NOISE AND ITS IMPACT ON BRAZILIAN HOSPITALS: A LITERATURE REVIEW

Ruído e seus impactos nos hospitais brasileiros: uma revisão de literatura

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ABSTRACT

The increase in noise levels at hospitals could be attributed to many factors as incorporation of new technologies, concentration and flow of people and non-compliance of silence by the workers and patients. Noise provokes negatively impact the work process and people's health. This study aimed a review the national literature on noise in hospital services in Brazil, by the analysis of the follow aspects: scientific research, measuring methods, noise levels in hospitals, and the findings and proposed strategies in studies. The noise level in Brazilian hospitals is above the recommended levels. There is an increasing knowledgement of this subject in Brazil. In order to expand this knowledge, intervention studies were recommended to eliminate the excessive noise into the hospitals. The noise control in hospitals should be considered as a priority to improve their surroundings.

KEYWORDS: Noise Measurement; Occupational Noise; Hospital Units

INTRODUCTION

Hospitals have become in noisy places due to different factors, including the large-scale incorporation of equipment[1]. In intensive care units (ICUs) there are numerous sources of noise, such as vacuum cleaners, monitors, mechanical ventilators, computers, printers, and compressed air vents[2-8].

The noises from this equipment as well as those from air conditioning units, instruments, areas where people group and move, transportation of patients, and physical infrastructure remodeling, are among the occupational risk factors that can compromise the health of nurses[9-14].

Increased noise in hospitals further relates to non-compliance of silence by the work teams and service users. In addition, silence is necessary for the proper functioning of the hospital routine, including patient recovery[15,16].

The National Health Surveillance Agency from the Ministry of Health (ANVISA/MS)[17] recognizes the occupational hazard in the hospital setting, calling attention to the high noise levels in the central air compression and vacuum units, the maintenance workshops, as well as in the maintenance and laundry areas[18], due to the large number of existing machines in these locations. ANVISA mentions that in ICUs, modern equipment with audible alarms, even though they make noises of lower intensity, can cause problems.

Health teams perform various tasks in the hospital environment, requiring constant attention so that there are no errors in the work process. A study in a hospital setting found that the process of preparation and administration of drugs occurring

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in a noisy environment hinders concentration of professionals and induces errors[19].

Regarding noise levels, the World Health Organization[20] recommends that sound levels in the hospital setting should not exceed 30 dBA. The Brazilian Association of Technical Standards (ABNT)[21] regulates normal levels at between 35 and 55 dBA for hospitals.

The Brazilian Standard, NBR 10152/8722, registered with the National Institute of Metrology, Standardization, and Industrial Quality (INMETRO), provides for hospitals to have sound levels of 35 dBA for comfort, and 45 dBA as acceptable for rooms, infirmaries, surgical centers and nurseries; laboratories and areas for public use should be at 40 dBA for comfort and 50 dBA as an acceptable level for those spaces; services are at 45 and 55 dBA.

In relation to worker health, Chapter V of the Consolidation of Labor Laws (CLT), through Regulation 3214/78, establishes, via Norm 15 (NR-15)[23], the tolerance limits or occupational exposure limits to noise, for continuous or intermittent noise, a level criterion of 85 dBA for an eight-hour work-day exposure. In workplaces where activities are performed that require attention and intellectual activity, it is recommended via Norm 17 (NR-17)[24] to follow the acoustic comfort conditions established by Brazilian Standard (NBR) 101152[22], with an acceptable level of 65 dBA.

High noise levels can cause behavioral disorders, resulting in physiological responses to stress in hospitalized patients. The intensity of sound pressure of 65 dBA can affect the hypothalamus and pituitary, raising levels of secretion of adrenaline, noradrenaline, and corticosteroids as well as cause increased blood pressure and changes in heart rate and peripheral vasoconstriction[3,25]. There are reports in the literature on the relationship between high levels of sound pressure and hearing loss, stress, as well as psychological and sleep abnormalities that can cause memory lapses and greater mental effort to accomplish tasks, exposing the group to risks of accidents and errors in the execution of their work[2,26].

Because of the potential risk that noise poses to patients and health care teams in hospitals, the measurement of sound levels is proscribed, which will facilitate the implementation of changes in effective control and noise reduction[27,28].

