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Noise in early childhood education institutions

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Abstract *High sound pressure levels have been observed in schools, and its interference in the health of children and teachers it was taken to analyze these levels in childhood education centers serving children aged zero to six years, investigate the staff's perceptions concerning noise exposure and identify the auditory conditions of these workers and the occurrence of diseases. The study was conducted in ten institutions employing 320 workers. Sound pressure levels were measured according to the technical norms; employees completed a questionnaire on the perception of noise and underwent auditory evaluation. There was high sound pressure level and differences between institutions, situations and places. Most employees are considered exposed to noise with attention and concentration difficulties, anxiety and headache. About 30% of employees had bilateral sensorineural hearing loss in specific frequency. The sound pressure levels found can affect children's learning and the health of all. The employees also perceived elevated levels of noise and indicated some possible negative aspects in their work routine. Actions to improve the acoustic comfort in these institutions will be discussed with the management teams.*

Key words *Noise occupational, Noise effects, Noise measurement, Child day care centers, Health promotion*

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Introduction

The negative impact of noise on the population's health has been a constant theme in the area of public health. Unfortunately sound mapping in big cities, which is an important tool for urban planning, is not widely done and is restricted to areas of general research[1].

In schools noise may affect the health of educators and children in the process of teaching and learning[2-4] as there is a distinct relationship between efficiency in teaching and acoustic conditions in institutions[5]. Communication between people and social interactions can be compromised along with the cognitive process[6]. A child that is exposed to loud noises, apart from being affected emotionally, may also present problems in relation to their language development. In Brazil the maximum level of noise that is acceptable in classes is 50 dB[7].

The higher the sound pressure levels (SPL) and the more frequent exposure to the negative impacts of loud noises are, the greater the chance of the individual having physical, mental or social problems[8]. The loss in hearing is related to the average exposure to noise for eight hours or more above 85 decibels (dB)[9]. Many health problems may occur or may even be worsen because of the above. For this reason children ought to be protected from the excesses of exposure to loud noises principally by the public authorities[10].

The following are other health problems that can occur due to the exposure to high SPL: an increase in baseline heart rate and respiratory rhythm, changes in blood pressure, intestinal problems, an increase in the production of thyroid hormones and an increase in body tension and stress levels[11-14].

Excessively loud noises can be prejudicial for professional educators who need to use their voices in a professional capacity[15]. There needs to be sound levels, which include speaking and general noise, which is less than 10 dB for pupils in classes so that they can understand the teacher. The determinants for the distribution of sound emitted by voices in an environment are: the size of the room, the way how the room is configured, and the positioning of both the teachers and the pupils. It should be noted that there is a reduction of 6 dB where there is a doubling of the distance in relation to the source of a sound[16]. For children's education where the use of voices is constant, consideration should be given to the use of open external spaces[17].

The measuring of noise allows for an initial analysis of the conditions of an environment[18]. This in turn allows for the search for solutions and actions that aid in the acoustic comfort in schools. In eight children's educational institutions[2,3,6,10], high levels of SPLs were found, with the average being 68.5 dB and there was a variation of 37.8 dB to 100.5 dB[19]. In a study carried out on 37 municipal schools in the city of João Pessoa (PB), only one class room was evaluated as having noise at an acceptable levels[20].

In an educational institution for children in the state of São Paulo, a study was done on the sound pressure levels in different areas which had children and adults. It was found that the canteen was the noisiest place in the building. After the findings were given to the coordinating team, alterations to the environment were made by the staff in the most affected areas and new practices were developed. It was subsequently proved through later analysis that the SPL was effectively reduced and the acoustic comfort in the environment was improved[21].

Controlling noise in schools depends on the collaboration of the children, the teachers, the employees and general managers. This is done through observation and permanent discussions[22] so that effect measures can be proposed, developed and improved upon[23].

Based on educational work covering health with a view to improving acoustic comfort, the objective of this study was to analyze the sound pressure levels in ten children's educational centers. The idea was to understand the employee's perceptions with reference to noise and related aspects and to analyze the conditions for hearing.

