

Perception and effects of noise in employees of a university hospital

Percepção do ruído e seus efeitos em funcionários de um hospital universitário

Percepción y efectos del ruido en empleados de un hospital universitario

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Abstract

Introduction: Hospital employees are exposed to noise from different sources. **Objective:** To investigate the perception and effects of noise in employees of a university hospital in the city of Lagarto-SE. **Methods:** Cross-sectional observational study. The sample consisted of 170 employees. The procedures included the application of anamnesis and a noise annoyance questionnaire adapted for the hospital environment. Noise levels were measured during day and night shifts. L_{eq} values between 66.1 and 79 dB(A) were found, with higher levels in the day shift. Data analysis was performed through the application of chi-square tests of independence and adjusted logistic regression models. **Results:** Most of the professionals interviewed were female (69.4%), the mean age was 38 years old. Most professionals (54.1%) considered the place repeatedly or always noisy and 85.9% classified its intensity as moderate or intense. The part of the day considered the noisiest was the morning. The main sources of noise cited by the research were hospital professionals. The majority (97.1%) of the professionals reported that the noise in the hospital can harm the patient and 79.4% pointed out that strategies can be carried out to minimize such exposure. The measure most pointed out was the performance of awareness actions by professionals (63%). **Conclusion:** We highlight the frequency, intensity, and complaints related to noise, on the part of the professionals. **Key words:** Noise; Occupational Health; Health Personnel.

Resumo

Introdução: Funcionários de hospitais são expostos ao ruído proveniente de diversas fontes. **Objetivo:** Investigar a percepção e os efeitos do ruído em funcionários de um hospital universitário no município de Lagarto-SE. **Método:** Estudo observacional de corte transversal realizado com 170 funcionários. Foram aplicados anamnese e questionário de incômodo ao ruído, adaptado para o ambiente hospitalar. Níveis de ruído foram medidos nos turnos diurno e noturno. Foram encontrados valores de L_{eq} entre 66,1 e 79 dB(A), com níveis mais elevados no turno diurno. Para análise dos dados foi realizada aplicação de testes qui-quadrado de independência e ajustes de modelos de regressão logística. **Resultados:** A maioria dos profissionais era do sexo feminino (69,4%), com idade média de 38 anos. A maioria (54,1%) considerou o local repetidamente ou sempre ruidoso e 85,9% classificaram a intensidade moderada ou intensa. O período da manhã foi considerado o mais ruidoso. A fonte de ruído mais citada foram os profissionais. A maioria (97,1%) acredita que o ruído no hospital pode prejudicar o paciente e 79,4% acredita que estratégias podem minimizar esta exposição, sendo a mais sugerida a realização de ações de conscientização aos profissionais (63%). **Conclusão:** Houve percepção quando a frequência, a intensidade e a queixas relacionadas ao ruído, por parte dos profissionais.

Palavras-chave: Ruído; Saúde do Trabalhador; Pessoal de saúde.

Resumen

Introducción: Los empleados del hospital están expuestos al ruido de diferentes fuentes. **Objetivo:** Investigar la percepción y efectos del ruido en empleados de un hospital universitario de la ciudad de xxxxxx. **Métodos:** Estudio observacional transversal. La muestra estuvo conformada por 170 empleados. Los procedimientos incluyeron la aplicación de una anamnesis y un cuestionario de molestia por ruido adaptado al medio hospitalario. Los niveles de ruido se midieron durante los turnos de día y de noche. Se encontraron valores de L_{eq} entre 66,1 y 79 dB(A), con niveles más altos en el turno diurno. El análisis de los datos se realizó mediante la aplicación de pruebas de independencia chi-cuadrado y modelos de regresión logística ajustados. **Resultados:** La mayoría de los profesionales entrevistados eran del sexo femenino (69,4%), la edad media fue de 38 años. La mayoría de los profesionales (54,1%) consideró el lugar reiteradamente o siempre ruidoso y el 85,9% clasificó su intensidad como moderada o intensa. La parte del día considerada más ruidosa fue la mañana. Las principales fuentes fueron los profesionales del hospital. La mayoría (97,1%) relató que el ruido en el hospital puede perjudicar al paciente y el 79,4% señaló que se pueden

realizar estrategias para minimizar esa exposición. La más destacada fue la realización de acciones de sensibilización por parte de los profesionales (63%). Conclusión: Destacamos la frecuencia, intensidad y quejas relacionadas con el ruido, por parte de los profesionales.