In this perspective, the present study aimed to perform a literature review about the noise in hospitals in Brazil, analyzing the different aspects related to scientific production related to the topic, the methods that were used to measure noise in hospitals, the results obtained, and the conclusions and proposed strategies analyzed in the study.

METHODS

The literature review was carried out using MEDLINE, LILACS, and SCIELO online databases, based on the keywords: noise and hospital and environment, hospital noise and sound pressure in the hospital. Inclusion criteria were quantitative studies of hospital noise in Brazil, published in full, in Portuguese, from January 2000 to March 2011. Studies not available in full in the searched databases were excluded, as well as those that were not in the time frame in question and not measure noise levels. After analyzing the inclusion criteria, 17 studies that were considered relevant for this study were identified. Of this total, 14 are published articles and 3 are dissertations.

The studies were numbered from 1 to 17, and for the collection and synthesis of data, a protocol was developed with the relevant variables for analysis and discussion, such as year of publication, educational background of the authors of the studies, methodology used to measure noise, scientific standards, and the main conclusions and recommendations found. The analyses of the studies also included descriptions of procedures, parameters for noise assessment, the results regarding noise levels in different hospital environments, and strategies proposed actions for noise reduction.

LITERATURE REVIEW

Table 1 shows the distribution of articles according to year of publication, and educational background of the authors. It was found that in the last five years, there has been increasing amount of research on hospital noise in Brazil. In the period 2000-2005, we identified 6 studies, while in the period 2006-2011, that number almost doubled to 11 publications. The highest number of publications occurred in nursing journals (47.1%) and medical journals (41.2%). Studies published in journals in the field of speech-language pathology and administration accounted for 5.9% of the total analyzed. Regarding the educational backgrounds of the authors, it was found that 35.3% of the publications were developed by research groups from different backgrounds.

Table 1 – Distribution of articles according to year of publication, area, and profession of the authors (n = 17)

Year	n	%
2006 – 2011	11	65
2000 – 2005	6	35
Area of Publication		
Nursing	8	47.1
Medical Area	7	41.2
Speech-Language Pathology	1	5.9
Administration	1	5.9
Educational Background of Authors		
Multi-professional (doctors, nurses, engineers, speech-language pathologists, etc.)	6	35.3
Doctor	3	17.6
Nurse	3	17.6
Speech-Language Pathologist	2	11.8
Engineer	1	5.9
Architect	1	5.9
Unknown	1	5.9

The increase in the number of studies in the period 2006-2011 occurred possibly as a result of interest from different health professionals related to the perception of the changing profile of noise in hospital settings, but also because of the advancement of engineering about noise and the knowledge of its effects on hearing and general health. It was observed that the highest number of publications occurred in nursing journals. This can be justified by the expanding role of the nurse within the area of Occupational Health, in that the nurse needs to be in constant pursuit of development and deepening of knowledge to be properly qualified. Moreover, nurses plan actions based on the work process, which are relevant for the implementation of awareness programs about the effects of noise in the hospital environment[29].

It was also observed that most of the papers came from multidisciplinary teams. This indicates the interaction of professionals from various fields, setting up a reciprocal relationship between multiple technical interventions and agent interaction[30]. One of the examples of collective work can be seen in the various professional areas, creating a network of relationships between people, power, knowledge, feelings, and desires in which it is possible to identify the group processes[31]. This constitutes a strategy to improve quality of life, because it seeks comprehensiveness in health care.

Table 2 shows the distribution of articles according to their locations and the evaluated areas in the hospitals. In data analysis, it was observed that most studies were conducted in public teaching hospitals (52.94%), followed by general public hospitals (29.41%). With reference to the hospital area surveyed, a predominance of ICUs was revealed, since 58.8% of the studies were performed in these areas. Still, the predominance of studies in neonatal ICUs and Intermediate Pediatric Care / Pediatric ICUs was seen, corresponding to 52.9% of the total analyzed.

