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Identification of hearing disorders in preschool children

Identificação de alterações auditivas em crianças pré-escolares

Identificación de trastornos auditivos en niños en edad preescolar

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Abstract

Hearing health programs are predominantly aimed at children between 0 and 3 years of age or those older than 7. Children between these two age groups are not in any of these programs, but it is in this group that the most middle ear problems occur, and, it is in this group, possible to detect minimal, mild, or unilateral hearing loss that was not identified in neonatal hearing screening programs. **Objective:** To identify hearing alterations in preschool children through a hearing screening program. **Method:** This is a descriptive, cross-sectional, and observational study conducted in two municipal schools in the municipality of Mauá. The sample consisted of children aged five and six years. The hearing screening program was composed of a. otoscopy; b. tympanometry and, c. recording of transient otoacoustic emissions (TOAE) and distortion product (DPOAE). In view of the pandemic that began in March 2020, it was not possible to evaluate the three and four-year-old children. **Results**: 28.44% (n= 31) of the children failed otoscopy. Of the 78 (71.55%) children who underwent otoscopy, 30.8% failed tympanometry: 16.7% in Distortion Product Otoacoustic Emissions (DPOAE) and 19.2% in Transient Stimulus Otoacoustic Emissions (TPOAE); 30.76% (n= 24) of the children failed at least one of the three procedures. **Conclusion:** 30.76% of children at risk of hearing impairment were identified and should be referred for medical and audiological evaluation.

Keywords: Hearing; Child; Screening; Preschool.

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SBL: Article writing, data collection, methodology, study outline, review and reference checking.
TMMS: Study conception, data analysis, intellectual contribution to the writing of the manuscript and article review.

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Resumo

Programas de saúde auditiva estão voltados predominantemente para crianças entre 0 e 3 anos de idade ou para os maiores de 7. As crianças entre estas duas faixas etárias não estão em nenhum destes programas, porém é neste grupo que mais ocorrem problemas de orelha média, e, é, neste grupo, possível detectar as perdas auditivas mínimas, leves ou unilaterais que não foram identificadas nos programas de triagem auditiva neonatal. **Objetivo:** Identificar alterações auditivas em crianças pré-escolares por meio de um programa de triagem auditiva. **Método:** Trata-se de estudo descritivo, transversal e observacional realizado em duas escolas municipais do município de Mauá. A amostra foi composta por crianças de cinco e seis anos de idade. O programa de triagem auditiva foi composto: a. otoscopia; b. timpanometria, e c. registro das emissões otoacústicas transiente (EOAT) e produto de distorção (EOAPD). Em vista da pandemia iniciada em março de 2020, não foi possível avaliar as crianças de três e quatro anos. **Resultados:** 28,44% (n= 31) de crianças falharam na otoscopia. Das 78 (71,55%) crianças que passaram na otoscopia, 30,8% falharam na timpanometria; 16,7% nas Emissões Otoacústicas Produto de Distorção (DPOAE) e 19,2% nas Emissões Otoacústicas por estímulo Transiente (TPOAE); 30,76% (n= 24) das crianças falharam em pelo menos um dos três procedimentos. **Conclusão:** foram identificadas 30,76% de crianças com risco de alteração auditiva que devem ser encaminhadas para avaliação médica e audiológica.

Palavras-chave: Audição; Criança; Triagem; Pré-escolar.

Resumen

Los programas de salud auditiva están dirigidos principalmente a niños entre 0 y 3 años o mayores de 7 años. Los niños entre estos dos grupos de edad no están en ninguno de estos programas, pero es en este grupo que ocurren la mayoría de los problemas del oído medio, y, es en este grupo, posible detectar la pérdida de audición mínima, leve o unilateral que no se identificó en los programas de cribado auditivo neonatal. **Objetivo:** Identificar las alteraciones auditivas en niños en edad preescolar a través de un programa de detección auditiva. **Método:** Se trata de un estudio descriptivo, transversal y observacional realizado en dos colegios municipales del municipio de Mauá. La muestra estuvo constituida por niños de cinco y seis años y sus padres/tutores. El programa de detección de audición estuvo compuesto por: a. Cuestionario para padres/tutores sobre la historia de la salud auditiva de los niños; b. otoscopia; c. timpanometria y, d. Registro de emisiones otoacústicas transitorias (EOT) y producto de distorsión (DPOAE). Ante la pandemia que comenzó en marzo de 2020, no fue posible realizar los reexámenes ni evaluar a los niños de tres y cuatro años. **Resultados:** 28,44% (n= 31) de los niños no pasaron la otoscopia. De los 78 (71,55%) niños que se sometieron a otoscopia, 30,8% fallaron la timpanometria; 16,7% en emisiones otoacústicas de productos de distorsión (DPOAE) y 19,2% en emisiones otoacústicas de estímulo transitorio (TPOAE); 30,76% (n= 24) de los niños fallaron por lo menos uno de los tres procedimientos. **Conclusión:** 30,76% de los niños con riesgo de deficiencia auditiva fueron identificados y deben ser referidos para evaluación médica y audiológica.