Palabras clave: Ruido; Salud Laboral; Personal de Salud.

1. Introduction

Noise is understood as a polluting agent that has increased with the growth and development of cities, being present for individuals in various contexts, such as in their work environments, thus becoming one of the most common occupational hazards worldwide (Themann & Masterson, 2019).

Studies carried out with various professional categories investigated occupational noise and its effects on the lives of the workers, such as truck drivers (Lopes, Russo & Fiorini, 2007), teachers (Fiorini & Matos, 2009), textile industry workers (Alves & Fiorini, 2012), civilian pilots (Falcão, Luiz, Schütz, Mello & Câmara, 2014), workers in mobile support units (Oliveira, Santos, Rabelo & Magalhães, 2015), military police officers (Gelardi & Fiorini, 2016), musicians (Passos & Fiorini, 2016; Muniz, Amorim, Felipe & Dias, 2017), and industrial workers (Lin *et al.*, 2018), among others. In addition to the professionals mentioned, health professionals, such as nurses and doctors, have also been heavily exposed to noise in their work environment (Ferreira, 2013; Ryan *et al.*, 2016; Mcneer, Bennett, Horn & Dudaryk, 2017; Disher *et al.*, 2017; Ornelas-Aguirre, Zárate-Coronado, Gaxiola-González & Neyoy-Sombra, 2018).

Despite being understood as silent environments, many hospitals are located in large urban areas, with strong noise pollution, and may have risks resulting from systematic exposure to noise. In addition, patients and professionals working in this environment are exposed to the noise of conversations, sirens, equipment and alarms. Thus, this environment, which should be peaceful and silent for individuals, becomes unpleasant and favors feelings such as stress and anxiety (Pereira, Toledo, Amaral & Guilherme, 3003).

As such, the noise in the hospital environment can impact several aspects related to hearing, emotion, physiology and performance at work. On the one hand, noise can cause harmful effects for hospital employees, such as fatigue, irritability, auditory symptoms and performance interference that can generate risks of work accidents. On the other hand, for patients, noise can cause stress and an increase in systolic blood pressure, favoring an increase in the length of hospital stay (Daraiseh, Hoying, Vidonish, Lin, & Wagner, 2016).

Studies have found that sound pressure levels in hospitals around the world exceed sound thresholds set by the guidelines of the World Health Organization. Data collected from several hospitals show a trend in noise levels increasing during the day and night shifts, and many facilities have little or no reduction in noise levels during the night. As such, there are significant implications of these results for patients, visitors and hospital staff (Busch-Vishniac *et al.*, 2005).

Studies that investigate the noise levels in the hospital and its effects are very relevant, as they favor the planning of actions that can minimize the harmful effects of noise in this place. In this sense, this study aimed to investigate the perception and effects of noise in employees of a University Hospital in the city of Lagarto-SE.

2. Methodology

This is a cross-sectional observational study that was submitted to the Research Ethics Committee of the Pontifícia Universidade Católica de São Paulo, being approved under the opinion No. 4,850,399. The details of the study were explained orally, and an Informed Consent Form (ICF) was provided before data collection.

The study was carried out at a University Hospital in Lagarto-SE, and the sample consisted of professionals who worked at the hospital, in the following departments: Medical clinic, Critical Care (red and yellow wings for adults) and

Intensive Care Unit (ICU). These areas of the hospital were selected due to the different profiles of professionals who work there. As an inclusion criterion, professionals should have worked at the institution for at least six months, working directly in patient care, and remaining their entire workday in a single sector.

All physicians, physical therapists, nurses, nursing technicians and occupational therapists who work in the aforementioned sectors were invited to participate in the study. The selection of subjects was based on the professionals' work schedules for August 2021. Despite the documents having a list of 220 professionals, the researchers excluded professionals on leave due to illness, leaves, vacations, as well as those who, for reasons of force majeure, were away from their work sectors during the data collection period. In total, 170 professionals met the inclusion criteria and agreed to answer the questionnaires.

