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NOISE LEVELS IN THE LEARNING-TEACHING ACTIVITIES IN A DENTAL MEDICINE SCHOOL

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ABSTRACT
The noise levels made by clinical handpieces and laboratory engines are the main descriptors of acoustical comfort in learning spaces in a dental medicine school. Sound levels were measured in five types of classrooms and teaching laboratories at the University of Porto Dental Medicine School. Handpiece noise measurements were made while instruments were running free and during operations with cutting tools (tooth, metal and acrylic). Noise levels were determined using a precision sound level meter, which was positioned at one-meter distance from the main noise source. Some of the handpieces were brand new and the others had a few years of use. The sound levels encountered were between 60 and 99 dB(A) and were compared with identical situations in other countries and with the noise limits in A-weighted sound pressure level for mechanical equipments installed in educational buildings included in several European Noise Codes. The daily personal noise exposure levels (*Leq,8*) of the students and professors were calculated to be between 85 and 90 dB(A) and were compared with the European legal limits. Some noise limits for this type of environment are proposed and suggestions for the improvement of the acoustical environment are given.

1 - INTRODUCTION

The learning-teaching activities in a dental medicine school require the use of diverse equipment that emits noise. The noise levels produced by the different mechanical equipments inherent to those educational activities are the main describers of the acoustic comfort in these spaces.

In dental medicine practical classes, the acoustic environment is characterized by high noise levels in relation to other school spaces, due to the exaggerated noise produced by some of these devices and due to the simultaneous use of some dental equipment by many users. This situation is aggravated when the rooms involving surfaces are hard and noise reflectors, as it is usually the case.

The long exposition to high noise levels by the students and professors has an extremely negative effect. It is known that high sound levels have negative effect in the extra-auditory systems with physical impacts (quickened pulse, increase in blood pressure, constriction of the blood vessels, etc.) and psychic (nervousness, mental fatigue, mental and emotional frustration, low productivity, etc.). Directly affecting the school learning-teaching activities, the noise also causes a reduction of the speech intelligibility and the vocal fatigue of the professors.

Therefore, it would be necessary to guarantee that in school buildings of this type the sound levels are not detrimental to the learning activities. It is therefore essential to control the noise in the learning environments, without forgetting that the acoustic comfort depends not only on the control over the emitted sound levels but also on the acoustic characteristics of the geometry and materials of the classrooms.

2 - METHODOLOGY

The acoustic environment was measured and analyzed in five types of classrooms and teaching laboratories of the Faculty of Dental Medicine of the University of Porto (Portugal).

The sound levels were measured with a precision sound level meter (B&K 2260) in five different rooms with distinct activities. The microphone was placed at a distance of 1 m of a main noise source, in each room, to simulate the auditory position of the student (dentist). The measurements were made with the equipments working freely (without cutting) and during cutting operations (in tooth, metal and acrylic). Some of the evaluated clinical equipment was "new" while other had a few years of use, being almost all from the brand *KAVO*.

The rooms and the activities tracked in this study were the following (see Table 1):
- Laboratory of prosthesis (Fig. 1) - The engine running free (without cutting) and during cutting operations in metal and acrylic; free use of the aspirator and joint use of the aspirator and engine in cutting operations;
- Gypsum Laboratory - Activities of cut and vibration of gypsum;
- Annex of the Gypsum Laboratory - Activities of cut and burnishing of gypsum in simultaneous with the functioning of the ventilation system;
- Preclinic (Fig. 2) - Use of a "new" turbine (Airotor handpiece), freely and during cutting operations in tooth and acrylic; of an Contra-angle handpiece (low speed handpiece), of a "new" Straight handpiece;
- Clinic - Use of "new" and "used" turbines, freely and during cutting operations in tooth and acrylic; of "new" and "used" Contra-angle handpieces, and of a new Straight handpiece;

Also measured were the overall equipment sound levels during classes in the Preclinic, Clinic and also in the Laboratory of Prosthesis as well as the typical background noise. The *NC* (Noise Criterion) and the daily personal noise exposure (*Leq,8*) values were also determined.

