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ORIGINAL ARTICLE

Noise level in a pediatric intensive care unit

Nível de ruídos em uma unidade de cuidados intensivos pediátricos

Werther B. Carvalho,[1] Mavilde L. G. Pedreira,[2] Maria Augusta L. de Aguiar[3]

Abstract

Objective: The purpose of this study was to verify the noise level at a PICU.

Methods: This prospective observational study was performed in a 10 bed PICU at a teaching hospital located in a densely populated district within the city of São Paulo, Brazil. Sound pressure levels (dBA) were measured 24 hours during a 6-day period. Noise recording equipment was placed in the PICU access corridor, nursing station, two open wards with three and five beds, and in isolation rooms. The resulting curves were analyzed.

Results: A basal noise level variation between 60 and 70 dBA was identified, with a maximum level of 120 dBA. The most significant noise levels were recorded during the day and were produced by the staff.

Conclusion: The basal noise level identified exceeds International Noise Council recommendations. Education regarding the effects of noise on human hearing and its relation to stress is the essential basis for the development of a noise reduction program.

J Pediatr (Rio J). 2005;81(6):495-8: Critical care unit, noise, hospital environment, pediatric nursing.

Resumo

Objetivo: Verificar o nível de ruídos em uma unidade de cuidados intensivos pediátricos.

Métodos: Estudo observacional e prospectivo realizado em uma unidade de cuidados intensivos pediátricos de 10 leitos de um hospital universitário da cidade de São Paulo, Brasil. Os níveis de ruídos foram medidos por meio de equipamento instalado no corredor de acesso à unidade de cuidados intensivos pediátricos, posto de enfermagem, duas salas com três e cinco leitos, bem como nas unidades de isolamento. O equipamento utilizado foi calibrado para registrar a pressão do som em dBA, durante 24 horas, por 6 dias. Os dados foram analisados de acordo com as curvas gráficas registradas pelo equipamento.

Resultados: Foi identificado um nível basal de ruídos de 60 a 70 dBA, com pico de 120 dBA. Os níveis mais elevados foram identificados no período diurno, decorrentes da atividade e comunicação dos profissionais.

Conclusão: Os níveis de ruídos identificados excederam as recomendações do *International Noise Council*, da Organização Mundial da Saúde. A educação sobre os efeitos prejudiciais de ruídos na audição humana e sua relação com o estresse constituem as bases para a implementação de programas de redução de ruídos.

J Pediatr (Rio J). 2005;81(6):495-8: Unidade de cuidado intensivo, ruídos, ambiente hospitalar, enfermagem pediátrica.

Introduction

Children admitted to pediatric intensive care units (PICU) endure a harsh reality, related to illness and its treatment, coupled with the actual unit's environment. The PICU is usually a new and unknown place for children and their families, with an overload of events that can promote either excess or deprivation of sensorial stimulation, which is capable of producing stress.[1]

Although the technological environment of the PICU has benefits in terms of biological equilibrium, it is also physically and psychologically aggressive. Critically ill infants and children are at high risk of developing stress-related behavioral disorders, and the PICU environment can significantly contribute to these alterations.[2] One of these harmful interactions is related to the noise level. PICUs are described as a technological symphony, due specifically to the high level of activity, equipment sounds and alarms, telephones, and voices of staff.[3]

Noise, particularly in large metropolitan areas, has been increasing over the years, an increase that can also be noted inside hospitals. The resulting disturbances in patients and caregivers can lead to serious health consequences. Increased noise levels may have physiological effects, such as increase in blood pressure, heart rhythm alterations, peripheral vasoconstriction, dilatation of pupils, and increased adrenaline secretion.[4] The hypothalamic pituitary adrenal

1. MD, PhD. Adjunct professor, Department of Pediatrics, Universidade Federal de São Paulo - Escola Paulista de Medicina (UNIFESP/EPM), São Paulo, SP.
2. RN, PhD. Adjunct professor, Nursing Department, Universidade Federal de São Paulo - Escola Paulista de Medicina (UNIFESP/EPM), São Paulo, SP.
3. RN. Pediatric nurse specialist, Universidade Federal de São Paulo - Escola Paulista de Medicina (UNIFESP/EPM), São Paulo, SP.

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axis is sensitive to noise at 65 dBA in adults, resulting in an increase in plasma corticosteroid levels and urinary excretion of epinephrine and norepinephrine.[3-5] Enhanced pain sensation can be present in some infants and children, thus requiring more analgesia.[6] Hearing loss, which has been reported to occur in premature infants, could be related, among other causes, to acoustic trauma to the cochlea cells.[7]

Psychological effects related to increased noise levels can lead to behavioral alterations, resulting in physiological stress responses. The degree of damage is related to the sound's nature, its significance, or whether it can be controlled and expected. Intensive noise can affect the child's personality and reduces the capacity to cope.[5,8-10]

Noise-induced sleep deprivation may consume energy needed for the healing process, because of its relation with immunosupression, impaired protein synthesis, confusion, irritability, disorientation, failure in the sense of control and anxiety. The suppression of rapid eye movement (REM) sleep pattern and psychosis after intensive care treatment can be associated to noise.[9-13]

The purpose of this study was to identify the noise level at a PICU, compare the results to recommended levels and develop interventions to reduce noise pollution.[4-5,14]

Methods

This prospective observational study was performed in a 10-bed PICU, housed in an area of 251.96 m², on the hospital's ninth floor. This teaching hospital, an 11-story high, three-sided building, is located in a densely populated district in the city of São Paulo, Brazil. The research protocol was approved by the institution's Ethics Committee.

