

THE USE OF INCUBATOR COVERS: REPERCUSSION ON NOISE LEVELS

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ABSTRACT

To assess the effectiveness of incubator covers (flannel) in decreasing sound pressure levels (SPL) coming from operating pulse oximeters and infusion pumps with alarms ringing. This quasi-experimental study measured SPL of 20 incubators divided into three groups according to brand, model, and age while they were functioning and had alarms ringing on the tops of the domes, with and without a cover. Only group 1 presented a significant decrease in noise levels when the alarm of the pulse oximeter went off while using a cover. The cover significantly increased noise produced by a working infusion pump in the groups 1 and 3. Noise levels significantly decreased with the use of a cover in the groups 2 and 3 when the alarm of the infusion pump went off. The conclusion is that no safe levels were achieved, despite decreased noise levels observed in some situations. Thus, incubator covers should not be used as a strategy to decrease noise and equipment should not be placed on domes.

Keywords: Noise. Incubators. Noise Control. Neonatology. Nursing.

INTRODUCTION

Incubators are widely used, often for long periods of time⁽¹⁾, in the care provided to preterm newborns to favor their development and thermoregulation. This device, however, also exposes infants to noise coming from its motor and alarm⁽²⁾ as well as from its handling^(2,3).

Changes in the infants' autonomous system to respond to stressful stimuli, such as altered blood pressure, heart beat and behavioral state, changes one clinical and neurologic stability contributing to morbidity over time⁽¹⁾.

Even brief auditory stimuli can result in increased response from the autonomous system, generating physiological decline and exposing infants to the risk of bradycardia and hypoxia episodes^(4,5).

Therefore, the sensory environment in which

preterm infants are inserted is an important aspect that should be observed in neonatal intensive care units (NICU)⁽⁶⁾. An intensively noisy environment is one of the main sources of stress among preterm babies and is of concern because it has potential to compromise hearing and interfere in the sleep-wake cycle, weakening the infant's physiological resources^(2,3), which when associated with other environmental factors, may interfere in normal growth and development^(3,4).

Brazilian and international parameters were established to control noise levels in NICU and incubators. The US Environmental Protection Agency⁽⁷⁾ recommends that noise levels, in the neonatal units and incubators, should not exceed $L_{eq}45\text{dBA SPL}$, while the Brazilian Association of Technical Standards establishes that such levels should be lower than 60dBA SPL and noise coming from alarms should not exceed 80dBA SPL ^(7,8).

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The most recent guideline proposed by the Committee to Establish Recommended Standards for Newborn ICU Design⁽⁹⁾ determines that continuous background noise and operating noise should not exceed L_{eq} 45dBA. L_{10} 50dBA and L_{max} 65dBA were established for neonatal wards and recovering rooms, while L_{eq} 50dBA, L_{10} 55dBA and L_{max} 70dBA⁽⁹⁾ were established for working areas, family areas, and rest areas for the staff, respectively. This recommendation holds for any bed rooms or neonatal area where intensive or intermediate neonatal care is provided⁽⁹⁾.

When providing neonatal care, equipment such as infusion pumps, pulse-oximeters and other objects are frequently placed on the dome of incubators. In order to darken its inside, which is key to favor the sleep of infants, flannel covers are also used so equipment is placed on top of covers. Authors report in the literature that this strategy minimizes sound pressure levels (SPL) inside incubators, though do not specify the type of fabrics used⁽¹⁰⁾.

Ideally, all incubators would have accessory trays to install equipment, however, incubators with such accessories are very rare in neonatal units (NICU) due to high costs, requiring the use of the alternative practices previously mentioned. These practices, however, lack evidence regarding their effects on sound levels inside incubators.

The literature recommends the use of incubator covers to minimize both light and noise, though there is no mention regarding the use of covers associated with other equipment placed on top of domes and consequent effects on sound levels⁽¹¹⁾.