Palabras clave: Audición; Niño; Detección; Preescolar.

Introduction

A child who is "learning" to interpret speech and language sounds needs to hear very accurately all the information or acoustic cues included in a message. Leek and Watson[1] reported that "children who have inadequate perception of speech messages or who confuse similar phonetic components in a word or sentence may have limitations in understanding these words or sentences as the volume of information increases".

When there is a hearing loss, the words are not clear and mix with the other sounds in the environment, making it very difficult to keep the attention on a particular speech, especially in noisy and reverberant environments.[2] Whether unilateral, mild or moderate, childhood hearing loss is a very wide-ranging problem with a significant impact on a child's life. According to Bess et al (2020)[3], children with unilateral hearing loss are at greater risk of hearing-related fatigue, and the degree of fatigue is similar to that experienced by children with bilateral hearing loss. Thus, hearing loss adversely affects the development of the auditory nervous system and may have negative impacts on the child's social, emotional, cognitive and learning aspects.[4]

The American Speech-Language Hearing Association (ASHA)[5] reported an average prevalence of hearing loss of 131 for every 1000 school-age children, while the World Health Organization (WHO) estimated in 2018 that 466 million people around the world have disabling hearing loss, representing 6.1% of the world's population, and including 34 million children.[6] Furthermore, in a new publication in 2019, the WHO reported that 60% of all cases of hearing loss in children are due to preventable causes.[7] In addition, epidemiological data show that the prevalence of hearing loss in children and adults in regions with low gross income in the country is twice the rate recorded in high income countries.[8] Hearing loss has also been described as the second most reported impairment in young children worldwide, mainly caused by otitis media.[9]

Findings from a survey conducted in Canada showed that less than 3.5% of Canadians aged between 3 and 19 years had conductive hearing loss. In this research, a lack of distortion product otoacoustic emissions was found in 7.1% of participants between 3 to 5 years of age, and in 3.4% of participants between 6 to 19 years of age. In addition, the authors found that 17.0% of participants eligible for hearing assessment had exudate, excess wax or impacted ear wax in one or both ears.[10]

Although some international authors report a prevalence of hearing alterations between 14.9%[11] and 23%[12] in school-age children, the national literature reports values ranging from 6.7%[13] to 16.84%[14]. Several studies also show a significant occurrence of mild hearing loss in children over 4 years of age.[13-14]

In this sense, Walker (2020)[15] held a forum on the effects of mild hearing loss including the following topics: progression of mild hearing loss in children; impact of mild or unilateral hearing loss on language, hearing, and cognitive skills; and expense and fatigue efforts in unilateral hearing loss. The author concluded that there is uncertainty about outcomes and treatment approaches for children with this condition, which leads to inconsistent interventions and increases the risk of typical development.

A study carried out in Kyrgyzstan with children between 7 and 13 years old found hearing loss in 27.2% of children, and 32.2% of children between 7-8 years old had unilateral and/or bilateral alterations.[16]

In turn, Lemajić-Komazec et al (2008)[17] conducted a prospective analysis of data from 70 children with suspected hearing loss, and found that 17 children had normal results or had mild hearing loss, 16 had moderate and severe hearing loss, and 37% had profound hearing loss. They also reported that 40% of 70 children underwent hearing assessment before 2 years of age and that 58% of these children had profound hearing loss, while 25% had moderate or severe hearing loss, and 17.64% had mild hearing loss. The authors found that the time between suspicion and confirmation of hearing loss ranged from 1.21 years (mild hearing loss) to 0.94 years (moderate and severe hearing loss) to 0.91 years (profound hearing loss).

In another study carried out in Malawi with 15,000 children, 2,903 children were suspected of having hearing loss and the most common degree of hearing loss was moderate, followed by mild and severe/profound.[18]

In Brazil, there are governmental programs in force for the early identification of hearing loss in newborns (Neonatal Hearing Screening Program), and for the care of students' hearing in the Health

in School Program (*Programa Saúde na Escola*, or PSE). On the one hand, the Guidelines for Attention for Neonatal Hearing Screening recommend the auditory monitoring of children who fail the ear test and/or who have any Risk Indicators for Hearing Loss (RIHL) up to 3 years of age.[19] On the other hand, the Health in School Program recommends that children over 6 years old must undergo hearing assessment, but this is not mandatory.[20] So what happens to the gap of children between three and six years old? Although this age group has a high prevalence of middle ear problems, in addition to cases of progressive onset hearing loss caused by infectious diseases caused by maternal-infant transmission,[19-20] there are no specific hearing health programs for this age group.