The professionals were approached and invited to participate in the research during their workday, both during the day and at night. After explaining the procedures and applying the ICF, the participants answered the anamnesis (which sought information on general health status, history and hearing complaints) and the noise-related annoyance questionnaire, which was initially prepared by Juang, Lee, Yang and Chang (2010), published in English, and later adapted to Portuguese by Ferreira (2013). The instrument addresses issues related to the discomfort associated with exposure to noise in the hospital, as well as issues related to its effects on the health of exposed professionals. The questionnaire consists of seven sections related to the different effects of exposure to noise, including open and closed questions. In this sense, the answers to the closed questions ranged from "Not at all", "Slightly", "Moderately", "Very" and "Extremely". The questionnaires were applied in person and read by the researcher, who recorded the responses in a form in Microsoft Forms, on a Samsung S6 lite tablet.

Noise dosimetry was performed on employees during their working hours, both during the day and at night, in the three departments selected for the study. For this purpose, a 01dB Wed007 dosimeter was used, which was duly calibrated before each measurement. In this context, the measurements aimed to characterize the exposure to noise in the work environment. At this stage of the research, only nursing technicians were selected, who were chosen at random. Only one employee from each sector in each shift participated in this stage.

The microphone was positioned close to the employee's ear, using an extension cable. The device measured the individual dose of the sound pressure level as a function of time, being configured as follows (Fundacentro, 2001):

- Threshold (dB): 85
- Exchange Rate (dB): 3
- Upper Threshold (dB): 115
- Criterion Level (dB): 85
- Response: Slow
- RMS Weighting: A
- Peak Weighting: Z

Measurements were performed minute by minute, obtaining the following levels:

- L_{eq} : Equivalent Sound Level.
- L_{max} : Maximum Sound Level.
- L_{min} : Minimum Sound Level.
- L_{10} : statistical descriptor of the sound level exceeded for 10% of the time of the measurement period.
- L_{50} : statistical descriptor of the sound level exceeded for 50% of the time of the measurement period.
- L_{90} : statistical descriptor of the sound level exceeded for 90% of the time of the measurement period.

Measurement data were transferred to the researcher's computer through the dBWED and the calculated values were extracted from the dBTrait.

Table 1 shows the measurement results, according to the previously defined parameters.

Table 1: Noise levels found in the departments selected for investigation, through dosimetry, in dB(A).

DEPARTMENTS PER WORK SHIFT	L_{eq}	L_{min}	L_{max}	L₁₀	L₅₀	L₉₀
Critical Care Day Shift	77.4	38.1	96.8	80.5	68.1	40.5
Critical Care Night Shift	75.0	38.4	91.2	78.2	64.5	42.0
Medical Clinic Day Shift	77.9	49.1	92.7	81.2	69.5	58.6
Medical Clinic Night Shift	68.2	44.2	87.2	69.5	56.7	48.9
ICU Day Shift	79.8	42.1	105.9	78.0	63.5	43.5
ICU Night Shift	66.1	44.0	87.0	67.7	53.9	46.6

Abbreviations: L_{eq}=Equivalent Sound Level, L_{min}=Minimum Sound Level, L_{max}=Maximum Sound Level, L₁₀= statistical descriptor of the sound level exceeded for 10% of the time of the measurement period (10th percentile), L₅₀= median (50th percentile), L₉₀= statistical descriptor of the sound level exceeded for 90% of the time of the measurement period (90th percentile). Source: Prepared by the authors.

3. Results

The study included 170 professionals, 118 female (69.4%) and 52 male (30.6%), aged between 24 and 73 years, with a mean age of 38, median of 37 and standard deviation of 7.69 years. The average time in the profession was 139 months, with a standard deviation of 73.13 and median of 132 months, with a minimum time of 12 months in the profession and a maximum of 360 months. With respect to how long they had worked at the institution, the minimum time was six months, while the mean time was 21.7 months, the standard deviation was 16.37 months and the median was 24 months.

In total, the researchers interviewed 37 nurses (21.8%) , 29 physiotherapists (17.1%), 13 physicians (7.6%), 88 nursing technicians (51.7%) and three occupational therapists (1.8%). As for professionals, most of them worked the day shift (60.6%), while 34.7% worked the night shift and only eight (4.75%) worked 24-hour shifts. Regarding hospital departments, most professionals worked in the Critical Care (n=68; 40%), followed by those working in the Medical Clinic (n=64; 37%) and Intensive Care Unit (n=38; 22.3%).

Most respondents reported not being exposed to noise in leisure environments, including the use of personal music devices (n=97; 57.1%). Regarding the difficulty in understanding speech, most respondents reported not having this complaint (n=117; 68.8%).