Methods

Ten children's educational institutions in the western region of São Paulo participated. These institutions catered for 1,400 children from zero to six years old and they employ 320 employees. These institutions were selected due to: their teaching activities and regular opportunities for internships and the optional courses in speech therapy that could be taken at the medical school in the University of São Paulo.

The research was approved by the Ethic's Commission in Research (protocol 231/13) and both the directors and staff were privy to and took part in the decision. A term of responsibility and consent was signed by the institutions that took part as well as a clause denoting that they took part without being coerced and through having had all their doubts allayed.

We considered, in this study, that the SPL equivalent (L_{eq}) represented the quantity of sound energy in a determined space during a specific time period and the measurement was in dB(A)[3]. Readings were done in the following different areas in the actual institutions: the class rooms, canteens, corridors, external areas outside of the institutions, the service areas and the general administrative rooms. Analysis was done during working days with specific equipment and it was also done when the children were not at school due to teacher's meetings.

In small spaces (up to 10m^2) readings were taken in central points. For example in average spaces (bigger than 10 m^2 and up 20 m^2) the readings took place in two diagonal positions. In large spaces (lager than 20 m^2) three different diagonal points were measured (internal and external). An average reading was taken in every area that was analyzed.

An SPL digital meter was used (the center model 322 with data logger was chosen) and we followed the guidelines and procedures given by ABNT[7]. The device was calibrated and it functioned with a slow response curve and with a noise gauge of between 30 and 130 dB. It was positioned so that it was a minimum of one meter from the ground and the walls. Taking readings at every point took 10 minutes.

The averages of the minimum values and the averages of maximum values for every given space were taken. They were divided in the following way: administrative areas and areas where people circulated (ADM) such as reception rooms, the management rooms, the matron's office and the corridors. The other divisions included: class rooms (ROOMS), external spaces (EXTERNAL) (including external areas just outside the buildings, parks and gardens), local places to eat (FOOD) (including places designated for eating such as refectories, and support services (SUPPORT) (including laundries, kitchens and the areas where milk was produced). In relation to presenting the data, the institutions were numbered from 1 to 10.

A questionnaire was developed and designed to evaluate the perception of the staff with reference to the exposure to noise and to look at the signs and symptoms related to possible exposure. In the development of the questionnaire some articles were used[11-13,24] and an initial version was tested on a small group of teachers. After the pilot study was done, adjustments were made and a definitive questionnaire was developed and produced having closed questions with the responses yes/no (the questions related to exposure to sound, the presence of illnesses and the use of medication) and they had the following responses: never, sometimes, always (for questions about signs and symptoms). Space was also made available on the questionnaire for any other comments relevant to the theme if the participant wanted to add more information. The employees were given the questionnaires in envelopes and they had a week to respond and give it back. An enquiry desk was set up to answers any questions or doubts and it lasted for a week. It was set up in the institutions.

After the questionnaires were returned the employees were sent to a department in an Audiology Clinic where basic audiological evaluations were carried out in an acoustic booth which included the following: Meatoscopy (otoscope made by Heine®), Tone Audiometry covering frequencies from 250 to 8000 Hz, Speaking Tests (audiometry, the Grason-Stadler® brand, model number GSI-61) and Imitanciometry (the equipment is from the Interacoustics® brand, model AT 235h).

In order to analyze the descriptive statistics, the measurement known as central tendency was used - average and median - and (variability readings) standard deviations, covering minimum and maximum readings were done. The Kolmogorov-Smirnov test was used to prove that the tests used were valid. This was guaranteed through the use of the Analysis of Variance (ANOVA) statistical method in order to compare the SPL's minimums, averages and maximums between: the different institutions, situations where there were and were not children present and various spaces. After the above, the multiple comparisons Tukey test was used so that the differences could be verified. Through the Qui-squared test, an evaluation was done covering the association between: hearing loss and the variable complaints of exposure to noise in schools, exposure to noise outside of schools, occurrences of illnesses and negative symptoms. In all of the analysis done the level of significance was considered as 5%.

