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Original Article

Artigo Original

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Measuring noise in classrooms: a systematic review

Mensuração do ruído em salas de aula: revisão sistemática

Keywords

Noise
Noise measurement
Noise meters
Signal-to-noise ratio
Schools

ABSTRACT

Purpose: The aim of this systematic review is to outline the main methodologies used for measuring noise in classrooms and if the noise levels found are suitable standards. **Methods:** A survey of articles published in the last ten years, using six different databases. Were verified 1.088 publications and only eight studies met the inclusion criteria: (a) articles published in the last ten years, (b) articles available in full, (c) studies that have measured the noise in the classrooms of regular schools. Data analysis: descriptive analysis was performed of selected publications. **Results:** Five studies conducted to measure the noise using a sound level meter. One measurement performed using a dosimeter and two studies used a laptop with audio recording software. In all classrooms, the noise level was higher than allowed. **Conclusion:** Classrooms are noisy environment and there is no standardization regarding the methodology that should be used to measure the noise in these places. Therefore, schools need to be guided constantly about the importance of acoustic adaptation in the classroom.

Descritores

Ruído
Medição de ruído
Medidores de ruído
Razão sinal-ruído
Instituições acadêmicas

RESUMO

Objetivos: Os objetivos desta revisão são elencar as principais metodologias utilizadas para a mensuração do ruído em salas de aula e se os níveis de ruído encontrados estão adequados às normas. **Métodos:** Realizou-se um levantamento dos artigos publicados nos últimos dez anos, utilizando seis diferentes bases de dados. Foram verificadas 1.088 publicações e somente oito trabalhos obedeceram aos critérios de inclusão: (a) artigos publicados nos últimos dez anos; (b) artigos disponíveis na íntegra; (c) estudos que mensurassem o ruído em salas de aula de escolas regulares. Foi realizada análise descritiva das publicações selecionadas. **Resultados:** Cinco estudos mensuraram ruído por meio de um medidor de nível de pressão sonora. Um realizou a mensuração por meio de um dosímetro e dois utilizaram um computador portátil com software de gravação de áudio. Todas as salas de aulas avaliadas nos estudos encontrados apresentaram nível de ruído acima do permitido. **Conclusão:** As salas de aula são ambientes ruidosos e não há padronização quanto à metodologia que deve ser utilizada para a mensuração do ruído nesses locais. As escolas precisam ser orientadas constantemente sobre a importância da adequação acústica na sala de aula.

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INTRODUCTION

Noise is defined as unwanted sound and is present in a variety of environments[1]. In classrooms, speech is rarely transmitted to children without interference from background noise. At the same time, the effective transmission of auditory information is essential for better academic performance[2].

In a school setting, noise is not only a nuisance but also interferes with performance in educational activities[3]. Teachers feel uncomfortable while teaching in noisy classrooms and students feel difficulty in receiving the information, as well as in dispersion of attention[4].

Acoustics is the science that studies sounds. By analyzing the acoustics of a classroom, all sounds present on the site are verified.

Noise sources can be classified in three types[5]:

- External sources: noise coming from outside the school, usually generated by vehicle and aircraft traffic, as well as from properties near the school (bars, horns, whistles, construction, nightclubs, gyms, etc.);
- In-school sources: noise generated within the school (in environments adjacent to the classroom) such as the schoolyard, recreation room, gymnasium, music room, kitchen, other classrooms, etc.
- Internal sources: noise generated inside the room itself, such as conversation, students' movement and activities, the use of teaching materials (paper, scissors, stapler, etc.) and noise from fans, lights and air-conditioning equipments.

In learning environments, the most important aspect for good speech perception is not the kind of noise or the overall level of background noise, but the relationship between signal strength and intensity of the background noise[2]. This relationship is called the signal/noise ratio. Children with normal hearing require a more favorable signal/noise ratio to achieve the same level of speech perception than adults. Those with hearing disabilities face even more disadvantages[6].

The maximum permissible noise level for a classroom is 40 decibels (dB)[7]. The ideal would be to maintain the signal/noise ratio higher than 10 dB (for individuals with normal hearing) in the whole room. Thus, intelligibility would be guaranteed. For a child with hearing deficiency, this ratio should be at least 15 dB, while some authors indicate values up to 25 dB. The ideal would be a silent a classroom (40 dB) with the teacher talking at their normal voice volume (65 dB). This would keep the speech/noise ratio above 10 dB, and would not cause the teacher any voice problems[3].

Knowing possible consequences of a noisy classroom, where speech intelligibility is hindered, some authors have carried out studies with the purpose of measuring noise in these environments.

OBJECTIVES

The objectives of this review are: to outline the main methodologies used for measuring noise in classrooms and to determine if the noise levels found are in compliance with standards.

SEARCH STRATEGY

A search was performed through a systematic literature review, in September 2013, in the following electronic databases: The Cochrane Library, EMBASE, ISI Web of Science, LILACS, PUBMED and SciELO. The following terms were used in English and Portuguese: noise (*ruído*), noise measurement (*medição de ruído*), noise meters (*medidores de ruídos*), noise monitoring (*monitoramento de ruído*), signal-to-noise ratio (*razão sinal-ruído*) and schools (*escolas*). The selection of descriptors was made after consultation with the Health Sciences Descriptors (DeCS) database, and they were combined by using the Boolean AND operator. Table 1 shows the combinations used for the present search.