Figures 1 and 2 - Images of the Prosthesis and Preclinic laboratories.

3 - RESULTS

The main measurements results are shown in Table 1, with the comparison among the sound levels of the tested equipment in free use and in cutting operations (in metal, tooth or acrylic), in five rooms.

4 - ANALYSIS

4.1 - Sound Levels

4.1.1 - Overall analysis

The results displayed in Table 1 show that the sound levels vary between 60 and 99 dB(A) being very high in the Gypsum Laboratory, where values of *LAeq* from 94 to 99 dB were reached.

The noisiest equipments are the equipments in the Gypsum Laboratory and the engine/aspirator in the Prosthesis Laboratory.

CLASSROOMS	EQUIPMENT	OPERATION	L_{Aeq} (dB)
PROSTHESIS LABORATORY	Engine	free use	67.9
		cutting in acrylic	76.9
		cutting in metal	81.3
	Aspirator	free use	71.8
	Aspirator and engine	cutting in acrylic	81.7
		cutting in metal	86.5
GYPSUM LABORATORY	Cutting equipment		93.5
	Vibrating equipment		98.5
GYPSUM LABORATORY ANNEX	Equipment for cutting gypsum + polish + ventilation		88.7
PRECLINIC LABORATORY	Turbine (new / used)	free use	67.0 / 68.7
		cutting in tooth	74.8 / 69.8
		cutting in acrylic	76.3 / 73.2
	Contra-angle handpiece (new)	free use	69.2
		cutting in tooth	73.1
		cutting in acrylic	73.5
	Straight Handpiece	free use	61.9
		cutting in tooth	65.0
		cutting in acrylic	73.1
	Contra-angle handpiece (used)	free use	73.2
		cutting in tooth	74.1
		cutting in acrylic	75.2
CLINIC	Turbine (new / used)	free use	65.5 / 70.3
		cutting in tooth	68.3 / 72.0
		cutting in acrylic	70.0 / 75.9
	Contra-angle handpiece (new / used)	free use	66.1 / 70.4
		cutting in tooth	70.7 / 71.9
		cutting in acrylic	70.7 / 71.3
	Straight handpiece	free use	60.5
		cutting in tooth	69.4
		cutting in acrylic	71.8

Table 1 – Sound levels (*LAeq*) measured for diverse rooms and activities (at 1 m).

4.1.2 - International comparison

The measured sound levels for the diverse equipment are not very distinct of those found in some other countries (United Kingdom and Saudi Arabia, such as indicated in Table 2) but in Portugal they can be slightly higher by +1 to +5 dB(A).

L_{Aeq} (dB)	ASPIRATOR	TURBINE	CONTRA-ANGLE HANDPIECE
Portugal	72	68-76	69-75
Saudi Arabia [1]	-	≈ 72	≈ 68
United Kingdom [2]	68-70	70-75	72-75

Table 2 – Comparison of the average sound levels for some equipment among different countries [1, 2].

4.1.3 - Free noise vs. cutting noise

The results show that the measured sound levels during cutting activities are significantly superior to those determined in the absence of these operations (free use). The average value of the differences (cutting/free) equals to +6 dB(A) (Table 3). This fact also is evidenced in [1], where the average value of these differences is about +10 dB(A).

TYPE OF USE	RANGE OF DIFFERENCES (cutting - free use) (dBA)	AVERAGE DIFFERENCE (dBA)
Cutting in acrylic	+1 to +11	+6
Cutting in metal	+13 to +14	+13
Cutting in tooth	+1 to +9	+4
All types	+1 to +14	+6

Table 3 – Differences of measured sound levels between the free use of the equipments and their use under normal cutting operations.

4.1.4 - Frequency spectra

The analysis of the noise spectra of the tested equipment shows raised sound pressure levels in the higher frequency bands (Fig. 3). This characteristic is not very common in other mechanical noise spectra in classrooms. This can be in the origin of typical disturbances and "irritability " caused in many persons by these noises.

