

Sound pressure level in a municipal preschool

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SUMMARY

Aim: To evaluate the sound pressure level to which preschool students are exposed.

Method: This was a prospective, quantitative, nonexperimental, and descriptive study. To achieve the aim of the study we used an audio dosimeter. The sound pressure level (SPL) measurements were obtained for 2 age based classrooms. Preschool I and II. The measurements were obtained over 4 days in 8-hour sessions, totaling 1920 minutes.

Results: Compared with established standards, the SPL measured ranged from 40.6 dB (A) to 105.8 dB (A). The frequency spectrum of the SPL was concentrated in the frequency range between 500 Hz and 4000 Hz. The older children produced higher SPLs than the younger ones, and the levels varied according to the activity performed. Painting and writing were the quietest activities, while free activities period and games were the noisiest.

Conclusion: The SPLs measured at the preschool were higher and exceeded the maximum permitted level according to the reference standards. Therefore, the implementation of actions that aim to minimize the negative impact of noise in this environment is essential.

Keywords: Noise; Noise Measurement; Child, Preschool.

INTRODUCTION

Noise in schools deserves special attention, as appropriate learning situations depend on good acoustic conditions.

Established by the Brazilian Association of Technical Standards (ABNT), the Standard NBR 10152 recommends that noise levels in schools should not exceed 50 dB sound pressure level (SPL) and remain below that of the human voice, which is 60 dB (SPL) at normal intensity (1).

In the school environment, children are exposed to several types of noise, such as external noise, environmental noise, and noise generated in the classroom. Previous studies have shown that in children, noise impairs the academic performance related to memory, motivation, and reading ability (2).

Thus, in this environment, students can develop difficulties in writing, reading, and maintaining attention and concentration, which can result in disciplinary problems (2).

The presence of noise in the communication process often causes difficulties in speech perception and high levels of stress, even in people with normal hearing (3).

Noise in a classroom can disrupt speech perception, even in short reverberation conditions. Researchers have demonstrated that children are the most affected by background noise both in speech perception and in auditory comprehension (4).

With this knowledge of the effects of noise on the learning process, it becomes necessary to measure the noise levels in the school environment in order to investigate the factors that may interfere with this process and propose educational and/or environmental modifications to minimize these adverse effects (5).

High levels of background noise are common in the natural environment of children, and are a major contributing factor to learning problems. The primary source of noise in nurseries is the children themselves (6).

A study developed in kindergartens and schools demonstrated that children's voices produce considerable

noise levels. Over an 8-hour period, the authors recorded average noise levels of 80.1 dB (A) near the teacher's ear and 70.87 dB (A) in the classroom. The maximum noise level near the teacher's ear was 112.55 dB (A) and that in the classroom was 103.77 dB (A) (7).

Thus, the aim of this study was to evaluate the SPL to which students are exposed in a municipal preschool.

METHOD

This was a quantitative, nonexperimental, and descriptive pilot study. This study was conducted in a municipal preschool located in a suburb of the city of Marília, whose population is of low socioeconomic status.

The project was first presented to the Municipal Secretary of Education, and after receiving approval, it was carried out at the school that had agreed to the study.

The school consists of 2 blocks and parks. On the first block are 4 classrooms, the principal's office, library, toilets and bathrooms and courtyard; there is a covered court and a cafeteria on the second block. The classrooms are constructed from concrete blocks, have ceramic-tiled floors, padded ceilings, iron doors that open to the outside, and wooden doors that open to the inner courtyard; 2 rooms face the street and the other 2 face the park. The cafeteria walls are made of concrete blocks; it has a plastic ceiling with acoustic treatment and a ceramic-tiled floor. There are wall fans in all rooms and in the cafeteria. The school furniture consists of iron cabinets, tables, and chairs with iron legs, and these do not occupy a fixed position in the school.

The SPL measurement was performed on 4 different days over a period of 8 hours per day, totaling 1920 minutes. The measurement was carried out in 2 classes that attended school in the integral period. On the first 2 days, we followed up the activities of 26 children who were 5 years of age (Preschool II), and on the other 2 days, we followed 28 children who were 4 years old (Preschool I).