Through the search strategies, 1,088 publications were found (22 in The Cochrane Library, 561 in EMBASE, 142 in ISI Web of Science, 17 in LILACS, 333 in PUBMED and 13 in SciELO). Firstly, an analysis of the titles of articles was carried out to select those that were unrelated to the theme proposed for the review. The second selection was performed by analyzing the articles' abstracts.

Table 1. Combinations used in the search

Strategy 1	*noise measurement AND schools*
Strategy 2	*noise meter AND schools*
Strategy 3	*noise monitoring AND schools*
Strategy 4	*noise AND schools*
Strategy 5	*signal-to-noise ratio AND schools*

SELECTION CRITERIA

To be included in this review, publications should meet the following inclusion criteria:

- articles published in the last ten years;
- articles available in full; and
- studies that measured noise in classrooms in regular schools.

Exclusion criteria were:

- studies that measured noise in environments outside of the classroom;
- studies that made measurements in simulated environments;
- measurements performed in music classes; and
- review articles. In the end, after thorough reading eight articles were used for this study.

DATA ANALYSIS

A descriptive analysis of the selected publications was performed according to the objectives of the review.

RESULTS

Despite the large number of articles found (1,088 publications), only eight of them met the inclusion criteria. Table 2 presents general information about them.

In addition, in five studies noise level was measured with a sound pressure level meter[8-12]. In one of these studies, a MSL-1325 digital sound pressure level meter from MINIPA Ltd. was used. The measurements took place at five different points of the classroom, and results show that the noise level reached maximum values of 84.3, 96.2, and 93.0 dB, and minimum values of 66.1, 71.1, and 67.4 dB[8].

In another study, a decibel meter type S 2AE from Simpson, model 897, was used, and the measurement was performed at only one point in the classroom during a dictation activity. Noise levels ranged from 59.5 to 71.3 dB[9].

In a study conducted in 2010, the author used an Instrutherm SL-4011 sound pressure level meter. The sound level ranged from 45.00 to 65.00 dB, with a mean value of 58.24 dB[10].

Authors of a study conducted in London, measured the noise with the use of a sound pressure level meter positioned in the classroom during an activity, and the mean total noise level was of 72 dB[11].

In 2013, in a study in Egypt, the author used of a type 2230 sound pressure level meter by Bruel and Kjaer[12]. The equipment was placed in the middle of the classroom, at a height corresponding to the position of the students' ears. The total noise level ranged from 61.3 to 73.2 dB.

Two other studies used some kind of software which were connected to a laptop computer in their methodology[13,14]. In one of them, authors used audio recording software (Cool Edit Pro) for measurements. Recordings from 15 to 20 minutes were conducted, in which the teacher spoke frequently to students. It was observed that, on average, the teachers presented the speech intensity of 60.4 dB and the average noise in classrooms was of 49.1 dB; therefore, the average signal/noise ratio during teaching activities was of 11.0 dB[13].

In another study, authors compared measurements performed in classrooms with and without infrared system. The methodology applied was the Techron TEF System-20, connected to a Macintosh laptop. Measurements of sound pressure levels were made for ten minutes at each location while the class was in session. The microphone was placed near the teacher and also at the height of one student's ears (approximately 3.2ft from the floor level), who was in a sitting position. In addition of measuring the signal/noise ratio, the authors compared the use of amplification (infrared) in classroom and the absence of amplification. The results showed average signal/noise ratio of 2 dB without the use of amplification, and of 13 dB using amplification[14].

In only one study, measurements were performed using dosimeters. Type 4436 equipment by the brand Brüel and Kjaer Inc. were used for a period of five hours per day, five days a week, with a dosimeter positioned at a point in the classroom and another positioned near the teacher's ear. The average noise levels were 78 dB near the teacher's ear, and of 70 dB in the room[15].

CONCLUSION

It is possible to conclude that there is no standardized methodology that can be used for measurements of noise in classrooms, as in other places, such as work environments, where there are occupational hygiene standards establishing criteria and procedures for evaluating exposure to noise. This lack of standardization makes us come across varying methodologies.

It can also be observed that studies using a laptop computer with any audio recording software installed in their methodology should receive attention. These software allow the recorded material to be subsequently analyzed, so that not only sound pressure level but also signal/noise ratio in the environment can be established as by using a decibel meter, for example.

All classrooms evaluated in the studies presented a noise level above the allowed levels. Thus, schools should receive constant guidance about the importance of acoustic adequacy of the classroom environment.

**VLDF was responsible for the project, search and analysis of the studies included in this manuscript; ALMM and RTSJ were responsible for the general orientation.*

Table 2. General information of the publications included in the review

First author	Location	Classrooms	Instrument	Noise level
Ali, 2013[12]	Egypt	6	Sound pressure level meter	Inadequate
Almeida Filho et al., 2012[8]	Brazil	3	Sound pressure level meter	Inadequate
Guidini et al., 2012[10]	Brazil	10	Sound pressure level meter	Inadequate
Eysel-Gosepath et al., 2012[15]	Germany	3	Dosimeter	Inadequate
Sato and Bradley, 2008[13]	Canada	27	Audio software	Inadequate
Larsen and Blair, 2008[13]	United States	5	Audio software	Inadequate
Jaroszewski, Zeigelboim and Lacerda, 2007[9]	Brazil	7	Sound pressure level meter	Inadequate
Shield and Dockrell, 2004[11]	United Kingdom	110	Sound pressure level meter	Inadequate

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