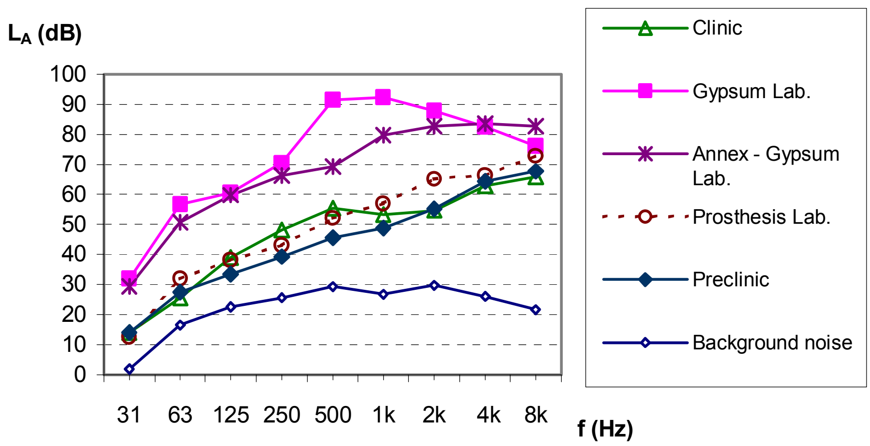

Figure 3 – Comparison among noise spectra (1/1 octave band) of the average noise in rooms, and with a typical background noise, after using an A-weighted filter to check their contribution for the global noise level (in dBA).

4.1.5 - New vs. used

The differences in the sound levels between "used" and "new" equipment was also checked (Table 1). In general, the "used" devices are noisier between 1 and 6 dB(A), and in average about 3 dB(A).

While in the "Clinic" the values of the sound level for the "new" turbine are inferior to the ones for the "used" turbine (in about 5 dBA), in the "Preclinic" the values of the "new" turbine are slightly superior to the ones for the "used" turbine (during cutting operations). This difference constitutes an exception, and it is justified by the fact that the "used" turbine in the "Preclinic" had yet very little time of use.

4.1.6 - Measured vs. catalog values

The Table 4 presents the comparison between the values measured and the values stated in their brand technical catalogues regarding three main equipments. On average, there is an increase of about 7 dB(A) in the measured values versus the stated values in their brand catalogue.

ROOM	EQUIPMENT	YEAR	BRAND - MODEL	CATALOGUE NOISE (dBA)	MEASURED NOISE [1] (dBA)
Prosthesis Laboratory	Engine	1986	KAVO - K10	76	68 / 77 - 81
Prosthesis Laboratory	Aspirator	1986	KAVO - 6583400	61	72 / 82 - 87
Preclinic Laboratory	Turbine	1995	KAVO - 640B	70	67 / 75 - 76

1 - free use / in cutting operations (at 1 m)

Table 4 – Comparison among measured values and the values in the technical catalogues of the model.

4.2 - Noise Criteria (NC)

To quantify the acoustic disturbance introduced in the rooms by the noise originated in the clinical equipment the values of the parameter *NC* "Noise Criterion" in each room were calculated (Fig. 4). Values from 70 to 91 dB were found being the Gypsum Laboratory the one that presents the highest value.

According to the classification proposed by Cavanaugh [3] the value of the suggested maximum *NC* for laboratories, clinics and shop classrooms is 50 dB. All the evaluated rooms presented a *NC* value higher than that maximum value.

As for an *NC* equal to 50 dB the corresponding equivalent sound level is of about 56 dB(A) [3] and this noise level still allows a relaxed communication at a normal voice at 3 m [3], it seems adequate as the upper limit value in places of learning in dental medicine schools.