Two studies report the adoption of incubator covers as a measure to decrease noise levels^(10,11). One of them used a four-layer padded cover to minimize noise generated by the unit and life support equipment, measuring SPL only before the intervention, which ranged from 56 to 77 dB SPL⁽¹⁰⁾. The authors, however, do not report noise levels measured after incubator covers were used.

None of these studies verified noise levels when operating equipment, such as infusion pumps or pulse oximeters, was placed on top of incubators, which motivated this study.

This study's hypothesis is that the use of a flannel cover placed on top of incubators minimizes SPL generated by this type of devices.

Therefore, we sought to present evidence of SPL generated by equipment placed on top of incubators with and without a flannel cover in order to enable changes in the care provided in NICU and contribute to neonatal care favoring the growth and development of preterm infants and those with special needs.

Therefore, this study's objective was: to assess the effectiveness of a flannel cover in decreasing sound pressure levels (SPL) coming from the operation of pulse oximeters and infusion pumps and ringing alarms.

MATERIAL AND METHODS

This quasi-experimental study⁽¹²⁾ was conducted in a university hospital in the interior of São Paulo, Brazil, which is a tertiary hospital, reference in perinatal care. It also provides care to individuals from surrounding cities and other states. This facility has neonatal intensive and intermediate care units with 17 and 27 beds, respectively.

The sample was selected according to the availability of incubators in regular operation from August to September 2013. The incubators were assessed without the presence of infants. A total of 20 incubators from three different brands were used and due to ethical issues, are not identified.

The incubators were divided into three groups according to brand, model, age, and handling situations. Group 1 was composed of six incubators manufactured in Brazil; only one was from a different brand; Group 2 was composed of nine incubators of the same Brazilian brand and model; and Group 3 was composed of five incubators of the same Brazilian brand and model.

Group 1 included incubators with three years of use; this was the group with the oldest incubators. Group 2 was composed of incubators with two years of use, while incubators in the group 3 had less than two years of use; these were the facility's newest incubators.

In order to clarify terminologies, we have: L_{eq} refers to fluctuation in noise levels measured over a period of time; decibel (dBA) is a dimensionless unit in A-weighted scale that attenuates low frequency sounds, similarly to a human ear; SPL (sound pressure level): relative intensity measurement process that takes $20\mu\text{Pa}$

as reference, while L_{\max} , refers to the highest SPL recorded during a given period⁽⁹⁾.

We used a Quest 400 noise dosimeter, properly calibrated, with 140x70x40mm in size, weighing 440g, with a 8mm ceramic microphone, and powered by a 9-volt alkaline battery with approximately 16 hours of duration.

Before measuring SPL inside incubators, we measured the level of ambient noise in the room where data would be collected, located in the same corridor of the NICU, away from the unit's routine flow.

The incubators were tested when operating in normal mode with all its hatches and intensive care door closed. Temperature was between 30 to 33°C and maximum humidity was kept when this feature was available. The dosimeter remained outside the incubator with its microphone installed inside the equipment in the center of the base platform, suspended and placed 10 to 15 cm away from the mattress⁽⁸⁾.

SPL was measured in the following situations: Situation A – functioning pulse oximeter placed on top of a functioning incubator; Situation B – functioning incubator while the alarm of the pulse oximeter was ringing; Situation C – functioning infusion pump placed on top of a functioning incubator; Situation D – functioning incubator while the alarm of the infusion pump was ringing.

To meet the study's second objective, the situations aforementioned were repeated, only this time the equipment was covered with a flannel cover: Situation A + cover; Situation B + cover; Situation C + cover; and Situation D + cover. Each measurement took one minute because the equipment was set to integrate data every minute. A flannel fabric with 140cm x 60 cm in size was placed on top of the dome.