Regarding previous auditory symptoms, the following results were obtained: discomfort to loud sounds (n=74; 43.5%), headache (n=74; 43.5%), otalgia (n=61; 35.9%), tinnitus (n=59; 34.7%), ear fullness (n=51; 30.0%), neck pain (n=38; 22.3%), dizziness (n=36; 21.2%) and otorrhea (n=16; 9.4%).

When asked about how often their work environment is noisy, 54.1% of respondents reported that they consider the environment “repeatedly” or “always” noisy, while 62 (36.5%) reported that the environment “sometimes” is noisy, and only 16 (9.4%) reported the work environment as “never” or “rarely” noisy. Regarding the noise level, more than half of the

individuals reported the noise as “moderate” (n=103; 60.6%), while 43 (25.3%) classified the noise as “intense”, and only 21 (12.3%) classified the noise as “light” or “absent”, while three reported not knowing how to respond.

In addition, the researchers asked day shift workers and 24-hour shift workers about what time of day the noise would be worst. In this sense, 72.1% of these professionals reported the morning period as noisier, while 10.8% reported the afternoon and 1.8% reported the night, while 15.3% said they did not know how to respond. Later, the participants were asked if they believed that they themselves contributed to the existing noise level, and 49.4% of the interviewees agreed, while 4.1% did not know how to answer and the others answered that they did not.

Next, there was an open question about what would be the main sources of noise in the hospital. In this context, Table 2 shows that the most reported sources of noise were: professionals (61.8%), infusion pumps (44.7%) and computer monitors (43.5%).

Table 2. Frequency distribution of the variable “*What are the main sources of noise inside the hospital?*”.

Source of noise	n	%
Professionals	105	61.8
Maintenance/works	39	22.9
Computer monitors	74	43.5
Pumps	76	44.7
Ventilation fans	37	21.8
Doors	17	10.0
Trash cans	18	10.6
Carts/stretchers	14	8.2
Users	49	28.8

Source: Prepared by the authors.

Table 3 shows that 50.6%, 43.6% and 59.4% of the professionals chose between the response categories “Moderately” or “Very” for the variables “*Does ambient noise make you stressed?*”, “*Does ambient noise make you inattentive?*” and “*Does ambient noise bother you?*”, respectively.

Table 3. Frequency distribution for the “*Subjective perception of ambient noise*” (n=170)

Does ambient noise...	Not at all		Slightly		Moderately		Very		Extremely	
	n	%	n	%	n	%	n	%	n	%
Make you stressed?	50	29.4	29	17.1	53	31.2	33	19.4	5	2.9
Make you inattentive?	58	34.1	32	18.8	36	21.2	38	22.4	6	3.5
Bother you?	30	17.7	31	18.2	48	28.2	53	31.2	8	4.7
Make you dizzy?	159	93.5	4	2.4	6	3.5	0	0.0	1	0.6

Source: Prepared by the authors.

In addition, Table 4 shows that most professionals (92.4% and 88.8%, respectively) chose the category “Not at all” for the variables “*Does ambient noise make your head tingle?*” and “*Does ambient noise increase your blood pressure?*”. On the other hand, 53.6% of the respondents chose the categories “Moderately” or “Very” for the variable “*Does ambient noise make it difficult to communicate with others?*”.

Table 4. Frequency distribution for the “*Effects of noise on emotion*” (n=170)

Does ambient noise	Not at all		Slightly		Moderately		Very		Extremely	
	n	%	n	%	n	%	n	%	n	%
Make it difficult to communicate with others?	43	25.3	28	16.5	47	27.7	44	25.9	8	4.7
Make your head tingle?	157	92.4	6	3.5	6	3.5	1	0.6	0	0.0
Increase your blood pressure?	151	88.8	8	4.7	9	5.3	2	1.2	0	0.0
Cause a bad mood?	82	48.2	24	14.1	42	24.7	18	10.6	4	2.4
Irritate you?	53	31.2	28	16.5	61	35.9	22	12.9	6	3.5

Source: Prepared by the authors.

In turn, Table 5 shows that among the “*Experience of noise from different sources in the rooms*”, the sources that bothered the respondents most often (More or less/A lot/Extremely) were: Monitoring alarms, patients moaning or crying and medical devices.