There are no actions aimed at preschool children, aged between 3 and 6 years, which allow for the identification of hearing disorders in this period of time between the nursery and school. Olusanya et al [21] ranked the ten countries with the most specific developmental problems in children under 5 years of age, and Brazil ranks ninth in this ranking in relation to hearing loss.

As this period between one screening and another is crucial for academic and language development, there is a huge issue with this finding. Delays in the identification of a hearing disorder, whether it is a transitory or permanent problem, in the language acquisition phase, cause damage to the child's socialization, emotional development, school learning, and communication, which may have consequences until adulthood.

In this sense, the identification of hearing alterations of any type or degree in preschool children is essential to provide adequate care for these children's needs, whether medical, educational or rehabilitation care. There are many programs for identifying hearing loss in children that have already been developed and are in place. Some of these programs are based on questionnaires applied to parents and/or teachers, while others use musical instruments as a way to assess hearing, and others propose the use of audiometric screening alone or in combination with tympanometry.

With the advancement of audiological assessment instruments, the recording of otoacoustic emissions was also included in these programs.

The identification of permanent or transient hearing loss of any type or degree, between 3 and 6 years old, is very relevant when considering the importance of preventing the implications that even an undetected mild hearing loss can represent for these children. The implementation of programs aimed at identifying hearing alterations, especially in developing countries, can allow for the early diagnosis and intervention necessary for each case.[22]

The combined use of Transient Otoacoustic Emissions and/or Distortion Product Otoacoustic Emissions tests, in addition to otoscopy and tympanometry, has been reported as a widely used method in student screening, due to the agility in the tests and its non-invasive nature.[23-24]

Given the need to identify hearing alterations, external auditory canal obstruction, middle ear diseases, and mild or unilateral hearing loss in children between 3 and 6 years of age, this study aimed to apply a hearing screening program to analyze the occurrence of hearing alterations in young children.

Material and methods

This is a cross-sectional, descriptive and observational study, carried out in two public schools located in Mauá (SP, Brazil) that are linked to the Health in School Program (PSE).

The case study of this study consisted of 109 preschool children, aged between 5 and 6 years, regularly enrolled in the selected educational institutions. Due to the determination of the State Government to close schools as of March 2020 due to the COVID-19 pandemic, it was not possible to apply the hearing screening program to children aged 3 and 4 years old. The inclusion criteria were as follows: being enrolled in the last preschool year and presenting the Informed Consent Form (ICF) signed by a guardian. In turn, participants who had a previous diagnosis of hearing loss were excluded from the sample.

The ICF was provided during the parent-teacher meeting, and parents who were unable to attend the meeting received the ICF along with student materials.

The hearing screening was carried out in two different acoustic conditions and, as such, the schools were named as follows: School A, in which the hearing screening was carried out in a quiet room, where noise was maintained at an average of 60-65 dB, being controlled through a mobile device application, *Decibelímetro* (a sound level meter); and School B, in which the screening procedures were carried out in a portable audiometric booth

provided by the researcher. In order to determine whether the results obtained had a statistically significant difference, the children's data were subjected to statistical analysis that showed no statistically significant differences.

All children underwent four audiological procedures: 1. Otoscopy - Inspection of the external auditory canal using a Mikatos Led Mini Otoscope, Registered at ANVISA under No. 80218930006. The results allowed distributing the children into two groups: Failed - This result was attributed to children who had partial and/or total obstruction in one or both ears. Passed - This result was attributed to children who had no obstruction in the external auditory canals in both ears. Children who Failed the test were referred for removal of earwax at the local Primary Health Unit, but were not removed from the study. 2. Tympanometry - In order to analyze and interpret tympanometric curves using the classification proposed by Jerger[25]. All students who obtained type A curves were classified as "passed". In turn, children who had type B, C, AD and AS curves in one or both ears were classified as "failed". 3. Recording of Distortion Product Otoacoustic Emissions (DPOAE) for the frequencies of 2000, 3000, 4000 and 5000 Hz; and 4. Recording of Transient Otoacoustic Emissions (TOAE) for the frequencies of 1000, 1500, 2000, 3000 and 4000 Hz. Tympanometry, DPOAE and TOAE tests were performed using Interacoustics TITAN portable automatic equipment.