Table 2 – Distribution of articles according to study location and the hospital area (n = 17)

Variable	n	%
Location of Study		
Public Teaching Hospital	9	52.94
Public General Hosptial	5	29.41
Private Hospital	2	11.76
Not described	1	5.88
Hospital Area Studied		
Neonatal ITU (Neonatal Intensive Therapy Unit)	5	29.4
ITU (Intensive Therapy Unit)	4	23.5
Various Areas	2	11.8
NICU (Neonatal Intensive Care Unit)	2	11.8
Laundry	2	11.8
Pediatric ICU	1	5.9
Surgical Center	1	5.9

Teaching hospitals or universities are the main institutions that, in practical terms, complement the practical training of health professionals. In addition, they are meant for medium and high complexity care, and have more equipment and a larger number of people in them. Referring to the areas of hospitals studied, ICUs are sites that are particularly affected by noise. They have a lot of equipment with essential acoustic alarms to alert doctors and nurses about changes in patients' clinical conditions or equipment malfunction[2]. Thus, these environments, which should be silent and quiet, become noisy and stressful. For the patient, it can also increase the perception of pain and anxiety, decrease sleep, and prolong convalescence[32,33].

In neonatal ICUs, according to some research[34], an overly stimulating environment may undermine the process of development and growth, especially in premature infants whose sensory receptors are extremely environmentally sensitive. There is evidence that the auditory system of a premature baby, because of its general immaturity, is probably more susceptible to injuries that can be normally caused by this environment because of the combination of noise with the use of ototoxic medications that increase the risk even further. Because of this, from the 1970s in some countries – Brazil, only in the 1990s – studies were carried out that addressed the issue of noise in neonatal environments, specifically in incubators. Other researchers[28] note that the technological environment of the Intensive Care Unit provides benefits in terms of biological balance, however, it is physically and psychologically aggressive, in which the noise level is one of the harmful interactions.

The data presented in Table 3 refer to the noise assessment protocol used in national articles. In the studies reviewed, in approximately ¾ of them (76.5%), the equipment used for noise assessment was a sound level meter, and in 23.5 % of the studies a noise dosimeter was used to measure sound levels.

Table 3 – Evaluation of the data protocols used in noise studies (n = 17)

Variable	n	%
Equipment used in evaluation		
Sound Level Meter	13	76.5
Dosimeter	4	23.5
Norms used for comparison		
National	8	47.1
National and International	6	35.3
Not given	2	11.8
International	1	5.9

Another factor considered was the time of measurement recorded in studies, shown in Figure 1. Observe that each researcher used a different authority, in accordance with the needs and requirements of the site and subject of study, and/ or measuring equipment used, it may be noted the diversity of measurement times, the intervals between measurements, and the duration of the measurements. It was found that most measurements were performed at three times (morning, afternoon, and night). In three studies, measurements were carried out at the times considered peak, i.e., in the morning. The measuring time varied from 27, 30, and 60 seconds to 5, 10, and 15 minutes. In four studies, sounds were measured continuously (24 hours per day). With regard to the standards used for the analysis of data from the studies, it was found that 47.1% chose to compare the values of noise levels recommended in national standards, while 35.3% of the researchers chose to use both national and international standards.

Time measured in minutes/ by study (E number)*	Interval between measurements	Duration of measurements in days/ hours
6000 (E.1)	27 s	8,12 or 24h
8640 (E.2)	0	6d – 24h
2400 (E.3)	1 m	7d – 24h
5160 (E.4)	0	7d – 12h
5040 (E.5)	0	14d – 12h
360 (E.6)	N/A	1d – 6h
10080 (E.7)	5 s	7d – 24h
Instantaneous (E.8)	10 m	3d – 3h
69 measurements/registry (E.9)	30 s	14d – 12h
3480 (E.10)	15 m	N/C
(E.11)	N/A	1d – 4h
(E.12)	N/A	13d – 2 - 4h
51840 (E.13)	0	9d – 24h
33 m (E.14)	1 m	11d – 6h
45 m (E.15)	5 m	3d – 3h
5760 registries (E.16)	0	4d – 24h
(E.17)	N/A	2d – 12h

* Number of STUDY
** Scoring: impact noise
N/A: Not applicable information

Figure 1 – Distribution of time measurement, intervals between measurements and duration of the measurements in each study