An audiologist performed the measurements using an audio dosimeter, monitoring the children's activities at school. These activities were held in different parts of the school, and most took place outdoors (court and park).

The equipment used for this study was an SV 102 Svantek audio dosimeter; the device was calibrated and checked before the beginning of each measurement according to the technical specification.

The SPLs were measured in dB, with the unit

operating in compensation circuits "A" and with a slow response in order to monitor low levels and continuous sounds in the environment studied according to the recommendations of Regulatory Standard-15 (NR-15) (8) and the FUNDACENTRO Standard of Occupational Hygiene (NHO-01) (9). Measurements were obtained for the following parameters: maximum (L_{max}), minimum (L_{min}) and equivalent noise level (Leq).

The equipment was programmed to operate at NPS intervals (SPL) between 40 and 140 dB. For the offsetting, we used the values proposed in the NR-15 and NHO-01 (8, 9).

In Brazil, 2 standards deal with the measurement of noise and its harmful effects; they were created to establish the criteria for occupational noise exposure. One of these standards is the NR-15 (8), which establishes in its Appendix No. 1 the limit of tolerance for continuous or intermittent noise, and the other is the NHO-01, which provides criteria for the assessment of personal exposure to noise that are more accurate but does not have legal authority (9). Neither standard specifies changes in measurement parameters and analysis based on an open or enclosed environment.

One difference between the 2 standards is the recommended rate of duplicity: the NR-15 states that it is equal to 5 dB, while the NHO-01 states that it is equal to 3 dB.

We used these 2 standards in this study, articulated with that advocated in the ABNT Standard NBR 10152 (1).

The Committee of Ethics on Research of a Public University (No. 0308/2011) approved the project.

The results were analyzed using descriptive statistics based on the SPL measurement parameters: L_{max}, L_{min} and Leq.

Complementary analysis was performed to compare the measured values (as related to both the NHO-01 and NR-15) for Preschool I and II; the Mann-Whitney test was used, the significance level was 5% ($p < 0.05$), and the confidence interval was constructed with 95% statistical confidence.

RESULTS

There were differences in the SPLs measured according to the 2 standards. The noise intensity measured at the school ranged between 40.6 dB (A) and 105.8 dB (A) on the NR-15 and between 40.6 dB (A) and 116.6 dB (A) on the NHO-01 (Table 1).

Table 1. Comparison of the sound pressure level measurement results (dB) on 2 groups of preschoolers as related to the NR-15 and NHO-01.

Groups	NR-15			NHO-01		
	MAX	MIN	LEQ	MAX	MIN	LEQ
Preschool III	102.3	45.5	76.1	110.3	62.7	84.4
Preschool III	104.8	45.7	82.1	116.6	61.4	90.2
Preschool I	105.8	40.6	75.5	105.8	40.6	81.2
Preschool I	104.1	42.6	73.9	104.1	42.6	79.1

Legend: MAX - Maximum; MIN - Minimum; LEQ - Equivalent Noise Level.

When we analyzed Table 1, it showed that according to the NR-15, Leq was 73.9 dB (A) and 75.5 dB (A) in Preschool I, and 76.1 dB (A) and 82.1 dB (A) in Preschool II.

In this sample, the band intensity of a higher recurrence of SPL was 53–55 dB (A) and 65–80 dB (A) in Preschool I and 53–57 dB (A) and 71–85 dB (A) in Preschool II (Figure 1); the Mann–Whitney test used to compare the standards determined that there were no statistically significant differences (NR-15, $p = 0.427$; NHO-01, $p = 0.186$). This suggests that despite the older children producing a higher SPL than the younger children, quantitative analysis determined that this difference was not significant.

The frequency spectrum of the SPL measured in the octave bands was concentrated in the frequency range between 500 Hz and 4000 Hz (Figure 2).

The activities performed by Preschool I (Chart 1) were related to the SPL measurement (Figure 3) during the 8-hour period. The SPL varied according to the activity: painting and writing were quieter activities and free activities and games were noisiest; these activities were carried out in the classroom. The only time the SPL was within the standards was during the children’s nap time.

DISCUSSION

The results demonstrated that most of the time, the noise level at school is higher than that recommended by the ABNT and the World Health Organization (1, 10).