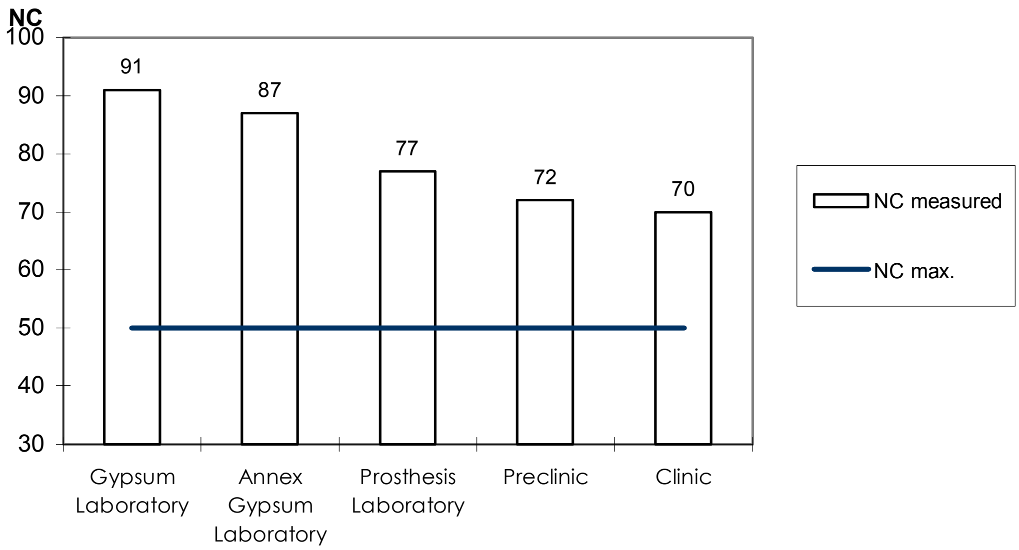

Figure 4 – *NC* values for each room and proposed maximum *NC* value for minimum comfort.

4.3 - Noise exposure

The levels of daily personal noise exposure for professors and students were calculated by the standard expression (ISO 1999):

$$L_{Aeq\,8} = 10\,.\log\left[(1/8)\sum_{k=1}^{n} T_k\,.10^{(0.1 L_{Aeq,Tk})}\right]$$

where *LAeq,Tk* is the A-weighed equivalent continuous noise level over a period of time *T* (hours) corresponding to the type of noise *k* that the person is exposed for a nominal eight-hour workday.

Considering that in the worst situations, a typical professor would be 4 h in the Preclinic, 1 h in the Gypsum Laboratory and 2 h in the Clinic and that a typical student would be 2 h in the Preclinic, 1 h in the Gypsum Laboratory and 2 h in the Clinic, the following result was found:

- Daily noise exposure (professors and students): *Leq,8* from 85 to 90 dB(A).

The European legislation limits the daily noise exposure of a worker to 85 dB(A). By the results found in this study the noise exposure of the professors (and students) are never inferior to 85 dB(A), in the typical worst situations.

Even if the values are below the risk of hearing loss, the sound levels are high enough for consideration of limitations. Since those are educative and laboratorial spaces, a limit of 75 dB(A) is suggested for the daily personal noise exposure as a limit for minimum acoustic comfort. To achieve that goal there is a need to reduce at least 10 dB(A) in the measured sound levels. However and as a pledge for ideal comfort the value of 70 dB(A) for the *Leq,8* is suggested for a design goal.

4.4 - Noise Limits

Several European regulations limit the value of the sound levels for mechanical equipments in school buildings (but normally mainly regarding ventilation noise or similar). Since in the classrooms of dental medicine schools the use of devices that produce noise are necessary, the existing legislation in Europe is not adequate to those spaces of learning, where the emitted sound levels are largely superior to the foreseen in the regulations. Comparing the measured sound levels (Table 1) with some European limits (Table 5 and Fig. 5), none of the measured values would fulfill these laws.

Since the existing legislation is not adjusted to those learning spaces in dental medicine schools, it becomes basic to suggest a limit for this type of spaces, where the sound levels are superior to other schools.

Considering the value of 60 dB(A) existing in the previous Portuguese Noise Code (1987) for the sound level limit in places where concentration and quietness are needed and the value of 56 dB(A) concerning the *NC* of 50 dB considered in chapter 4.2, it seems adequate to stipulate the 60 dB(A) as the permissible maximum for this type of spaces.