Once the analysis was completed, a meeting was held with each institution in order for the results to be presented to them. The results were given to the coordinators and discussions took place on possible actions that could be taken to improve their acoustic comfort.

Results

Sound Pressure Levels

The general average sound pressure level for the ten institutions was 61.6 dB with a variation of between 36.2 dB (the average of the minimum values) and 96.9 dB (the average of the maximum values). With the application of the ANOVA test we observed differences between the institutions (Table 1). Through the use of Tukey's multiple comparison test, we noted that in relation to the minimum values institution 8 presented an average that was higher in comparison to the others, except for institutions 3 and 10. For the maximum values we observed that institution 1 had a lesser average than institutions 3, 7, 9 and 10. With reference to average values, institution 1 presented a lesser average than institutions 8 and 10.

Upon comparing the average values of the days in which the children were not present with the readings that were carried out for normal working days at the institutions, we observed

Table 1. Minimum, average and maximum values (in dB) obtained through measuring noise levels for the institutions and on a general basis.

Institutions		Average	Median	Deviation from Standard	Min	Max	IC	Value of p
Minimum	1	49.43	50.2	9.28	34.7	67.2	2.13	< 0.001*
	2	49.31	49.6	10.96	29.6	68.0		3.32
	3	52.92	54.3	7.85	39.4	69.2		2.64
	4	49.76	48.8	9.54	36.3	74.1		2.85
	5	50.21	49.7	9.90	34.3	72.6		3.11
	6	49.09	47.6	10.97	33.5	67.2		3.40
	7	51.00	51.0	8.39	35.9	72.7		1.97
	8	57.82	57.8	11.13	36.5	80.0		1.94
	9	50.11	49.3	6.87	36.5	70.2		1.60
	10	53.97	53.9	5.35	45.5	64.9		1.91
Average of the minimum values		51.36		36.2	70.6			
Maximum	1	71.75	75.2	13.57	46.0	97.0	3.11	0.036*
	2	77.14	81.2	12.64	49.8	93.2		3.82
	3	78.74	80.8	11.19	56.0	95.2		3.76
	4	76.65	77.6	10.65	49.1	94.0		3.18
	5	77.73	78.4	11.54	46.2	96.4		3.62
	6	75.68	74.6	12.87	48.8	101.7		3.99
	7	77.45	79.5	10.91	51.0	102.8		2.56
	8	75.86	78.7	9.67	52.5	96.9		1.68
	9	77.45	77.8	10.81	47.5	103.9		2.51
	10	79.11	81.3	7.36	57.0	88.6		2.63
Average of the maximum values		77.31		50.4	96.9			
Average	1	57.34	58.8	11.57	37.5	77.6	2.65	< 0.001*
	2	61.33	64.9	12.50	38.0	79.1		3.78
	3	63.60	65.4	9.99	46.9	81.0		3.36
	4	61.03	59.9	10.90	39.1	81.4		3.26
	5	61.50	62.1	12.03	38.8	82.0		3.78
	6	59.10	54.2	13.21	38.7	78.9		4.09
	7	61.42	64.4	10.56	39.7	81.9		2.47
	8	65.26	67.4	10.92	40.6	82.5		1.90
	9	60.73	62.7	9.03	40.6	75.5		2.10
	10	65.08	66.6	6.41	49.3	74.7		2.29
General Average		61.64		40.9	79.5			

* statistically significant (ANOVA).

higher averages in the second situation with differences of up to 14.03 dB (Table 2).

When the SPL was compared in the different spaces covering external areas and areas where work was done, we noted that the values were higher in the averages for the minimum levels. For the averages covering the maximum values, the highest readings were in external areas particularly where there was food. For the general average values, local areas where people circulated tended to show lower readings, with food areas registering the highest readings (Table 3 and 4).

Aspects related to exposure to noise

The questionnaire was completed and given back by 209 (65.3%) of the employees. In general there were not many queries that were given to

Table 2. Comparison between the averages of the minimum, medium and maximum values (in dB) obtained through measuring noise levels considering the moments with and without the presence of children.