Three of the 10 beds are intended for pediatric cardiac surgery, and are located in one ward. The other beds are designated for clinical and other surgical treatments; five beds are located in a large ward, and two are set apart for patients who need isolation.

This study was conducted in strict confidentiality, in order to prevent influencing the routine of the staff. Everyday, about 20 people work in the PICU, including physicians, nurses, nurse assistants, and students. These professionals work six or 12-hour shifts.

Sound pressure levels were measured and registered using Entelbra® ETB 142 equipment, with the assistance of a biomedical engineer, who set up the equipment in the PICU access corridor, nursing station, two open wards with three and five beds, as well as in the isolations rooms.

Noise is defined in physics as a random, inharmonious and fluctuating wave, whose measurement involves the analysis of intensity, frequency and the temporal dimensions of acoustic sound, which can be verified by equipment capable of registering the force per unit area that the sound waves produce.[5-6,15-16]

In physics, the measurement of sound intensity is performed by means of a scale based on multiples of 10. On such a scale, the threshold of hearing is 0 dB, the sound intensity at which no sound is perceivable. A sound 10 times more intense than 0 dB is recorded as 10 dB, a sound 100 times more intense is 20 dB, and a sound 1,000 times more intense is 30 dB. The noise level near the threshold of pain is 130 dB (10 trillion times more intense than a sound at the threshold of hearing).[17] To more accurately reflect the ear's sensitivity to sound intensity over the range of audible frequencies, researchers developed a "weighted" unit of sound intensity, known as the A-weighted decibel, or dBA.[17] On the dBA scale, an increase of 10 dBA results in a perceived doubling of loudness. In this study, the equipment utilized was calibrated to measure sound intensity in dBA.

In the wards, including the isolations rooms, the Entelbra® ETB 142 equipment was placed at a distance of 1.5 m from the head of the child's bed, and 1 m from the floor. Utilizing the same distance from the floor, the equipment was placed in the middle of the nursing station and in a corner of the access corridor, near to the wards' doors.

The equipment was calibrated for recording sound pressure in dBA, a linear scale defining a logarithmic amplitude scale, during a 6-day, 24-hour period, and was checked daily to verify the printed data. The biomedical engineer also intermittently monitored the noise emitted by each equipment located at bedside, during normal operation and triggering of the alarms.

The data obtained were analyzed in accordance with the graphic curves produced by the equipment.

Results

The basal noise level observed in the PICU ranged between 60 and 70 dBA. Peak hours of noise were between 10:00 AM and 4:00 PM. The nurses' station and the corridor leading to the PICU had the highest noise levels. However, a basal noise level of 80 dBA, with a maximum level of 120 dBA, was detected during the admission of a child for cardiac surgery postoperative care, originating from the communication between the PICU staff, anesthesiologists, and surgeons.

The most significant noise levels were produced in the daytime periods, at the nursing station and corridor leading to the PICU, where no equipment is available. These PICU areas are characterizing by dense traffic and talking related to teaching activities, whereby, during certain periods of the day, the number of students, staff and other health care personnel is greater than recommended. In these areas clinical discussions and decisions about patient care take place, and therefore the high level of noise could potentially compromise the communication process.

Regarding the noise produced by equipment, the most significant was generated during the triggering of certain alarms and during the normal operation of the mechanical ventilator, followed by the "bip" of the cardiac monitors, as described in Table 1.

The high level of noise identified in this study demonstrates the need of a program to reduce sound levels in the PICU development. Staff education was considered as the major focus of a noise reduction program.

Table 1 - Noise sources and levels at a pediatric intensive care unit

Noise source	Intensity (dBA)
Mechanical ventilator	60-65
Mechanical ventilator alarm	70-85
Infusion pump alarm	65-75
Pulse oximetry alarm	60-75
Cardiac monitor (ECG)	50-55
Endotracheal aspiration system	50-60

Discussion

The noise levels of 60 to 70 dBA at the PICU exceed by 15 to 35 dBA the recommendations of the United States of America Environmental Protection Agency for the day and night periods, respectively. This basal noise level also exceeds the recommendations of the International Noise Council.[4-5,18]

A similar study performed in a nine-bed medical and surgical adult ICU identified a mean measured sound of 71 dBA, with a maximum measured sound of 82 dBA, lower than the 120 dBA verified in our study.[19]