The pass/fail criteria adopted for the evaluation of otoacoustic emissions were based on the manufacturer's recommendations for evaluating both Transient and Distortion Product Otoacoustic Emissions records. In TOAE, amplitude values equal to or greater than -12 dB and a signal-to-noise ratio equal to or greater than 5 dB in at least three or more of the frequencies tested were classified as "passed". In turn, DPOAE tests required amplitude values equal to or greater than -5 dB and a signal-to-noise ratio equal to or greater than 6 dB in at least three or more of the frequencies tested to classify a result as "passed".

All children who failed the Tympanometry, Distortion Product Otoacoustic Emissions and/or Transient Otoacoustic Emissions tests, in one or both ears, underwent a retest that was performed in the week after the tests. If the failure was found in the retest, the children were referred to their local Primary Health Unit for audiological diagnosis.

Data analysis was performed through the preparation of contingency tables, and the application of Chi-Squared tests for homogeneity and independence. The study adopted a significance level of 5% for each test.

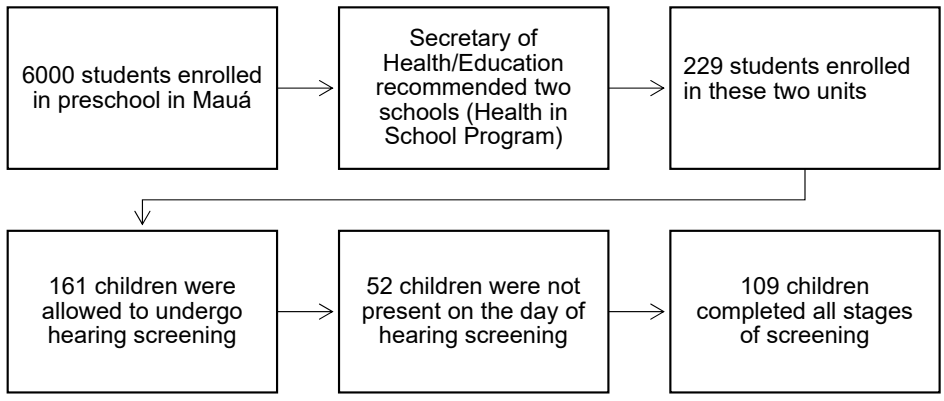

Figure 1. Flowchart of the sample of children included in this study

Results

The Chi-Squared test for homogeneity was applied in order to verify whether the frequency distributions of the variables age, gender, otoscopy, impedance, DPOAE and TOAE differed between the two schools. Tables 1 to 6 show that there is no evidence that the frequency distributions of all variables differ between the two schools (p-values>0.05).

Table 1. Age frequency distribution by School (% calculated by school)

School	Age				Total	
	5 years		6 years			
	N	%	n	%	N	%
A	31	55.4	25	44.6	56	100.0
B	28	52.8	25	47.2	53	100.0
p-value=0.791						

Table 2. Gender frequency distribution by School (% calculated by school)

School	Gender				Total	
	Female		Male			
	n	%	n	%	N	%
A	31	55.4	25	44.6	56	100.0
B	25	47.2	28	52.8	53	100.0
p-value=0.393						

Table 3. Analysis of the distribution of children in relation to the result obtained in the otoscopy procedure according to pass/fail criteria

Otoscopy with no obstruction	Otoscopy with obstruction	
71.55% (n=78)	31 (28.44%)	28.44% (n=31)

Table 4. Analysis of the association between the results found in the otoscopy and in the tympanometry. All children who participated in the study were included (n=109)

Otoscopy	Tympanometry				p-value
	Failed		Passed		
	N	%	N	%	
With no obstruction (n=78)	24	30.8	54	69.2	0.859
With obstruction (n=31)	9	29.0	22	71.0	

Table 5. Joint frequency distribution between Otoscopy and Distortion product otoacoustic emissions (DPOAE)

Otoscopy	DPOAE				p-value
	Failed		Passed		
	N	%	n	%	
With no obstruction (n=78)	13	16.7	65	83.3	0.275
With obstruction (n=31)	8	25.8	23	74.2	

Table 6. Joint frequency distribution between Otoscopy and Transient otoacoustic emissions (TOAE)

Otoscopy	TOAE				p-value
	Failed		Passed		
	N	%	N	%	
With no obstruction (n=78)	15	19.2	63	80.8	0,694
With obstruction (n=31)	7	22.6	24	77.4	

Table 7. Distribution of otoscopy results and failure in one, two or three procedures

Otoscopy	Failure in all three procedures		Failure in two procedures		Failure in one procedure		Total	
	N	%	N	%	N	%	N	%
Passed (n=78)	10	12.82	3	3.84	11	14.10	24	30.76
Failed (n=31)	4	12.90	4	12.90	2	6.45	10	32.25

Discussion

As in the researched literature, of the 109 children included in the sample of this study, 56 (51.4%) were female and 51 (48.6%) were male.[18] Regarding age, 59 (54.1%) participants were 5 years old and 50 (45.9%) participants were 6 years old.