Considering the diversity of brands, the same infusion pump and pulse oximeter acquired by the facility at the same time were used, that is, both were two years old. Both devices were manufactured in Brazil, had visual and sound alarms and were the most frequently used in the facility's NICU. The auto syringe pump is micro processed with speed and infusion volume control. The pulse oximeter monitors blood oxygen saturation, plethysmographic curve and heart rate.

To avoid noise interferences, equipment was always placed on the top right side of domes.

The various SPL recorded during the measurement were integrated in the dosimeter in a single SPL (L_{eq}), which was the value used in data analysis.

Every day, before beginning data collection, the dosimeter was calibrated using a Quest QC-10 Sound Calibrator and then set to A-weighting with slow response and to operate in SPL intervals between 40 and 140dB (lowest and highest value recorded by the equipment).

After each day of data collection, the values recorded by the dosimeter were downloaded to the same computer, using Quest Suit[™] system and program for Windows. Data were transferred to Excel 5.0 to perform statistical analyzes using the Statistical Package for the Social Science (version 10.1).

Data analysis included the Wilcoxon nonparametric test for two dependent samples because dB is a logarithmic scale that does not follow a normal distribution. Median, minimum and maximum values were used to present L_{eq} in the graphs since these are appropriate for the statistical test used. The level of significance adopted was equal to 0.05.

It is worth noting that because it does not involve human subjects, this study did not require approval from an Institutional Review Board. Nonetheless, the study was only initiated after the heads of the facility's Pediatrics and Child Care Department, Nursing Division, and the Center for Engineering and Bio-equipment Maintenance authorized the procedure.

RESULTS AND DISCUSSION

In regard to noise levels generated in the environment, group 3 presented the lowest median L_{eq} of 51.3dBA SPL. Group 1 presented the lowest L_{eq} 49.28dBA SPL and also the highest L_{eq} of 72.8dBA SPL.

The values measured inside the incubator with the pulse oximeter placed on top of the incubator with its alarm going off, with and without a flannel cover, at some points reached levels that exceeded the recommended by Brazilian standards⁽⁸⁾, 60dBA SPL, though medians remained within the recommended as well as noise verified when incubators were under regular functioning (Table 1).

Table 1. Continuous noise (L_{eq} dBA SPL) coming from a functioning pulse oximeter and ringing alarm, with and without a flannel cover, and p values from the three groups.

Continuous noise	Groups												Geral		
	1				2				3						
	Min	Med	Max	P	Min	Med	Max	p	Min	Med	Max	P	Min	Med	Max
Situation A*	49.4	51.1	55.5	0.715	54.4	55.5	62	0.723	50.4	53.6	55.4	0.08	49.4	54.7	62
Situation A + cover	49.4	51.1	55.5		54.7	55.6	59.6		50.5	51.6	53		49.4	54	59.6
Situation B**	50.9	54.6	64.5	0.028***	55.8	58.6	65.4	0.092	53.7	59.1	65.6	0.5	50.9	58.4	65.6
Situation B + cover	50.3	54.3	63.5		55.5	57.9	63.3		53.4	60.1	63.1		50.3	57.8	63.5

Min – minimum value Med - Median Max – maximum value *Noise from incubator and pulse oximeter **Noise from incubator and pulse oximeter's ringing alarm. ***Statistically significant

Noise levels equal to or higher than 60dB are associated with sleep disorders and when noise is continuous, it can enhance ototoxic effects of drugs frequently used by preterm infants in neonatal units⁽¹³⁾.

When comparing noise levels coming from ringing alarms with those coming from regular functioning equipment, the noise levels intensified 3.5dBA for group 1; 3.1dBA for group 2; and 5.5dBA for group 3, as shown in table 1. Again, sound pressure almost doubled in the incubator's microenvironment in the last group, which would expose infants to 14.1dBA (group 3), i.e. above the parameter recommended by international standards⁽⁷⁾.