A study conducted in a school showed that the noise levels measured in the classrooms and the school yard were the same as that caused by heavy traffic, race cars, and subway trains, ranging from 80 dB to 110 dB (10), and

Table 2. Activities performed by preschoolers during the periods measured.

Schedule	Place	Activity
8:15 to 8:30	Covered court (open space)	Songs and prayers
8:30 to 9:15	Classroom (enclosed space)	Painting
9:15 to 9:30	Cafeteria (enclosed space)	Breakfast
9:30 to 10:00	Classroom (enclosed space)	Painting
10:00 to 10:30	Playground (open space)	Games
10:30 to 11:10	Cafeteria (enclosed space)	Lunch
11:10 to 11:45	TV room (enclosed space)	Watch a DVD
11:45 to 13:40	Classroom (enclosed space)	Naptime
13:40 to 14:30	Classroom (enclosed space)	Writing activity
14:30 to 14:50	Covered court (open space)	Free activity
14:50 to 15:10	Cafeteria (enclosed space)	Afternoon coffee
15:10 to 16:00	Playground (open space)	Storytime

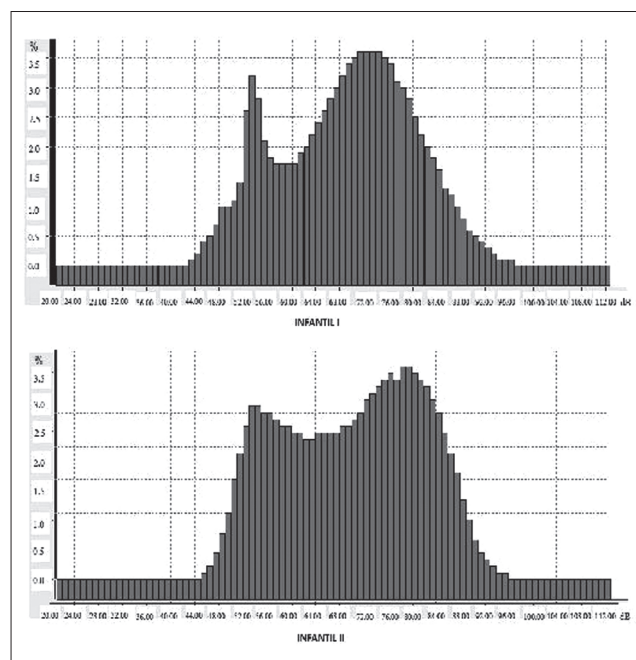


Figure 1. Distribution of the frequency of noise occurrence according to intensity.

this shows that the measurements obtained in this study are not appropriate for the school environment, the physical and mental health of children in this learning phase, and for other school professionals (11).

In this study, the average SPL, determined from 4 days’ measurement, was 73.9 dB (A) and 75.5 dB (A) in Preschool I and 76.1 dB (A) and 82.1 dB (A) in Preschool

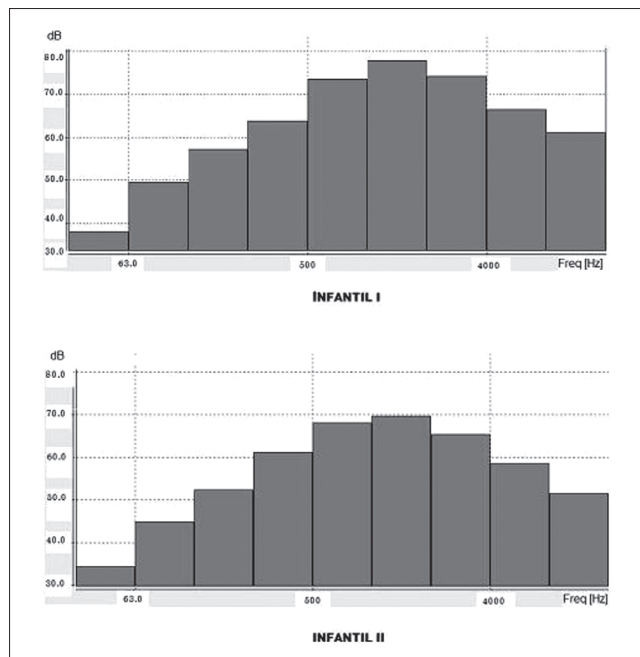


Figure 2. Distribution of the sound pressure level measured at Preschool I and II according to frequency spectrum (octave bands).