NBR 10151[21] states that the measuring time should be chosen so as to enable the characterization of noise. The measurement may involve a single sample or a series of them. This explains the great diversity of patterns used in the studies. National standards include Norm NR 15 of Regulation 3214/78 of the Ministry of Labor and Employment when the risk is occupational, i.e., with noise levels above 85 dBA for 8 hours of exposure[23], and NBR 10152/1987 of the ABNT, which recommends 35 to 45 dBA for acoustic comfort (ABNT, 1996). International standards used were the recommendations of the World Health Organization (WHO), which states that equivalent sound levels for different hospital environments should not exceed 40 dBA for daytime and 35 dBA for nighttime. Another international standard, the Committee to Establish Recommended Standards for Newborn ICU Design, states that the usual noise of the Neonatal Intensive Care Unit (NICU) and the Neonatal Intensive Therapy Unit (NITU), shall not exceed the equivalent level of 50 dBA. The American Academy of Neonatology, based on the Environmental Protection Agency 74 Guidelines in the United States, recommends a sound pressure level not exceeding 45 dBA daytime and 35 dBA nighttime. It can be verified that the recommended levels are very close, both domestically and internationally, with a consensus on the values indicated.

In Figure 2, we present the noise levels for the study area, where we used sound level meters as well as noise dosimeters. In the measurement of sound pressure levels, it was found that the minimum average was 50.1 dBA and the maximum was 96.0 dBA.

Hospital Area	**Maximum dBA**	**Minimum dBA**	**Average Leq dBA**	**Observation dBA**
SOUND LEVEL METER				
(E.1)* General ITU	**108.4**	**40**	**65.36** Day- **65.23** Night – **63.89**	Varied: **62.9 to 69.3**
(E.2)* Pediatric ITU	**120.0**		**60.0** to **70.0**	Base level
(E.3)* Various hospital areas	**58.0**	**101.0**	**63.7** ER Reception – **64.2** Cast Room **– 60.6** Neonatal **ITU – 61.4** ITU **– 62.7** Surgery Center **– 59.1** Sterilization Center **– 66.0** Pharmacy **– 63.3** Pediatrics **– 60.0** Kitchen **– 62.9** Laundry **– 71.5**	
(E.6)* ITU	1 – **80.4** 2 – **82.4** Coronary - **73.3**	1 – **80.4** 2 – **82.4** Coronary - 7**3.3**	1 – **64.1** 2 – **64.0** Coronary – **58.9**	
(E.7)* ITU			Day – **60.86** ± 4.90 Night – **55.60** ± 5.98 Business Days - **58.21 ± 5.93** Weekends - **56.83 ± 5.90** **Shift Change:** Day – **61.35 ± 5.08** Night – **62.31 ± 4.70** **Visiting:** Morn.- **60,50 ± 4.59** Afternoon**- 62.04 ± 4.48** Night **– 60.05 ± 4.27**	
(E.7)*Surgery Center	**96,0** steam on		Reception **- 73.6 a 83.6** Hallway **- 68.2 a 85.0** Operating Room **- 66.4 a 79.2** Recovery **- 79.9 a 83.8** Material Prep - **68.1 a 83.6** Sterilization **- 69.6 a 96.0**	**86.5** at CM
(E.9)*Incubators –(impact)	**116** dBC	**76,1** dBC		
(E.10)*Health Establishments	**94.9** O^2 Supply	**45.9** Patient Hygiene	--------	