A previous study⁽¹⁾ verified that one of the main elements contributing to ambient noise is the alarm of pulse oximeters and reports it increased 7.5dBA in the ambient sound level. In this study, variations were smaller than those found in the aforementioned study but still meant exposure to levels almost twice as higher (group 3) inside the incubator.

No statistically significant differences were found in any of the groups between sound levels produced by a functioning pulse oximeter with and without a flannel cover (Table 1).

A statistically significant difference ($p=0.028$), however, was presented only by group 1 when the equipment's alarm went off, with and without a flannel cover; noise

decreased 0.3dBA with the presence of a cover. A decrease of 0.7dBA ($p=0.092$) was presented by group 2 with the use of a cover, while the use of a cover intensified sound levels in 1dBA ($p=0.5$) in the group 3.

In regard to the infusion pump, all the medians of L_{eq} obtained when the alarm went off, with and without a flannel cover, exceeded the recommended 60dBA. Even though these values exceeded the international recommendation of 60dBA SPL, they remained below 80dBA SPL, which is the parameter recommended by the Brazilian agency⁽⁸⁾ (Table 2). Again, SPL generated by the alarms were more intense than those generated by regular functioning equipment.

A previous study⁽¹³⁾ verified that the alarms of equipment placed on top of incubators exposed 74.3%⁽²⁶⁾ of preterm infants to intense noise.

The noise produced by the infusion pump, with and without a flannel cover, showed statistically significant differences ($p=0.046$) for group 1, increasing 0.7dBA with the use of cover, and group 3 ($p=0.043$) with a median L_{eq} of 51.8dBA SPL when not using a cover, and 54.9dBA SPL when using a flannel cover. Thus, the level of noise was 3.1dBA higher with a cover, noting that dB is a logarithmic scale and therefore, small variations represent significant changes in sound pressure.

Table 2. Continuous noise (L_{eq} dBA SPL) coming from an operating infusion pump and its ringing alarm, with and without a flannel cover, and p values of the three groups.

Continuous noise	Groups												General		
	1				2				3						
	Min	Med	Max	P	Min	Med	Max	P	Min	Med	Max	p	Min	Med	Max
Situation C*	49.2	51.1	55.8	0.046***	55.1	57.5	65.5	0.183	50.0	51.8	52.6	0.043***	49.2	53.9	65.5
Situation C + cover	51	51.8	55.7		55.1	57.3	58.9		50.7	54.9	65.6		50.7	55.1	65.6
Situation D**	55.8	65.5	70.7	0.753	59.3	65.2	73.8	0.017***	64.5	68.8	73.1	0.043***	55.8	66.1	73.8
Situation D + cover	57.6	63.7	71.3		57.8	61.3	70.5		53.5	60.7	66.1		53.5	61.7	71.3

Min – minimum value Med – Median Max – maximum value *Noise from incubator and infusion pump **Noise from incubator and infusion pump's ringing alarm. ***Statistically significant.

In all the groups, the median of SPL generated by the alarm of the infusion pump was lower when a cover was used than without it, with statistically significant differences found in the groups 2 ($p=0.017$) and 3 ($p=0.043$). The general median of the groups without a flannel cover was Leq 66.1dBA SPL and with a cover was 61.7dBA. In this case, the use of a cover, when compared to the groups' general medians, enabled a decrease of 4.4dBA in the sound pressure level (Table 2).

Another investigation⁽¹⁾ reports that a decrease 3.27dBA SPL inside incubators enabled improved oxygenation in 1%, situation that was maintained after the acoustic foam used inside the incubator was removed, and also improved sleep among infants. According to the author, the oxygenation effects should be seen with caution because the infants were receiving respiratory support.

A decrease in noise levels coming from the ringing alarm of the infusion pump placed on top of the incubator when using a flannel cover was statistically significant for groups 2 and 3 (Table 2), confirming the hypothesis in these groups, with differences between levels, which according to Johnson⁽¹⁾, improve the infants' behavioral and physiological state.