Table 5. Frequency distribution for the “*Experience of noise from different sources in the rooms*” (n=170)

Does the noise bother you?	Not at all		Slightly		Moderately		Very		Extremely	
	n	%	n	%	n	%	n	%	n	%
Opening drawers or cabinets	110	64.7	30	17.7	17	10.0	8	4.7	5	2.9
Suction devices	107	62.9	34	20.0	20	11.8	6	3.5	3	1.8
Opening and closing doors	74	43.5	32	18.8	33	19.4	21	12.4	10	5.9
Doorbell	116	68.3	14	8.2	16	9.4	19	11.2	5	2.9
Monitoring alarms	49	28.8	25	14.7	39	22.9	46	27.1	11	6.5
Patients moaning or crying	67	39.4	19	11.2	34	20.0	40	23.5	10	5.9
Medical devices	50	29.4	29	17.0	36	21.2	44	25.9	11	6.5
Conversation of visitors/caregivers	93	54.7	35	20.6	30	17.6	10	5.9	2	1.2

Source: Prepared by the authors.

In turn, Table 6 shows that among the “*Experience noise from different sources outside the rooms*”, the sources that bothered the respondents most often (More or less/A lot/Extremely) were: Professionals talking loudly or screaming, carts and stretchers, conversation between professionals and phones ringing.

Table 6. Frequency distribution for the “*Experience noise from different sources outside the rooms*” (n=170)

Does the noise bother you?	Not at all		Slightly		Moderately		Very		Extremely	
	n	%	n	%	n	%	n	%	n	%
Printers	155	91.2	14	8.2	1	0.6	0	0.0	0	0.0
Shift change time for professionals	75	44.1	34	20.0	25	14.7	30	17.7	6	3.5
Professionals talking loudly or screaming	34	20.0	24	14.1	45	26.5	56	32.9	11	6.5
Carts/stretchers	71	41.8	31	18.2	36	21.2	23	13.5	9	5.3
Speakers	135	79.4	11	6.5	9	5.3	13	7.6	2	1.2
Mobile phones	98	57.6	30	17.6	29	17.1	10	5.9	3	1.8
Phones ringing	89	52.3	30	17.6	27	15.9	20	11.8	4	2.4
Footsteps (walking)	139	81.7	17	10.0	11	6.5	2	1.2	1	0.6
Cleaning	141	82.9	16	9.4	10	5.9	3	1.8	0	0.0
Conversation between professionals	78	45.9	38	22.3	29	17.1	21	12.3	4	2.4
Conversation of visitors/caregivers	116	68.2	26	15.3	20	11.8	7	4.1	1	0.6

Source: Prepared by the authors.

Table 7 shows the results for “*Impact of ambient noise on work performance*”, indicating that the most frequent response (Moderately/Very/Extremely) was “Understanding what others are talking about” (55.3%).

Table 7. Frequency distribution for the “*Impact of ambient noise on work performance*” (n=170)

Does noise interfere with your activities?	Not at all		Slightly		Moderately		Very		Extremely	
	n	%	n	%	n	%	n	%	n	%
Efficiency at work	73	43.0	38	22.3	38	22.3	19	11.2	2	1.2
Reasoning	53	31.2	30	17.6	52	30.6	29	17.1	6	3.5
Task execution	69	40.6	38	22.3	32	18.8	28	16.5	3	1.8
Understanding what others are talking about	27	15.9	38	22.3	49	28.8	45	26.5	11	6.5
Care	65	38.2	30	17.7	39	22.9	30	17.7	6	3.5

Source: Prepared by the authors.

Professionals were asked whether, in their opinion, noise in the hospital environment could harm patients. The vast majority of respondents agreed with the statement (97.1%), and 84.8% of them reported that ambient noise disturbs sleep, 68.5% reported that noise causes irritability, 66.7% believe that noise is the cause of stress, 49.7% reported behavioral changes, 15.2% believe that noise impacts clinical recovery, while 12.7% reported that noise causes hearing changes and, finally, 4.2% believe that noise affects the provision of adequate patient care. It should be noted that this question allowed participants to select more than one noise-related consequence.

When asked whether the noise in the hospital could harm professionals, 88.8% of the participants agreed. Among these, 70.2% believe that noise causes stress, while 66.9% believe that noise impacts the level of attention, 66.9% reported that noise causes irritability, 41.1% believe that noise causes tiredness, 39.7% reported noise as a cause of headache, and 21.2% believe that noise causes hearing disorders.