PORTUGAL	ITALY	FRANCE	BELGIUM	SWEDEN
$L_A \le 46$ dB	$L_A \le 40$ dB	$L_A \le 38$ dB	$L_A \le L_{A\,background} + 6$ dB (≈ 51 dB)	$L_A \le 35$ dB

Table 5 – Some European prescribed legal limits for equipment sound level in school spaces (but mainly thinking in ventilation noise) [4, 5, 6].

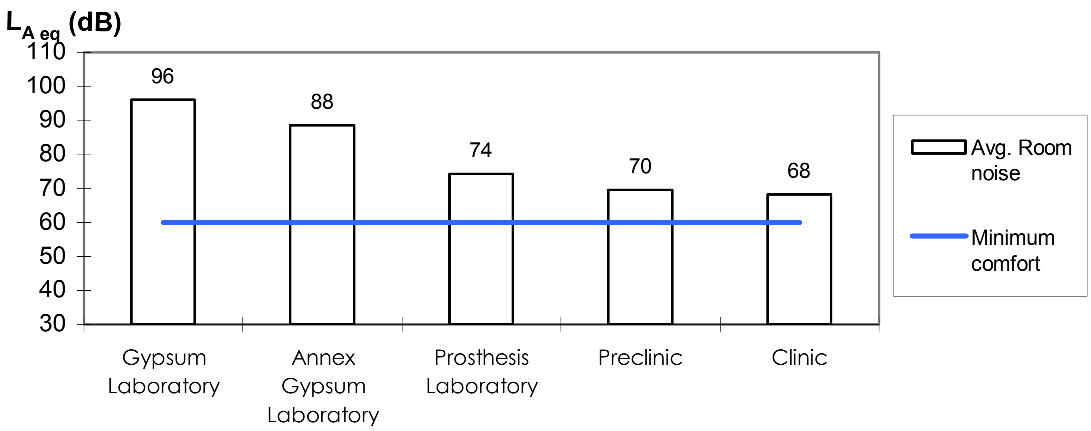

Figure 5 – Average noise level in rooms (at 1 m) and suggested maximum sound level for minimum comfort.

4.5 - Actions

The necessary reduction of the exposure sound levels can be obtained by reducing the sound level of the noise sources (where a decrease of 4 to 7 dB(A) can be obtained by regular maintenance, early repairs, replacement of defective items and use of newer less noisier models) or by increasing the sound absorption of the room (where a decrease of 3 to 5 dB(A) is possible). In this way, with some measures it would be possible to reduce about 7 to 12 dB(A) achieving a level of minimum comfort for most of the situations in this type of spaces.

In particular, the increase of the sound absorption in the rooms through the employ of porous materials (baffles or others) would act exactly in the high frequencies where the noise is more intense and disturbing (Fig. 3).

5 - CONCLUSIONS

With the use of the customary equipment in five classrooms of the Faculty of Dental Medicine of the University of Porto (Portugal), sound levels of 61 to 99 dB(A) and *NC* between 70 and 91 dB were measured what causes a *Leq,8* of 85 to 90 dB(A) for students and professors.

In general, the "used" equipments are noisier than the "new" equipments in about 2 to 5 dB(A). It was also established that in this Portuguese school the sound levels in these spaces are similar or slightly superior in about 1 to 3 dB(A) to those in two other countries.

It was shown that the clinic equipment presents raised sound pressure levels in the higher frequency bands, being then acoustically efficient to correct these spaces with sound absorbent materials (since it is in this range of frequency that the sound reduction achieved by these materials is larger).

It was suggested that the maximum permissible noise limits for these situations would be a *Leq,8* of 75 dB(A), a *NC* of 50 dB and a *LAeq* of 60 dB. Acting in the sound sources and on the rooms physical surrounding it would be possible to get sound reductions of 7 to 12 dB(A) that could assure a level of minimum acoustic comfort for most of these spaces.

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