Situation	minimum		maximum		average	
	with children	without children	with children	without children	with children	without children
Average	55.04	43.79	79.64	67.13	65.52	51.49
Median	55.0	43.0	81.7	68.0	67.2	50.9
Deviation from Standard	9.21	6.77	10.00	9.42	9.73	7.63
Min	33.5	29.6	46.2	46.0	38.8	37.5
Max	80.0	70.2	103.9	88.4	82.5	73.8
IC	0.88	1.08	0.96	1.51	0.93	1.22
Value of p	< 0.001*		< 0.001*		< 0.001*	

* statistically significant (ANOVA).

Table 3. Comparison between the averages of the minimum, medium and maximum values (in dB) obtained through measuring noise levels considering the different spaces in the institutions.

	Spaces	Average	Median	Deviation from Standard	Min	Max	IC	p-value
Minimum	ADM	48.51	48.8	6.51	34.7	65.4	1.37	<0.001*
	Rooms	49.00	46.7	10.66	29.6	80.0	1.52	
	External	52.95	54.1	8.25	34.6	69.2	2.05	
	Food	56.31	56.6	9.13	35.2	79.0	1.35	
	Support	53.79	51.8	10.74	36.5	79.7	2.81	
Maximum	ADM	73.22	74.3	9.00	46.1	92.7	1.89	<0.001*
	Rooms	73.39	73.0	13.44	46.0	101.7	1.92	
	External	78.18	79.2	10.11	53.6	95.2	2.52	
	Food	79.99	81.0	8.76	52.3	103.9	1.30	
	Support	77.68	80.1	10.99	46.5	102.8	2.88	
Average	ADM	57.68	57.1	7.73	37.5	77.6	1.62	<0.001*
	Rooms	58.64	54.3	12.72	38.0	82.5	1.81	
	External	62.74	65.7	9.73	40.2	81.0	2.42	
	Food	66.54	68.3	9.48	39.1	82.0	1.40	
	Support	63.01	64.1	10.18	40.6	81.9	2.67	

* statistically significant (ANOVA).

Key: ADM = administrative rooms, nurse's room, corridors; Room = internal spaces for groups of children, class rooms; External = external spaces such as parks, outside areas and gardens; Food = canteens and similar areas; Support = laundries, kitchens and areas where milk is produced.

Table 4. Comparison between the different spaces with reference to the minimum, medium and maximum values obtained through measuring noise levels.

	Spaces	ADM	Rooms	External	Food
Minimum	Rooms	0.997			
	External	0.052	0.045*		
	Food	<0.001*	<0.001*	0.100	
	Support	0.011*	0.008*	0.984	0.407
Maximum	Rooms	1.000			
	External	0.063	0.033*		
	Food	<0.001*	<0.001*	0.748	
	Support	0.120	0.077	1.000	0.639
Average	Rooms	0.934			
	External	0.045*	0.105		
	Food	<0.001*	<0.001*	0.088	
	Support	0.030*	0.070	1.000	0.183

* statistically significant (Tukey's multiple comparison test).

Key: ADM = administrative rooms, nurse's room, corridors; Room = internal spaces for groups of children, class rooms; External = external spaces such as parks, outside areas and gardens; Food = canteens and similar areas; Support = laundries, kitchens and areas where milk is produced.

the enquiry desk although some questions were left blank.

The majority of the employees noted that they had been exposed to high levels of noise in the work place (88.5%). Aside from this, many said that: they lived in noisy areas (40.7%), that they used head phones to listen to music (33.7%), that they watched television or listen to the radio with the volume at its highest point (22.6%) and that they practiced sport and/or leisure activities that involved exposure to noise (21.7%).

In relation to difficulties that they found at their work place owing to noise, they said that their main gripes were: the annoyance caused by loud sounds and problems with attention and concentration. Difficulties related to interactions and identifications of sounds were not noted by many people.

With reference to illnesses that they had: 31 (14.8%) said they suffered from systematic high blood pressure, 26 (12.4%) stated that they had gastro-intestinal problems and 18 (8.6%) referred to hormonal problems. The constant use of medication was mentioned by 99 people (47.4%).