This continuous and excessive noise level can produce physiologic and psychological effects in the health care staff, such as increased blood pressure, impaired heart rate and muscle tone, headache, hearing loss, confusion, low attention span, and irritability.[19-23] All these problems can be exacerbated, if individuals are constantly exposed to a noise level of 80 dBA for a period of more than 8 hours, as stated by the Brazilian Federal Labor Institute.[21,22]

The high level of noise is an occupational hazard that can interfere on the health care professional's quality of life and work performance. An interactive effect of chronic exposure to noise on changes in blood pressure and job satisfaction was identified in a research performed with industry employees. The exposure to occupational noise has a negative impact on blood pressure and job satisfaction over time, mainly among workers that performed complex jobs.[24]

Health care professionals must be protected from this adverse environmental hazard, which can compromise their performance and contribute to undesirable events in patient care, decrease of job satisfaction and lead to high burnout rates among critical care professionals.

Equally, children in critical care units must be protected from this adverse stimulation that can compromise the healing process by increasing the production of somatotropin, adrenocortical stimulating hormone, catecholamines, epinephrine, norepinephrine, metabolic rate, and other important physiological alterations. The psychological effects caused by excessive noise trigger an individual response that may be interconnected with a series of problems.[8-10,25-26]

Studies performed with healthy children have proved that increasing environmental noise exposure may have an adverse effect on children's school performance (reading and mathematics) and in the mental health of children with early biological risk, such as low birthweight or preterm birth.[27]

The assessment of patient sedation can also be influenced by noise, according to an investigation regarding the effect of experimental noise on the bispectral index (BIS) value of adult patients submitted to propofol sedation. In that study, noise increased the BIS and appears to have had a greater effect on lower levels of propofol sedation, when BIS values at 80, 110 and 120 dBA were significantly higher, as compared to values at 50 dBA.[28]

The development of equipment for intensive care should contemplate the need for noise reduction. However, this will only be possible if intensive care professionals and medical equipment manufactures are aware of the problem. It is also important to emphasize the need of adjusting the equipment's alarms in accordance with the child's age and physical conditions to prevent unnecessary noise. For the recovery of seriously ill children, and to protect the staff from the harmful effects of high noise levels, it is necessary to establish an agenda to reduce sound levels in the PICU.

We consider the education regarding the effects of noise on human hearing, and its relation to stress and healing process impairment, as the key point for a noise reduction program. There is evidence showing that staff education and behavior adjustment are essential in the effort to reduce noise.[17]

Additionally, the sharing of accountabilities between staff and institutional leaders are critical to achieve success in this process, which requires continuing education, environmental changes, and accomplishment of quality improvement assessment strategies regarding noise level control. Some of these strategies are:

- promote architectural adjustments in the PICU, with the use of noise absorbing flooring, ceiling and walls, partitions between beds in large wards, and setting up rubber buffers for windows and doors;
- assess noise levels prior to the acquisition of equipment;
- implement a continuing education program for professionals that work in the PICU, as well as for those who frequently have patients admitted in the PICU.

This educational program should be designed to cover information about noise level influences on human health and to foster behavioral changes, such as reducing loud talk at bedside and areas near to the patients, the use of appropriate shoes, designation of specific areas for clinical discussions, and control of equipment alarm sets and volumes. It should also focus on additional behavioral adjustments to control the dropping of telephones as well as televisions, rings and alarms, pagers and cellular phones (which should be used in vibrator mode). Signs should be posted to communicate rules to reduce noise reduction in critical areas, and a "quiet time" period should be defined, at least between 1:00 to 3:00 AM, designated as "sleep time." During this period, equipment alarm sounds should be reduced or turned off, and nursing care interventions

reduced in patients with stable conditions. The patients' room doors should be kept closed and "silence guardians" should be designated, for example physicians or nurses responsible for the continuing assessment of patients. In addition, noise levels should be periodically assessed, as well as hearing levels of the staff.

Finally, a successful noise reduction program requires the cooperation of ancillary staff, including housekeeping staff, laboratory and X-ray technicians. Thereby, to achieve the desired outcomes, it is important that the hospital leaders promote continuous education programs outside the units at risk for high noise levels, such as the PICU, in order to promote a cultural change in all members of the health care team.

In conclusion, the noise level at the PICU under study (60-70 dBA) exceeds the recommendations of the World Health Organization's International Noise Council and of the U.S. Environmental Protection Agency. The maximum noise level of 120 dBA also exceeds the noise levels identified in other studies. The most significant noise was produced in daytime periods, principally by the staff, and not by the equipment. Education regarding the effects of noise on human hearing and its relation to stress is the essential basis for the implementation of a noise reduction program.

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Correspondence:
Mavilde L. G. Pedreira.
Rua Napoleão de Barros, 754/sala 112, Vila Clementino
CEP 04024-002 – São Paulo, SP
Tel.: (11) 9709.2429
Fax: (11) 5576.4430
E-mail: mavilde@denf.epm.br