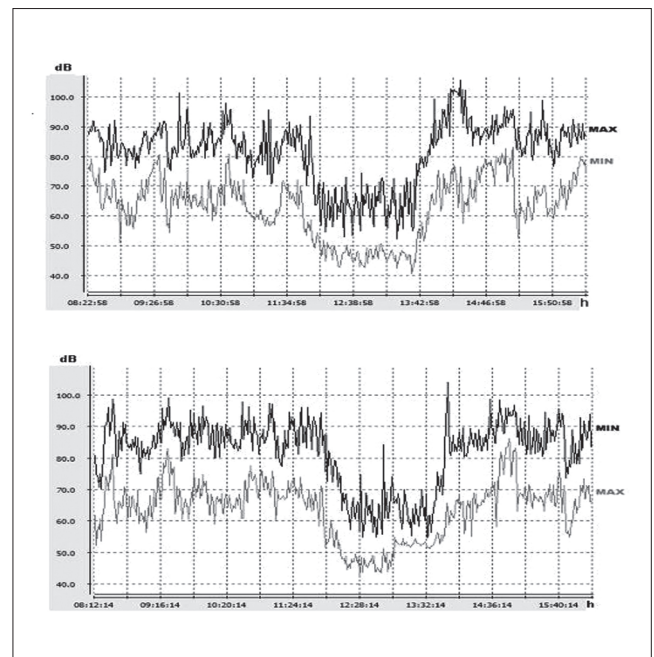


Figure 3. Sound pressure level measurement (MIN and MAX) in dB (A).

II; these results are similar to those found in the literature. In other studies involving schools, the SPLs in classrooms ranged 49–75 dB (A), 59.5–71.3 dB (A), 59–87 dB (A), and 71.1–96.2 dB (A) (12,13,14, 15).

In daycare centers and schools, children's voices produce considerable levels of noise; the equivalent noise levels (Leq) measured over 8 hours were 80.1 dB (A) near the teachers' ears and 70.87 dB (A) in the classroom. The Lmax was 112.55 dB (A) near the teachers' ears and 103.77 dB (A) in the classroom (7).

A study that measured the influence of external noise in an empty classroom obtained a Leq of 56.2 dB (A) when there was activity in only one classroom in the school and 63.3 dB (A) when activity was carried out in another 3 classrooms (16).

This difference in SPLs observed in the literature can be explained by the influence of different factors, such as equipment position, the number of children in the classroom and/or activity, type of activity performed, the environment acoustic characteristics, and school location.

The noise levels in schools should not exceed 50 dB (SPL), remaining below the human voice, which is 60 dB (SPL) at normal intensity¹. Measurements in the classroom demonstrated that excessive noise is a more relevant issue than the poor acoustics of the room, and the levels of

environmental noise are almost always higher than the 35 dB (A) recommended by the ABNT, even in empty rooms (1).

The SPL measured at the school in octave band was concentrated in the frequency range between 500 Hz and 4000 Hz, the frequencies that favor speech perception. This finding suggests the interference of SPL in the understanding of speech due to the signal-to-noise ratio.

Several studies have indicated that the contribution to the intelligibility of speech is specific to certain frequency bands, and speech sounds consist of low and high frequencies that vary continuously in intensity (17). For sounds below 500 Hz, there is a concentration of 60% of the energy; however, only 5% contributes to speech intelligibility. At frequencies of 500–1000 Hz, the energy and intelligibility are around 35%, and finally, at frequencies above 1000 Hz, only 5% of the acoustic energy is responsible for 60% of the intelligibility and information (18).

Noise in the classroom disrupts children's speech perception, even in short reverberations. Research has shown that children are the most affected by background noise, either in speech perception or in listening (4).

Regarding the recommendations for noise in schools, we observe that concern has increased because noise from internal sources (conversations, furniture, and equipment)

and external sources (traffic, movement of people, and proximity to urban centers) has increased. In addition, few measures have been implemented to improve the acoustic environments. Thus, the teaching–learning process suffers interference, as the environment does not favor concentration and understanding of speech (19).

