

NOISE IN INFANT INCUBATORS AND IN NEONATAL INTENSIVE CARE UNITS

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1. INTRODUCTION

In Portugal, the number of children born alive was in 1996 of about 110,000. Near 10% to 15% of these need intensive neonatal care what represents about 14,000 newborn children requiring a stay within an Neonatal Intensive Care Unit (NICU), an environment usually noisy.

Regarding noise, the possible damage of the cochlea in newborn children caused by the exposure to high level pressure levels has been studied [1,2]. By previously held studies [3,4,5] it is known that the cochlea of some newborn animals can be more vulnerable to excessive auditory stimulation than adult cochleas. For this reason, it is usual to suggest the hypothesis that the human newborn can also present a reduction in the tolerance to noise regarding that of the adult [6].

However, a hypothesis that has been studied is that noise within the fetus intrauterine environment can be louder than the normal values in the exterior. If so, the high sound levels within the incubators would not be so unsafe as expected. By measuring the sound levels in the uterus of pregnant women and close to the fetus, averaged values were registered [15], corrected of the environment impedance mismatch, of about 95 dB (± 2.5 dB standard deviation) but with maximum values in the low frequency bands (≤ 250 Hz). These sound pressure levels are associated with the turbulent blood flow and muscle movement.

During the last three decades, studies have been published evaluating and stating that newborn children are exposed in the incubators to loud sound pressure levels [2,6,7]. The goal of this research is to continue these studies, regarding the situation in Portugal and to briefly analyze the possible changes in identical situations in other countries in the last 30 years.

2. STUDY DESCRIPTION

The goal of this study was to characterize the acoustic environment in two situations: within Neonatal Intensive Care Units (NICU) and in the incubators (within these NICU). Three hospitals in the urban area of Porto (second largest Portuguese town) were selected: V. N. Gaia Hospital with two NICU rooms (large regional unit built in the 1970's); Matosinhos Hospital (very large regional hospital built in 1997) and the Porto St. John Hospital (very large general and university hospital built in the 1960's). The selection of these hospitals was done by logistic reasons and also for been representative of the Portuguese hospitals with NICU's. Nine incubators and four NICU's were evaluated (Table 1).

The measurements were held during daytime on June 10, 1997. The equipment used was a 2231-B&K sound level meter (SLM) with a 1/3 octave filter set model 1625. The measurements in the incubators were done placing the microphone (attached to the SLM) a few centimeters from the infant's head. In all cases except for incubator 6 the infant was present during the measurements. For the measurements in the NICU's the SLM was placed in the middle of the room at a height of about 1.4 m and far from windows and doors. In any case was the noise of opening/closing the incubators doors included in the evaluation. The assessed noise is only the representative of the normal sound environment within these places but with occasional sounding warning alarms in the surrounding incubators.

The parameters used were the sound pressure levels L (dB) in the frequency bands 20 Hz to 20 kHz, the global sound pressure levels L (dB) and the noise criterion curves (*NC-noise criteria* [11], *NR-noise rating* [12], *RC-room criteria* [13] and *NCB-balanced noise criteria* [13]). The evaluations were done using the equivalent continuous sound pressure levels (Leq) during each measuring time (a few minutes).

Table 1. Incubators analyzed.

INCUB.	BRAND-MODEL-BUILDER	PLACE	INFANT
1	<i>Air Shields-142 MK2-Vickers Médical</i>	V.N.Gaia H. room 1	with infant
2	<i>Dräger-8000 SC-Drägerwerk</i>	"	with infant
3	<i>Ameda-Amecare-Ameda Egnell</i>	"	with infant
4	<i>Air Shields-142-Vickers Médical</i>	V.N.Gaia room 2	with infant
5	<i>Air Shields-C450-Vickers Médical</i>	Matosinhos H.	with infant
6	<i>Ohmeda-Careplus-Boc hearth Care</i>	"	without infant
7	<i>Air Shields-C2 HS/1C-Vickers Médical</i>	Porto St. John H.	with infant
8	<i>Air Shields-C200-Vickers Médical</i>	"	with infant
9	<i>Air Shields-C100-Vickers Médical</i>	"	with infant

3. RESULTS

Table 2 presents the summary of the averaged results found for Leq and for the noise criterion curves *NC*, *NR*, *RC* and *NCB* in 4 NICU's and in 9 incubators.