The most frequent negative symptoms were: anxiety and headaches, irritability and/or nervousness and stress. Less mentioned symptoms were: depression and the feeling of having a constant ringing in the ears.

It was not possible to analyze any associations between SPL and the variables in the questionnaires as was hoped, on account of all of the institutions having presented levels that were above what was deemed as adequate.

Hearing Evaluations

All of the 209 employees that filled in and had given back the questionnaire were sent to have their hearing evaluated. Of those that were sent: 177 (84.7%) turned up to be examined, 141 (79.7%) presented normal results and 36 (20.3%) had results which differed from the norm. Those that had results which were outside of the parameters for being considered normal, were firstly informed of their results and then were referred to otolaryngological treatment and were advised on the need for ongoing audiological monitoring.

Amongst those with these poor results, 11 (31%) presented neurosensory bilateral losses for frequencies of 3, 4 or 6 kHz (Table 5).

We did not find an association between hearing loss and the following variables: complaints of exposure to noise, exposure to noise outside of schools, the occurrence of illnesses or negative symptoms.

Education in Health

In every institution a meeting was held with the coordinators in order for the results to be presented to them. The first measure that was proposed was for the results to be given to the

Table 5. Distribution of the types of losses in hearing found when the employees were examined.

Types of hearing losses	N	%
Unilateral and Neurosensory losses for the frequencies 3, 4, 6 and 8 kHz	15	42
Neurosensory and bilateral losses for the frequencies 3, 4 or 6 kHz	11	31
Conductive	4	11
Mixed	2	5
Others	4	11
Total	36	100

employees so that improvements could be made to increase their acoustic comfort. Thus meetings were scheduled with them to occur on a monthly basis. The following were the main proposals: gradually changing the kitchen and laundry appliances as they were both noisy and old, for more up to date equipment, changing daily routines principally in the lunchroom, changing practices in the use of the televisions and other devices in relation to their volume settings and improving the acoustic conditions of the floors, windows, walls and furniture. Other proposed measures included: making children aware of the value of silence and the effects of loud activities, placing limits on certain activities so that noise levels would not be excessive and making a kids sound traffic light which would help educators manage the noise levels in class rooms. Other measures were also proposed, all of which were called Sensorial Education[25].

Discussion

Just like other studies carried out in schools[6,10,19-21], the averages of the SPLs were above the acceptable values for these types of institutions. There was a difference of more than 10 dB for the average values and more than 20 dB for the maximum values. A discussion about the findings sparked off a deep analysis on aspects of the routines for the institutions that participated. The discussions were on the acoustic conditions of the buildings and their surroundings. The intention was to identify how best to improve the situation based on literature in this area[1,3]. Based on the results of this study a start was made on planning actions to be taken in order to reduce the level of noise in the institutions which would in turn minimize the impacts on health for the employees and children as well as the problems aligned with the process of teaching and learning. The idea was also to remove the negative communication situations that occur due to the excess of noise that was discovered in studies[2,4,6].

Even though in all of the institutions, high SPLs were identified, the highest were found in institutions 3, 8 and 10. These institutions are located on roads that have a high circulation of cars and people, which was different to the other institutions. External sounds join with internal noise producing an elevation of vocal intensity which includes sounds that come from devices such as radios and televisions. This is known as the Lombard effect[26]. Therefore these institutions will need solutions that involve acoustic isolation.

Where there was the presence of children, the SPLs were higher. The very young, entering school for the first time, have vocal exuberance which ought to be taken in consideration by managers. Aside from speaking loudly, they tend to laugh, shout and cry a lot during their interactions[27]. In children's education, playing is the guiding force for the majority of their activities, the implications of which, is the natural rise of noise in a given environment. Thus the number of children that occupy a given area should be considered, along with practices that raise children's awareness of the importance of silence, sounds, acoustic comfort and excessive sounds[25]. Apart from having many children in the institutions, the circulation of many people includes those that work in the kitchens, the canteens, and the laundries as part of their daily routine. Thus the proposal to obtain new appliances, change routines, modify the acoustics in class rooms and change the furniture is a promising. This is also the case for dedicated eating areas where noise is at its highest level. These areas are large and have a lot of movement with adults helping children whilst they eat. Noise comes from plates, cutlery and oven dishes. Again it is worth highlighting the benefits of investing in educational practices aim at reducing noise in these areas, allowing for moments of tranquility[25]. This is important because the children will, as a result, eat well and take pleasure in eating. It is also fundamental for their biopsychosocial development[28].