Data analysis showed that 78.9% (n=78) of the subjects passed the otoscopy, and 28.44% (n=31) had some degree of obstruction in the external auditory canal. Since this study aimed to identify hearing impairment in all children, all 109 participants performed the three procedures, namely: tympanometry, DPOAE and TOAE. Although the percentage of children who failed otoscopy is similar to the percentage reported in another study,[23] this result is not in line with the studies by Olusanya. Okolo, Ijaduola (2000) [26] who found total obstruction by impacted earwax in 52.6% of children evaluated. On the other hand, Feder et al (2017) found 17.0% of individuals with excess wax, exudate or impacted wax in a sample with 2,575 subjects between 3 and 19 years old, and this value was 19.9% in the group between 3 and 5 years.[10]

As shown in Tables 4, 5, and 6, no association was found between otoscopy and the other three tests (p-values>0.05). Both for children who had partial or total obstruction at otoscopy, and for children who had no obstruction, the percentage of children who passed each of the three tests is close to, and equal to, or greater than 69.2%. The results of the association analysis between the results of tympanometry and otoscopy found no statistically significant difference between the two groups. Simple otoscopy has been shown to be successful in providing an accurate diagnosis when signs of effusion are clear, such as the presence of fluid-filled blisters behind the tympanic membrane.[27] The investigators did not find studies determining the impossibility of performing tympanometry when there is partial or total obstruction of the external auditory canal. Factors such as the examiner's training, the angle and the quality of illumination can affect the visualization of the external auditory canal and reduce the sensitivity of this test. Thus, otoscopy should not be used as the only test to determine which children need to be referred for a more complete evaluation.

After the analysis did not find a statistically significant difference between the findings of children from School A and School B, the records of children in the otoacoustic emissions tests were analyzed together.

When analyzing the association between the results found in otoscopy and distortion product otoacoustic emissions (DPOAE), it was found that there is no statistically significant difference between failure in otoscopy and failure in DPOAE (p=0.275). However, it should be noted that children with external auditory canal obstruction had a slightly higher failure rate than children without any reported obstruction. When comparing these data with the values obtained in the otoscopy analysis and the responses in transient otoacoustic emissions, it can be concluded that the percentage of failure is very similar between the two groups.

These data are very relevant from a clinical point of view, as they suggest that the other procedures (tympanometry and recording of otoacoustic emissions) should be applied regardless of the result obtained in the otoscopy. Studies carried out with groups of adolescents with a history of previous otitis media showed little difference in the TOAE and DPOAE records when compared with individuals without a history of otitis media.[28] In this study, we found a 16.7% failure rate for DPOAE and a 19.2% failure rate for TOAE.

The percentage of children who failed the tympanometry test represents a higher number compared to those children who failed the emission test, as shown by other studies.[29] The Tympanometry test in the hearing screening of students proves to be an important tool in the identification of middle ear alterations when linked to the Otoacoustic Emissions test, as recommended by the American Academy of Audiology. [3]

It should be noted that all children who failed screening were male and these findings are in line with data found in the literature reporting a higher prevalence of failure in males.[12, 23] In turn, this study found a failure rate of 30.76% in this preschool Hearing Screening program, which is a value above the rates reported in the literature.[10,14,23] As also reported by other previous studies, this study found a higher failure rate in the left ear.[14, 25]

In this study, 3 subjects who had failed the test procedure passed the retest one week later and had a normal result.

However, limitations of this study included the impossibility of performing the retest and complete audiological assessment in all children due to the onset of the COVID-19 pandemic, which resulted in the closing of schools. Finally, there was a sample loss during data collection of 51 children who attended the test but did not attend the retest, or whose parents consented to participate, but the children did not attend on the day of some stage of the tests.

Conclusion

After analyzing the results, it was possible to notice that 30.76% of the children failed in any of the three procedures applied and, as such, were referred to the local Primary Health Units with hearing impairments.

The analysis of the results of the procedures showed the following failure rates: a) Otoscopy, 28.44% (n=31); b) Tympanometry, 30.8% (24); c) In DPOAE, 16.7% (13); and d) In TPOAE, 19.2% (15).

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