In this study, the SPLs in the classroom reached values above 80 dB (A) according to the activity performed, where painting and writing were the quietest activities. During free activities periods and games that took place on the covered court and playground, the SPL exceeded 90 dB (A), and these were the noisiest activities in this sample. These findings contradict the recommendations endorsing the classroom-tolerated limit of 40–50 dB (1).

In the literature, studies have reported that the SPL depended on the activity performed in the classroom (12,20,21).

In elementary schools, the noise levels measured were 44 dB (A) when the children were silent, 56 dB (A) when they were carrying out some activity in silence (silent reading), 65 dB (A) when they were carrying out individual work in a noisy environment (conversation), and 70–77 dB (A) when group work was being done (20,21).

Students' activities are a dominant source of noise in the classroom, even when they are quiet and well behaved. In this environment, any activity can increase the noise level by 5–10 dB (A) (19).

A recent study measured noise during recess, demonstrating that the noise was excessive during both periods (morning and afternoon), reaching maximum values of 88.7 dB (A) in the morning and 102 dB (A) in the afternoon (15).

The same study observed the occurrence of SPL peaks. The authors stated that these peaks are caused by the objects falling or being used, furniture being moved, or students shouting. The peaks interrupted the teacher's activity and the student group lost its focus (19).

In this study, the children of Preschool II, aged between 5 and 6 years, produced a higher level of noise than the younger children did. It has been reported that kindergarten rooms frequented by children aged 5 years were noisier than rooms frequented by high school students (22).

We used 2 different standards (NR-15 and NHO-01) to analyze the results and observed differences in the measurements obtained, and these differences were

justified by the parameters used, for example, the duplicity rate of the dose.

It is worth mentioning that the rules that deal with noise measurement and its harmful effects were created to establish criteria for occupational noise exposure. However, as there are no specific rules in Brazil for noise measurement in schools, we decided to use these standards (1).

The criteria established by the NHO-01 are based on modern concepts and scientific and technical parameters, follow current international trends, but without the commitment of equivalence with the legal criteria. Thus, the results obtained and their interpretation when applying this standard may differ from those compared against the NR-15.

When we consider the high SPLs found in schools and their negative impact in this environment, it is essential to implement actions that aim to minimize this disadvantage. It is important to remember that a good acoustic design ensures efficient distribution of the desirable sounds, as well as the exclusion of unwanted noise (noise from the roof, floor, ceiling, and walls) (23).

The high level of noise in the school environment was reported as a disturbing finding in a study because it impairs the academic activities of students. This problem goes beyond the perception of the discomfort caused by noise: it demands reflection about the physical layout of the school environment, classroom acoustics, and student and staff awareness of the noise generated at school (24).

Researchers have stated that noise should be considered a risk factor in the school environment. Once the acceptable noise levels for classrooms are exceeded, it is necessary to reduce them within the legal and medical scope. Smaller classes built with acoustic materials and suitable furniture could be examples of immediate actions (14).

Changes in students' attitudes, such as behavior in the classroom, will affect the noise level. A reduced noise level combined with treatment for the acoustic environment would produce a significant beneficial effect (19).

CONCLUSION

The SPLs measured at the school were higher and exceeded the maximum permitted level according to the reference standards. Therefore, the implementation of actions that aim to minimize the negative impact of noise in this environment thus becomes essential.