External spaces also presented high levels of noises. There is the most amount of noise interference from surrounding areas and play areas and there is a natural increase in vocal intensity. As these areas have little acoustic reverberation, the impact of higher SPL is less for children and

educators except in respect of the use of their voices[15].

The staff recognized the noises and were annoyed by them, which also was the case in other studies[29]. This could be a positive factor so that improvement practices for acoustic comfort can be brought in. Also these issues are not just pertinent to a person's place of work, but also cover a person's place of abode and their leisure and sporting practices.

Professionals in this area note that noise has an important impact on communicative situations where the process of learning can be adversely affected. This also includes negative cognitive effects for children[3,4,5]. The educators may also become tired and exhaustive during their working day. People can have difficulties being understood which will affect the activities that are done. This will also affect the ability to bring in conflict resolutions and the implementation of limits for children. A person's health can also be placed at risk due to communicative difficulties which could lead to dysphonia[15,29,30]. The exposure to noise and the related difficulties that present themselves can aggravate a person's anxiety and irritability and can cause nervous spells. It can also increase stress and headache periods. The aforementioned were frequently mentioned in other studies.

Aside from this, some educators stated that these health problems required medical monitoring particularly for high blood pressure, which has been related to exposure to noise. The following health problems can occur: physical problems related to the body, mental and social problems[31], interference with a person's quality of life and a reduction in the productivity of their work[18]. Actions that should be taken to help in the health of the employees are often not taken, which results in poor health for the children. Both employees and children need to be prioritized[32].

The number of hearing exams where problems were identified was worrying. It should be not that many had neurosensory bilateral hearing losses in the frequencies that are commonly related to hearing losses induced by noise (known as PAIR)[14,33]. PAIR is caused by high exposure to noise levels over 85 dB for eight hours per day. This typically occurs on a regular basis and goes on for the first five years[34]. It is generally considered irreversible. It is symmetrical and bilateral and occurs in the following frequencies: 3, 4 or 6 kHz[14]. In order for these findings to be well understood and later discussed, the back history of the employees with reference to their exposure to noise needed to be looked at. This is because their hearing losses did not relate to any of the aspects that were studied namely: complaints due to exposure to noise, exposure to noise outside of schools and the occurrence of illnesses or negative symptoms probably due to the occurrence of these complaints amongst staff in general. It is important to note that in three of the institutions that were studied, the body charged with the responsibility for health and safety in the work place, started to request audiometry medical examinations for their employees on a periodic basis, due to their concerns.

The data shows the need to empower the main people involved in this area so that actions can be taken together to develop and implement measure to improve noise levels, providing acoustic comfort and well-being in schools.

We can therefore conclude this study by affirming that the SPL in the institutions are above adequate and acceptable limits for all concerned parties. The employees noted the high noise levels and made reference to it impacting on their work and their health. Approximately 10% of the total of employees that were studied showed signs of losses in hearing. The process for searching for solutions is promising. In spite of this study being restricted to the institutions that were a part of the study, it can serve as a basis for other similar actions in this area.

This research was conducted at the Department of Physiotherapy, Communication Science & Disorders, Occupational Therapy. Faculty of Medicine. University of São Paulo.

Collaborations

Regarding the contribution of each author, ML Bitar was responsible for the conception and design of the study, contributed substantially to the analysis and interpretation of data, critical review of the content and approval of the final version of the manuscript; LF Calaço Sobrinho participated in the data collect, analysis and interpretation of data and writing of the article; M Simões-Zenari contributed to the planning of data collection for the analysis and interpretation of data, critical review and preparation of the final version of the manuscript.

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