Table 2. Mean values for Leq (dB and dBA) and noise criterion curves.

PLACE	Leq (dB)	Leq (dBA)	NC	NR (1)	RC	NCB
V. N. Gaia Hospital - NICU #1	76.7	71.1	68	70	64	63

V. N. Gaia Hospital - NICU #2	73.0	62.2	56	58	57	55
Matosinhos Hospital (2)	67.8	53.2	49	50	47	45
Porto St. John Hospital	69.3	73.0	68	71	68	66
<i>average of NICU's</i>	<i>72</i>	<i>65</i>	<i>60</i>	<i>62</i>	<i>59</i>	<i>57</i>
Incubator 1	78.5	68.1	67	65	61	59
Incubator 2	76.0	61.7	59	58	56	54
Incubator 3	74.2	61.4	58	59	55	51
Incubator 4	71.6	58.0	57	55	49	47
Incubator 5	84.8	59.5	60	56	49	47
Incubator 6	68.7	56.3	57	55	45	41
Incubator 7	70.9	56.1	58	52	49	47
Incubator 8	68.1	55.5	52	54	49	48
Incubator 9	76.9	61.0	64	60	52	48
<i>average of Incubators</i>	<i>73</i>	<i>58</i>	<i>59</i>	<i>57</i>	<i>52</i>	<i>49</i>

(1) not using the corrections presented in [12] (2) the values express the still reduced activity of this new hospital and the better quality of the facilities.

4. LEGISLATION AND IDEAL VALUES

Regarding interior acoustical comfort the Portuguese Noise Code (*Regulamento Geral sobre o Ruído*, DL 251/87) states only that in hospital areas occupied by patients, the L_{50} of equipment noise should be less than 35 dB(A). This value is possibly exceeded in all the evaluated situations. As requirements of acoustic comfort regarding Noise Criterion Curves, the reference values shown in Table 3 can be used as ideal values [13,14].

Table 3. Ideal upper limit values for noise criterion curves *RC* [13] and *NC* [14].

PLACES IN HOSPITALS	<i>RC</i>	<i>NC</i>
private rooms, trauma units, operating rooms, etc.	25-35	-
public areas, corridors, etc.	30-40	-
(general)	-	25-35

5. ANALYSIS

As stated above, the evaluated situations do not reach, in any of the cases, the ideal values (noise criterion curves) and appear to be in disagreement with the essence of the legislative noise code rules (with validity since 01.01.1988).

The measured values indicate acoustical environments just a little louder in the NICU's than within the incubators. This reveals that one of the best ways to decrease the sound levels close to the infants must also deal with the reduction of sound levels in the NICU's and namely by decreasing (or eliminating) the sound of the warning alarms used in monitoring; increasing the total sound absorption in the room, by changing the characteristics of the floor coverings and ceilings; diminishing (or eliminating) all the speech in the NICU's and damping the impacts produced by the opening/closing of the doors to the incubator or to the shelves usually available below the incubator.

It seems to be a small but positive evolution towards quieter environments shown in the measured values when compared with the ones available in the

literature for similar situations at two or three decades ago (Table 4). Notwithstanding being this analysis very restrictive due to the particularly small data base used, that positive evolution seems to exist especially for the acoustical conditions existent in the incubators graded by its maximum *NC* values that appear to have reduced about 14 to 16 dB. Within the NICU's it does not seem to be any great change in the last three decades. Similarly favorable is the decrease (of about 11 to 15 dB) in the sound pressure levels in the low frequencies (125 Hz) but without significant change in the last 20 years for its maximum values. The *Leq* (dBA) do not appear to have greatly changed in the last two decades.

Table 4. Short historical analysis with available data (incubators and NICU's).

DATE/PLACE	NC (NICU)	NC (incub.)	L @125Hz (dB) (inc.)	Leq (dB) (incub.)	Leq (dBA) (incub.)
1968 Chicago -EUA [7]	55-65	55-83	64-86	67-86 (1)	50-69 (1)
1978 Vanderbilt-EUA [2]	na	na	66-72	74-80	52-58
1997 Porto -Portugal	49-68	52-67	53-71	68-78	56-68

na - not available (1) calculated from available values in [7].

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