REFERENCES

1. Associação Brasileira de Normas Técnicas (ABNT). Níveis de ruídos para conforto acústico. NBR 10152. Rio de Janeiro: Associação Brasileira de Normas Técnicas; 1987.
2. Jaroszewski GC, Zeigelboim BS, Lacerda A. Ruído escolar e sua implicação na atividade de ditado. *Ver CEFAC*. 2007;9(1):122-32.
3. Soncini F, Costa MJ, Oliveira TMT. Queixa de dificuldade para reconhecer a fala X limiares de reconhecimento de sentenças no ruído em normo-ouvintes com mais de 50 anos. *Pancast. Revista Fono Atual*. 2003;6(26):4-11.
4. Klatt M, Lachmann T, Meis M. Effects of noise and reverberation on speech perception and listening comprehension of children and adults in a classroom-like setting. *Noise Health*. 2010;12(49):270-82.
5. Nascimento LS, Lemos SMA. A influência do ruído ambiental no desempenho de escolares nos testes de padrão tonal de frequência e padrão tonal de duração. *Rev CEFAC*. No prelo 2012.
6. McAllister A, Brandt SK. Uma comparação de gravações de frases e fala espontânea: medidas perceptuais e acústicas em vozes de crianças pre-escolares. *Voz J*. 2012; 26(5):673.e1-5.
7. Eysel-Gosepath K, Pape HG, Erren T, Thinschmidt M, Lehmacher W, Piekarski C. [Sound levels in nursery schools]. *HNO*. 2010;58(10):1013-20.
8. Giampaoli E, Saad IFSD, Cunha IA. Normas de Higiene Ocupacional NHO 1: Avaliação da Exposição Ocupacional ao Ruído, Procedimento Técnico. São Paulo: FUNDACENTRO; 1999.
9. Brasil. Ministério do Trabalho. NR 15: Atividades e operações insalubres. Portaria nº 3214; 1978 Jul 8. *Diário Oficial da União: Brasília (DF)*; 1978 Jul 06.
10. World Health Organization (WHO). Noise, environmental health criteria [Internet]. Geneva (Swz); 1980. [cited 2009 Apr 05]. Available from: <http://www.inchem.org/documents/ehc/ehc/ehc012.htm>
11. Almeida Filho N, Filletti F, Guillaumon HR, Serafini F. Intensidade do ruído produzido em sala de aula e análise de emissões acústicas em escolares. *Int Arch Otorhinolaryngol*. 2012;16(1):91-5.
12. Shield BM, Dockrell JE. The effects of environmental and classroom noise on the academic attainments of primary school children. *J Acoust Soc Am*. 2008; 123(1):133-44.
13. Wålander R, Gunnarsson K, Runeson R, Smedje G. Physiological and psychological stress reactions in relation to classroom noise. *Scand J Work Environ Health*. 2007;33(4):260-6.
14. Lacerda A, Marasca C. Níveis de pressão sonora de escolas municipais de Itapiranga – Santa Catarina. *Pró-Fono*. 2001;3(2):277-80.
15. Filho NA, Filletti F, Guillaumon HR, Serafini F. Intensidade do ruído produzido em sala de aula e análise de emissões acústicas em escolares. *Int. Arch. Otorhinolaryngol*. 2012;16(1):91-5.
16. Zannin PH, Marcon CR. Objective and subjective evaluation of the acoustic comfort in classrooms. *Appl Ergon*. 2007;38(5):675-80.
17. Russo ICP, Pereira LD, Carvalho RMM, Anastasio ART. Encaminhamentos sobre a classificação do grau de perda auditiva em nossa realidade. *Rev Soc Bras Fonoaudiol*. 2009;14(2):287-8.
18. Fletcher H. *Speech and hearing communication*. New Jersey: D. Van Nostrand; 1953.
19. Hans RF. Avaliação de ruído em escolas [master's thesis]. [Porto Alegre (RS)]: Universidade Federal do Rio Grande do Sul; 2001.
20. Shield BM, Dockrell JE. External and internal noise surveys of London Primary Schools. *J Acoust Soc Am*. 2004;115:730-8.
21. Sato H, Bradley JS. Evaluation of acoustical conditions for speech communication in working elementary school classrooms. *J Acoust Soc Am*. 2008;123(4):2064-77.
22. Picard M, Bradley JC. Revisiting speech interference and remedial solutions in classrooms. *Audiology*. 2001; 40:221-44.
23. Gonçalves VSB, Silva LB, Coutinho AS. Ruído como agente comprometedor da inteligibilidade de fala dos professores. *Prod [internet]*. 2009;19(3):466-76.
24. Jamieson DG, Kranjc G, Yu K, Hodgetts WE. Speech intelligibility of young school-aged children in the presence of real-life classroom noise. *J Am Acad Audiol*. 2004;15(7):508-17.