum energy in the low frequency range (to 500 Hz). Incubators produce noise particularly into interior area, they do not practically influence the acoustic properties of the exterior area or deteriorate them only in a very low degree [2]: background noise L_A=41 dB(A), 1 incubator working L_A=41 dB(A), 3 incubators working L_A=43 dB(A), 7 incubators working L_A=49 dB(A).

All other equipment do not only increase the total noise levels (by about 6 − 18 dB(A) but also cause shift of energy maximum to higher frequency range (1 − 16 kHz): alarm increased noise level in all types by 10 − 18 dB(A) with maximum in the range of 1 − 16 kHz; perfusor by 6 dB(A) (maximum in the range of 4 − 8 kHz); oxygen therapy by 6 dB(A) (maximum in the range 500 − 2000 Hz), assisted respiratory device by 4 dB(A) (maximum in the range of 1 − 2 kHz and 8 − 16 kHz).

Incubator type		n	L [dB]			L_A [dB(A)]		
			mean	SD	x_1 - x_n	mean	SD	x_1 - x_n
Older types	TYPE 1A	24	70.2	4.3	62 - 78	54.4	2.9	50 − 60
	TYPE 1B	13	79.7	4.1	75 - 89	60.7	4.2	56 − 70
	TYPE 2	9	74.7	3.1	71 - 81	61.7	1.2	60 − 63
	TYPE 3A	26	64.2	2.8	59 - 72	51.6	3.7	47 − 64
New types	TYPE 3B	4	71.1	2.4	67 - 74	50.9	2.1	50 − 52
	TYPE 4	5	73.9	3.2	67 - 80	59.5	2.5	58 − 61

Table 1: Mean SPL (L) and noise levels (L_A) in 6 types of incubators (A − older type B − new type of the same producer).

The maximal levels were found during baby's crying (L = 105 − 108 dB; L_A = 105 − 108 dB(A) and especially by closing and opening the incubator doors (Table 2) and knocking on the incubator wall (L = 92 − 111 dB; L_A = 86 − 94 dB/A).

Incubator type	opening				opening			
	L [dB]	L_{max} [dB]	L_A [dB(A)]	L_c [dB(A)]	L [dB]	L_{max} [dB]	L_A [dB(A)]	L_{Amax} [dB(A)]
TYPE 1A	100.1	105.0	93.7	103.5	100.4	103.6	93.9	99.0
TYPE 1B	94.3	97.9	87.5	93.5	105.4	108.6	96.5	97.9
TYPE 2	101.5	107.5	81.8	89.5	105.4	114.0	90.1	93.0
TYPE 3A	96.9	100.4	82.2	95.5	108.9	123.2	95.6	113.2
TYPE 3B	99.3	107.8	88.0	98.3	98.5	103.4	84.6	97.6
TYPE 4	99.1	100.0	84.2	86.2	114.8	115.4	104.0	104.5

Table 2: Noise levels in 6 types of incubators during opening and closing the doors.

A long-term (24-hour) recordings of the equivalent, minimal and maximal noise levels inside the incubators during the care of infants showed statistically highly significant ($p < 0.001$) increase of noise levels − in average by 15 dB(A) in comparison with noise levels in empty incubators, minimal levels did not decrease under 47 dB(A) (Table 3).

In comparison − the 24-hour noise load of infant in open crib in neonatal unit was in average only 59.9 dB(A); minimal level only 23.6 dB(A) and it is statistically significantly lower than noise load in incubators TYPE 1B and 2 ($p<0.001$) and also TYPE 3A ($p<0.05$) (maximal levels in these cases were caused by infants crying directly to the microphone). Low minimal levels are very important − infant in open crib has possibility of regeneration and quiet sleep in silent environment so the noise load is not permanent.

Incubator type	n	Empty incubator	Incubator with infant			Increase by
		L_{Aeq}	L_{Aeq}	L_{Amin}	L_{Amax}	L_{Aeq}
		[dB(A)]				
TYPE 1A	1	58.2	70.5	55.4	99.0	12.3
TYPE 1B	16	56.0	73.7	51.3	104.3	17.7
TYPE 2	14	60.4	72.9	57.3	101.7	12.5
TYPE 3A	7	49.6	67.1	47.2	99.9	17.5
open crib	5	-	59.9	23.7	91.8	-

Table 3: Equivalent, minimal and maximal noise levels in empty incubators and in incubators during the care of infants (24-hour analysis).

The level analysis showed extension of noise range to high levels (Figure 1). The highest noise levels are present only in low percentage and short duration but their extremely high energy levels cause considerable increase of equivalent noise levels.

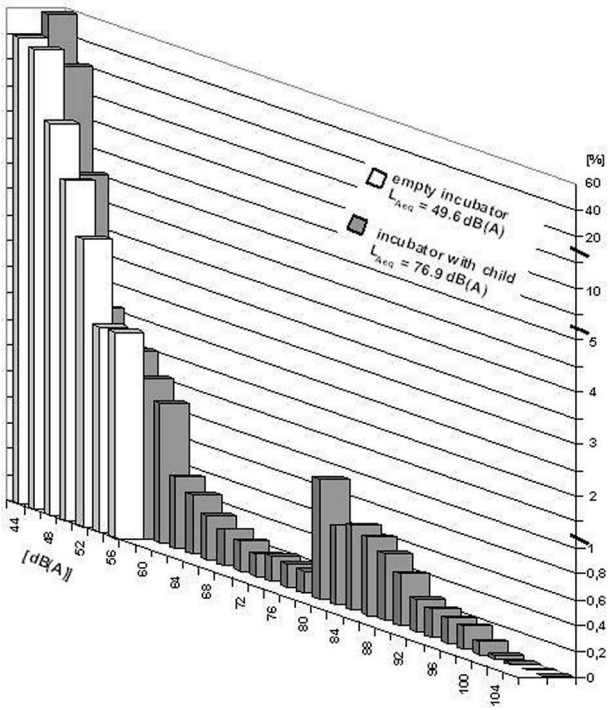

Figure 1: 24-hour level analysis of empty incubator and incubator with child type 3A).

However, these noise levels are in the range of absolute noise (> 65 dB/A) with the effects on the vegetative nervous system and/or with possible hearing damage [3, 4]. Exposure to these high noise levels may disrupt the normal growth and development of premature infants [5]. In 29 % cases the 24-hour noise load of newborn infants was even higher than the WHO limit for the 8-hour work time in the workplace (> 75 dB/A) and in all cases much higher than recommended sound level in hospital (45 dB during the day and 35 dB at night).

4 - CONCLUSIONS

Recent standards require that the mean noise levels inside the incubator should not exceed 60 dB(A) which is safe for the adult ear but real noise conditions in incubators are much more higher. When compared with the in utero environment the noise levels in incubators are high and potentially hazardous. Noise levels inside different types of incubators are very different, sometimes the newer type of the same producer has higher noise levels than older type. Real noise load of low-birth-weight and/or immature infants in incubators is significantly higher and is in the range of absolute noise permanently 24 hours a day several weeks even months without possibility of rest, it is significantly higher than noise load in open crib and is also higher (in 29 % cases) than limit for 8-hour work time in industry.

The following procedures could be taken to reduce the level of noise: reduction of alarm sounds to minimal level, better construction of incubator doors, instruction to nursing staff on how to reduce such

noise by taking more care in the handling of infants. Noise-induced health effects on fetuses and newborns merit further study as clinical and public health concerns [5].

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