Hospital Area	Maximum dBA	Minimum dBA	Average Leq dBA	Observation dBA
(E.11)* NIHL in Laundry			Entire Hospital – **75.0** Laundry Morning– **91.0** Laundry Evening – **90.0** Kitchen Morning – **81.0** Kitchen Evening – **80.0** Maintenance Morning – **80.0** Maintenance Evening – **75.0** Hallway Morning – **75.0** Hallway Evening – **55.0**	
(E.12)* Neonatal ITU	Morning **- 80.4** (hand wash) Night **78.1** (equipment change)		Morning **84.5** Afternoon **76.6** Night **76.6**	
(E.14)* Neonatal ITU			**50.1** to **62.0**	
(E.15)* Laundry	Morning **- 98.0** Afternoon – **97.0** Night – **101.0**	Morning **- 81.0** Afternoon – **76.0** Night – **70.0**	-------	
(E.17)* ITU	Day – **89.3** Morning – **89.3** Evening – **83.4**	Day - **55.6** Morning – **61.4** Evening – **55.6**	Day – **71.0** Morning – **71.6** Evening – **70.4**	
DOSIMETER				
(E.4)*NICU (Neonatal)			**Shift Change:** *Nursing* - **55.3 a 72.2** Morning – 55.3 a 72.2 Afternoon – 57.4 a 70.9 Night – 55.2 a 70.5 **Shift Change:** *Doctors* – **57.2 a 70.5** Morning – 57.2 a 70.5 Afternoon – 60.7 a 67.8 Night – 58.3 a 67.6 **Medical Visit:56,0 a 75.7** Morning – 56.0 a 69.9 Afternoon – 56.2 a 75.7 Night – 58.3 a 75,7	NICU limit: 50 dBA
(E.5)* NICU (Neonatal)	Friday **– 54,5 a 82,2** Saturday **– 54,2 a 86,0** Sunday **– 52,6 a 72,6** Monday **– 52,7 a 76,2** Tuesday **– 53,0 a 71,6** Wednesday **– 51,8 a 71,6** Thursday **- 52,8 a 71,6**	Friday**- 52,0** Saturday**- 51,9** Sunday**- 51,7** Monday **- 51,9** Tuesday **- 50,7** Wednesday **- 51,2** Thursday **- 52,1**	Friday **- 61,1** Saturday **- 59,5** Sunday **- 60,9** Monday **- 60,1** Tuesday **- 62,3** Wednesday **- 59,6** Thursday **- 6 1,6**	
(E.13)* NITU (Neonatal)	Intensive Care -**114.1** Intermediate Care -**90.2** Isolation - **100.8** Hallway **- 104.9**		Intensive Care - **64.8** Intermediate Care – **62.1** Isolation **–** **63.8** Hallway **–** **61.9**	
(E.16)* NITU (Neonatal)	**96.8 a 121.0 dBC** **90.8 a 100.3 dBC** **98.9 a 123.4 dBC** **103,4 a107.6 dBC**		Thursday **- 62,2** Friday **- 61.3** Saturday **- 66,0** Sunday**- 66.6**	Night **123.4dBC** Morning **103.4dBC** Evening **90.8 dBC**

N* Number of Study
NICU = Neonatal Intensive Care Unit

Figure 2 – Example of studies and levels of hospital noise in areas found using the sound level meter and dosimeter

As for noise levels detected in different studies, it was observed that they are within recommended ranges based on both national and international standards for occupational health and for acoustic comfort values. It appears that there are sound pressure levels which can cause noise-induced hearing loss, since they are above the tolerance limits indicated in Norm NR 15, being an occupational hazard for workers in hospital laundries as well as for users in standard and neonatal ICUs and other hospital areas. The studies also show that the noise levels that are below the tolerance limit set out in NR 15 should be compared to the limits recommended by ABNT standards for acoustic comfort given by NBR 10152[22].

For the specification of the measurement equipment, the method and procedures for evaluation are listed in NBR 10151[21], in June 2000. The standard recommends that the sound level meter or other measuring system meets the specifications of IEC 60651 for type 0, type 1, or type 2 and that the evaluation device has features for the measurement of equivalent weighted "A" (Leq) sound pressure levels.

The equivalent level (Leq) is defined as the steady sound level that occurs during the registered interval, and would produce the same sound energy produced by recorded sound events. Some meters provide a direct reading of Leq at intervals chosen by researchers[35]. Some models of sound level meters have this feature, as well as some models of noise dosimeters. Therefore, these two types of equipment can be used in the evaluations provided they meet the standards recommended by regulatory bodies. By definition[35], the noise dosimeter was designed to be a monitoring device for personal use, allowing measurement of the noise dose and other quantities that characterize worker exposure to noise. But currently these devices can provide much information regarding the assessment of noise in work environments, meeting different standards and legislation, as well as for environmental reviews considering acoustic comfort.