The intervention enabled less intense noise levels though they remained above 45dBA SPL, which is the recommended by international standards, while all the medians were above 60dBA SPL.

We believe that the recommendation for the units under study, to place a flannel cover to reduce noise⁽³⁾, should not be coupled with placing equipment on top of the incubator, as it generated more intense noise levels.

Based on data collected in this study, we conclude⁽¹³⁾ that handling and installing these monitor devices on the top of incubators should be avoided or abolished from the practice of neonatal units.

It is worth noting that, under Situation A, both ambient SPL from the room where data were collected and SPL from the inside of regular functioning incubators, were above 45dBA SPL, which is the parameter recommended by international standards⁽⁹⁾.

Corroborating with these results, a study verified that the use of a four-layer padded cover placed on top of incubators significantly decreased ($p=0.017$) noise levels inside the incubators with the presence of infants, though remained above 58dBA. Before using a cover, noise levels ranged from 56 to 77dBA, with an average of 65.9dBA⁽¹⁰⁾. A limitation of the aforementioned study is that it does not report SPL verified after the intervention.

The decrease obtained in this study was higher than the 3.27dBA SPL obtained in a study that verified that the use of acoustic foam inside the incubator during neonatal care resulted in improved oxygenation and sleep, though 69.2% of the preterm newborns were also receiving oxygen support⁽¹⁾.

Even though the aforementioned study verified the newborns experienced improved behavioral and physiological state with decreased noise levels within the incubators, we note that in this study, when the alarm of devices placed on top of the incubators went off, noise levels inside the incubator intensified, and even with the buffering effect from the use of a flannel cover, SPL still remained intense reaching maximum Leq of 71.3dBA SPL.

Sound levels of 70dBA may compromise the infant's auditory system⁽¹⁴⁾. A study reports that cochlear-palpebral and startle reflexes are triggered and behavioral and wake-sleep states are changed when newborns are exposed to Lmax above than 65dBA⁽¹³⁾.

Note that even the handling of incubators may generate intense SPL, especially when tasks are performed abruptly⁽³⁾.

Even though the use of flannel covers significantly decreased SPL coming from ringing alarms, the results indicate that the nursing practice of placing equipment on top of incubators should be abolished. This strategy used in humanized neonatal care intended to minimize lighting significantly decreased SPL but did not ensure safe sound levels for newborns under the situations tested. Note the biological fragility of this population exposed to various risks and harm, considering that many newborns require continuous nursing care is provided in incubators for long periods of time. Therefore, flannel covers should not be used to minimize noise nor justify

placing equipment on top of incubators. We reaffirm the need to abolish the placement of equipment on top of incubators such as infusion pumps and pulse oximeters.

We emphasize the importance of using accessory trays attached to the incubators' supports or formic-covered shelves on the walls of the neonatal unit to place equipment whenever appropriate environment, with working stations and continuous monitoring, is not available so to provide a less noisy environment for newborns.

There is a need to develop strategies that promote changes in the behavior of the nursing staff to minimize noise in neonatal units. Therefore, promoting continuous education for the nursing and multidisciplinary staff, using a participatory methodology, is key to establish an environment conducive to the development and growth of newborns.

Further studies are needed to continue this investigation addressing situations that assess SPL inside incubators using covers with different degrees of thickness. For the results of studies to be consistent with real contexts of care, incubators should remain in the neonatal unit with the presence of newborns, though equipment should not be placed on top of incubators. We also suggest that newborns' reactivity be assessed during the situations under study.

We agree with an investigation that addresses noise in neonatal unit and highlights that reducing noise levels should be a priority among managers and healthcare providers⁽¹⁵⁾. Additionally, healthcare providers should encourage appropriate management of equipment, physical infrastructure, and

interpersonal communication with children and families⁽¹⁶⁾.

We expect this study supports changes in nursing care practice focusing on managing ambient noise to promote developmental and humanized care in neonatal units.