Respondents were also asked whether hospital noise could harm companions or visitors of hospitalized patients, and 100 (58.8%) of them agreed. Of these, 67% believe that noise causes irritability, 63% believe that noise causes stress, 27% that it causes tiredness, 25% that noise impacts the level of attention, 19% reported that noise causes headache, 10% that it affects communication, 10% that it negatively affects sleep and 5% believe that noise can cause hearing changes.

At the end of the questionnaire, respondents were asked if anything could be done to improve noise in the hospital environment and, if so, what changes they would suggest. Although 17 people believe that it is not possible to improve this aspect and 18 report not knowing how to respond, the majority (n=135; 79.4%) believe that there are strategies to minimize this exposure. Among these, 63% suggest awareness actions to professionals, 28.9% suggest adjustments in medical equipment, 23.7% suggest changes in the physical space of the hospital, 17% suggest awareness actions for users and 16.3% believe that changes in logistics could improve the situation.

4. Discussion

When analyzing the profile of the professionals included in the sample, it can be seen that the majority were female, with an average age of 38 years. This profile of the participants is in line with the profile found in other studies carried out in the hospital environment, and is also in line with the fact that a large part of the professional categories in the health area is occupied mainly by women (Costa, Pereira & Aguiar, 2013; Sampaio *et al.*, 2010; Filus, Sampaio, Albizu, Marques & Lacerda, 2018). The professional category with the highest number of individuals included in the study was nursing technicians, as in the study by Sampaio *et al.* (2010), which was carried out with a multidisciplinary team from a hospital.

Most professionals who participated in the research worked in the day shift, whose workday starts at 7:00 AM and ends at 7:00 PM. Data collection was based on the work schedules of each department, which had the highest number of employees scheduled for the shift. In addition, professionals have a longer rest break during the night shift, which reduced their availability to participate in the study.

Day shift professionals remain at the hospital during the morning, afternoon and early evening periods, so it was expected that only these professionals, and those with a 24-hour workday, could answer which period of the day they consider as the noisiest. Among those who answered this question, the vast majority believe that the morning shift (72.1%) is the noisiest, which differs from the findings of the study by Filus *et al.* (2018), carried out in an emergency room, in which the participants considered the afternoon as the noisiest. The noise measurements carried out in this study aimed to characterize the environment, but ended up confirming the aforementioned research, since the sound levels were higher during the day, in all evaluated departments (daytime L_{eq} from 77.4 to 79.8 dB(A) and nighttime L_{eq} from 66.1 to 75 dB(A)).

The noise level was perceived as moderate by 60.6% of the respondents, while 25.3% reported it as intense. These results are similar to those found by Ferreira (2013), who studied the exposure of nursing professionals to noise in the hospital environment, and found that 59% of individuals classified noise as moderate and 24.2% as intense. Sampaio *et al.* (2010) investigated the professionals' perception of noise in the ICU and 97.3% of the respondents classified it as moderate to intense.

The perception of a more intense noise was expected due to the sound levels found in the measurements performed in this study. The results were above those recommended by the current norms for hospital environments in all the departments investigated, during the day and night, with a L_{eq} between 66.1 and 79 dB(A). The World Health Organization (WHO, 2000) recommends that hospitals have equivalent levels (L_{eq}) of up to 40 dB(A) during the day and 35 dB(A) at night. In addition, the Environmental Protection Agency recommends that noise levels in hospitals should not exceed 45 dB(A). As for labor legislation, the levels found are not above the maximum allowed according to the NR 15 standard, which represents a risk to hearing (85 dB(A) for an eight-hour working day). However, it should be noted that this standard does not apply to hospital workers, since it should not only consider the risk to hearing, but other changes to health and work performance. Thus, it would be appropriate to consider the NR 17 standard, since it aims to establish guidelines and requirements that allow the adaptation of working conditions to the psychophysiological characteristics of workers, in order to provide comfort, safety, health and efficient performance at work.

Among others, the item of the NR 17 standard entitled "Comfort conditions in the work environment" establishes the adoption of acoustic and thermal comfort measures for workplaces in indoor environments where activities that require constant intellectual demand and attention are performed. As for acoustic comfort, the background noise level must follow the reference values of official technical standards. In other cases, the acceptable background noise level for the purpose of acoustic comfort will be up to 65 dB(A) (BRASIL, 1990).