To conclude this review of the literature, we included the synthesis of the findings and recommendations related to hospital noise studies, as shown in Table 4. Observing different outcomes or conclusions, noise levels above the recommended standards in Brazilian hospitals are dominant (in 42.85% of the studies), the need for greater worker awareness (in 17.85% of the studies), and the noise that is more pronounced in daytime (in 14.28% of the studies).

Table 4 – Summary of conclusions and recommendations related to hospital noise according to the studies analyzed

Variables	n	%
Summary of findings of studies		
Noise above recommended levels	12	42.85
Awareness of worker	5	17.85
Sharp noise during day shift	4	14.28
Causes damage to health worker	3	10.71
No occupational risk	2	7.14
Professionals know the source of noise	1	3.57
Considered intense and moderate noise by workers	1	3.57
Total	28	100
Summary of recommendations of studies		
Education about the effects of noise	8	38.09
Monitoring of noise	4	19.04
Adjustment of sound equipment	3	14.28
Architectural adjustments	3	14.28
Involvement of managers	3	14.28
Total	21	100

Obs.: Some studies cite more than one recommendation

In relation to the recommendations made by the authors, more than one third (39.09%) of the research cited the need for education about the effects of noise. The need for noise monitoring was reported in 19.04% of the studies. Three other suggestions mentioned were the adequacy of sound equipment, architectural adjustments, and the involvement of managers respectively in 14.28% of the studies.

Finally, studies indicate that health facilities should have physical space with basic conditions of environmental comfort, including acoustic comfort, which would benefit the patient and everyone involved in the process[10]. As recommendations for reducing noise in the observed areas, the vast majority of studies cited education and awareness about the effects of noise, the need for adaptations of the physical environment for greater comfort, and preventive sound maintenance for equipment, as well as the purchase of equipment with reduced noise emission levels. These factors enable the hospital staff to act more effectively in reducing noise pollution which is beneficial to labor and the recovery of patients, reducing noise's impact on Brazilian hospitals.

FINAL CONSIDERATIONS

This review showed that there is a relative accumulation of knowledge about hospital noise in Brazil, noise generating sources, and their effects on health. It is recommended, therefore, to perform intervention studies, with experimentation and experience reports on strategies for mitigation of excessive noise in different hospital settings, which would broaden the knowledge and contributes positive results in practice. Observed by the studies in this review, was that noise control in hospitals should be considered a priority for improving the surroundings. Thus, an important investment should be made in studies that show different forms of noise exposure in the hospital environment that are affect both professionals and users, as well as the impact on the health of this population, in order to correct the situation and implement preventive measures.

CONCLUSION

The highest number of publications occurred in the period 2006-2011, in nursing journals and developed by multidisciplinary groups of researchers, mostly in public teaching hospitals, and predominantly in ICUs. The most measuring equipment used was a sound level meter, and each researcher developed a different approach to systematic measurements, as well as the time of measurement. Most measurements were done at three time periods. Most data were compared with national standards. In all studies, the noise in Brazilian hospitals was above the recommended levels.

RESUMO

O aumento dos níveis de ruído nos hospitais, atribuído a diferentes fatores, dentre eles a grande incorporação de tecnologias, a concentração e o fluxo de pessoas e a não observância do silêncio pela própria equipe de trabalho e usuários do serviço, pode impactar negativamente no processo de trabalho e na saúde de profissionais e usuários. Este estudo teve como objetivo realizar revisão de literatura nacional sobre ruído em serviços hospitalares no Brasil, analisando aspectos referentes à produção científica, aos métodos de mensuração, aos níveis de ruído presentes nos hospitais, e às conclusões e estratégias propostas nos estudos analisados. O nível de ruído nos hospitais brasileiros está acima dos padrões recomendados acarretando impactos nesses serviços. Existe um relativo acúmulo de conhecimento sobre o tema no Brasil. Para ampliação desse conhecimento foram recomendados estudos de intervenção para mitigação do excesso de ruídos nos hospitalais. O controle do ruído nos hospitais deve ser considerado como uma das prioridades para melhoria de sua ambiência.

DESCRITORES: Medição de Ruído; Ruído Ocupacional; Unidades Hospitalares

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