CONCLUSION

The conclusion is that the ringing alarms of pulse oximeters and infusion pumps without the use of a cover intensified sound pressure levels.

Only group 1, composed of Brazilian incubators, showed significant decrease in noise levels when the alarm of the pulse oximeter went off and a cover was used. Groups 1 and 3, showed significant increased noise levels when a cover was used under a functioning infusion pump, though noises levels decreased significantly for groups 2 and 3 when the alarm of the infusion pump went off and a cover was being used.

Therefore, the study's hypothesis was confirmed when the alarms of the pulse oximeter (only group 1) and of the infusion pump (groups 2 and 3) went off, given significant decreased SPL observed when a flannel cover was used, though noise levels remained intense and above the recommended.

Even though a flannel cover enabled significant reduction in SPL in the situations previously described, it did not ensure safe noise levels and for this reason should not be used as a strategy to reduce noise levels and equipment should not be placed on top of incubators.

O USO DE TECIDO FLANELADO SOBRE INCUBADORAS: REPERCUSSÃO NOS NÍVEIS DE RUÍDO

RESUMO

Avaliar a efetividade do uso de um tecido flanelado sobre a cúpula das incubadoras na diminuição do nível de pressão sonora (SPL) decorrente da presença do pulso oxímetro e da bomba de infusão em funcionamento e seus alarmes soando. Estudo quase-experimental em que foram mensurados os níveis de pressão sonora de 20 incubadoras, divididas em três grupos conforme a marca, modelo, tempo de uso, com os equipamentos em funcionamento e como soar dos alarmes sobre suas cúpulas, com e sem tecido flanelado. Ao soar o alarme do pulso oxímetro, somente no grupo 1 houve redução significativa dos níveis com o uso do tecido. O uso do tecido aumentou significativamente os níveis produzidos pelo funcionamento da bomba de infusão nos grupos 1 e 3. Ao soar do alarme da bomba de infusão, houve redução significativa de níveis com o uso do tecido nos grupos 2 e 3. Conclui-se que o uso do tecido flanelado, embora tenha reduzido os níveis em algumas situações, não atingiu níveis sonoros seguros e não deve ser utilizado como estratégia de redução de ruído e os equipamentos não devem permanecer sobre a cúpula.

Palavras-chave: Ruído. Incubadoras. Controle de ruídos. Neonatologia. Enfermagem.

EL USO DEL PAÑO SOBRE LA CÚPULA DE INCUBADORAS: REPERCUSIÓN EN LOS NIVELES DE RUIDO

RESUMEN

Se tuvo por objetivo evaluar la efectividad del uso de un tejido afranelado sobre la cúpula de las incubadoras para disminuir el nivel de presión sonora (SPL) proveniente de la presencia del oxímetro de pulso y del funcionamiento de la bomba de infusión y de sus alarmas sonando. Se trata de estudio casi experimental en que fueron medidos los niveles de presión sonora de 20 incubadoras, divididas en tres grupos de acuerdo con: marca; modelo; tiempo de uso; equipamientos funcionando y con las alarmas sonando sobre sus cúpulas; y, con y sin el tejido afranelado. Al sonar la alarma del oxímetro de pulso, solamente en el grupo 1 hubo reducción significativa de los niveles con el uso del tejido afranelado. El uso de ese tejido aumentó significativamente los niveles producidos por el funcionamiento de la bomba de infusión en los grupos 1 y 3. Al sonar la alarma de la bomba de infusión, hubo reducción significativa de los niveles con el uso del tejido en los grupos 2 e 3. Se concluye que el uso del tejido afranelado, a pesar de que hubiese reducido los niveles de ruido en algunas situaciones, no alcanzó niveles sonoros seguros y no debe ser utilizado como estrategia para reducir el ruido, y los equipamientos no deben permanecer sobre la cúpula.

Palabras clave: Ruido. Incubadoras. Control de ruidos. Neonatología. Enfermería.

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