In Brazil, the official technical standard for acoustic comfort is ABNT's NBR 10.152 standard, published for the first time in 1997, which determines acceptable sound levels (dB(A)) and comfort levels (CL) for hospital environments according to the locations, as follows: between 35 and 45 dB(A) and CL between 30 and 40 dB(A) in rooms, wards, nurseries or surgical centers; between 40 and 50 dB(A) and CL between 35 and 45 dB(A) for laboratories and areas for public use; and, finally, between 45 to 55 dB(A) and CL between 40 and 50 dB(A) for sectors of hospital services (ABNT, 1997; BRASIL, 1990). From this information, it is clear that the sound levels evaluated in this study are much higher than the comfort levels established for hospital environments.

It should be noted that other studies carried out in hospital environments also found noise levels that exceeded recommended limits and could pose risks to workers' health (Pereira *et al.*, 2003; Busch-Vishniac *et al.*, 2005; Carvalho *et al.*,

2005; Sampaio *et al.*, 2010; Daraiseh *et al.*, 2016; Costa *et al.*, 2013; Oliveira *et al.*, 2013; Ryan *et al.*, 2016; Ornelas-Aguirre *et al.*, 2018).

When asked about the main sources of noise within the hospital, the most cited by professionals were noise from the employees (61.8%), from infusion pumps (44.7%) and from computer monitors (43, 5%). These sources of noise were also the most reported as causing annoyance, inside and outside the rooms. Similar results, which also reported conversations between professionals as an important source of environmental noise, were found in other studies carried out in hospital environments (Ferreira, 2013; Oliveira *et al.*, 2013; Daraiseh *et al.*, 2016). It should be noted that the perception of sources is subjective and may vary according to each individual and/or professional category. In a study carried out by Filus *et al.* (2018), which compared the perception among professionals in the nursing and administrative areas regarding noise in the emergency room, nursing professionals reported noise from equipment (60.53%) as the highest noise source, while administrative professionals had a higher perception of noise for people noise (85.71%).

The effects of noise perceived more intensely by the professionals were annoyance, communication difficulties, stress and irritability. These results are in line with the results of other studies that also found a high occurrence of effects, such as stress (Ryherd, Waye, & Ljungkvist, 2008; Carvalho *et al.*, 2005; Filus *et al.*, 2018), irritability (Costa *et al.*, 2013; Filus *et al.*, 2018) and annoyance (Costa *et al.*, 2013; Andrade, Oliveira, Souza & Matos, 2016; Nazario *et al.*, 2015), reported by hospital staff.

As for the potential impact of noise on work performance, the main complaints were related to the impact on reasoning and difficulty in understanding speech. Nazário *et al.* (2015) investigated the effects of noise in the work routine in a neonatal unit of a University Hospital, and reported a decrease in concentration, irritability, stress, distraction, agitation and hearing alterations. In addition, a study carried out by Ferreira (2013) found an association between the noisy environment and the perception of professionals that hospital noise can make it difficult to understand speech.

When asked about the frequency of noise, 54.1% of professionals classified the environment as repeatedly noisy and 36.5% as sometimes noisy. Statistical analyzes performed by outcome show that the occurrence of some complaints increased as ambient noise became more frequent. These results were applied to complaints of tiredness, stress, irritability, bad mood, communication difficulties and discomfort with medical equipment, alarms, telephones and noise from professionals. A study by Ferreira (2013) found significant associations between the perception that the environment is noisy and the outcomes stress, annoyance and fatigue.

In addition, Daraiseh *et al.* (2016) investigated the correlation between sound pressure levels (SPL), heart rate and stress in nurses of a pediatric inpatient unit. In this context, the analyzes showed that noise was significantly associated with heart rate but not with stress.

The complaint of annoyance to loud sounds reported in the anamnesis was associated with some variables related to noise in the work environment, such as tiredness, headache, bad mood, communication difficulties, lack of attention, stress and irritability. In addition, the proportion of professionals who are bothered by the noise of alarms, medical equipment and noise from professionals was higher among those who had or are bothered by intense sounds.

Profession was a variable associated with some study outcomes. The analyzes showed that, when compared to professionals from other categories, nursing technicians reported less annoyance to the noise of medical equipment, alarms, mobile phones, telephones ringing and noise from professionals. Regarding noise in the work environment, this category also presented fewer complaints of stress, annoyance and lack of attention, as well as fewer complaints related to work performance, such as an impact on efficiency and task execution. This finding is relevant, since nursing technicians work directly with the patient for longer periods of time, compared to other categories. However, many participants reported during

the interviews that they got used to the ambient noise, which can be explained by the possibility of the occurrence of auditory accommodation that occurs in alarm fatigue, for example (Sykes *et al.*, 2011).

The professional activity sector was associated with the following outcomes: “Does ambient noise impact reasoning?”; “Does ambient noise prevent you from understanding what others are saying?”; “Does ambient noise make you inattentive?”; and “Does the noise of medical equipment bother you?”. The findings show that the least affected professionals were those who worked in the medical clinic. This finding can be explained by the fact that the other investigated departments (ICU and Critical Care) treat patients with more severe clinical conditions, including some in an acute stage of the disease, and consequently, demand greater attention and immediate measures by professionals (Filus *et al.*, 2014; Bolela and Jericó, 2006). In addition, these departments have a greater number of medical equipment may be a source of intense noise, such as infusion pumps, computer monitors and mechanical ventilators. The predominance of this equipment in these wards may even justify the focus on intensive care units in most studies that investigate noise in hospital environments (Carvalho *et al.*, 2005; Ryherd *et al.*, 2008; Macedo *et al.*, 2009; Sampaio *et al.*, 2010; Oliveira *et al.*, 2013; Johansson, Knutsson, Bergbom & Lindahl, 2016; Knauert *et al.*, 2016).

Despite the above information, the noise measurements performed found very similar sound levels in the three departments (Critical, Care, ICU and Medical Clinic). In the day shift, the equivalent noise level obtained in the Medical Clinic was higher than the level found in the Critical Care, while in the night shift, the lowest levels were obtained in the ICU. Although these measurements were carried out only to characterize the professionals' work environments, they were essential to show the importance of future environmental assessment in all wards of the hospital.

The adjusted logistic regression models found very significant results to recognize the behavior between the outcome and explanatory variables, related to the data obtained from the professionals who work in the hospital. In a succinct way and applying to all professionals, it is possible to affirm that the greater the perception of noise in the environment, the greater the following complaints will be: discomfort, bad mood, tiredness, impact on efficiency at work, headache, annoyance with noise equipment, stress, irritability, nervousness, changes in productivity and eye strain.

However, it was possible to observe that the data of some variables differ according to the profession. Nurses have a greater perception that noise can make communication difficult, the longer they work. In turn, nurses and doctors have a greater perception that noise impacts reasoning, task execution, speech understanding, increases discomfort, causes inattention, and affecting productivity. These perceptions are related to working time, which means that the longer the working time, the greater the perception. These two categories of professionals were also the ones who complained the most about professionals talking loudly or screaming and conversations between professionals, especially those who worked in the Emergency Room and had more time on the job.

Most respondents believe that noise can harm patients (97.1%), visitors (58.8%) and staff (88.8%). In addition, 79.4% believe that there are strategies that can minimize noise exposure in the hospital environment. In this sense, the main measures reported were raising awareness among professionals and making adjustments to equipment. Actions aimed at raising the awareness of professionals and users were also suggested in other studies as strategies to reduce noise in hospitals (Carvalho *et al.*, 2005; Oliveira *et al.*, 2013; Filus *et al.*, 2014; Andrade *et al.*, 2016; Daraiseh *et al.*, 2016; Johansson *et al.*, 2016; Ornelas-Aguirre *et al.*, 2018; Joseph, Mehazabeen & U, 2020). In turn, studies carried out in hospitals have suggested other control strategies, such as structural changes in the physical space (Johansson *et al.*, 2016; Mcneer *et al.*, 2017; Juang, Lee, Yang & Chang; 2020) and maintenance of equipment (Nazário *et al.*, 2015; Andrade *et al.*, 2016).

5. Conclusion

There was a perception regarding the frequency, intensity and complaints related to noise by professionals, since most of them believe that hospital noise can harm employees, hospitalized patients and visitors. In addition, the respondents believe that there are strategies that can minimize noise exposure in the hospital environment. Raising the awareness of professionals and equipment adjustments were the most suggested measures. The professional category, the complaint of annoyance to loud sounds and the perception of noise frequency were the variables most associated with the perception and discomfort of noise in the hospital environment.

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