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ORIGINAL ARTICLE

Passive smoking and hearing loss in preschoolers and school-aged children: a case-control study.

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Abstract

Introduction: Nonsmoking individuals who live with indoor smokers are included among those at higher risk of hearing loss, as the inner ear is sensitive to systemic changes, especially vascular ones. **Objective:** To investigate whether there is an association between passive smoking and hearing loss in preschoolers and school-aged children. **Method:** retrospective, descriptive, case control study, comprising 76 children between 2 and 10 years of age, who underwent audiometric assessment between January 2016 and December 2018. The included children were divided into two groups: passively exposed to tobacco and not exposed to tobacco. The association between exposure or not to tobacco and type of hearing loss was evaluated using Fishers exact test, and the odds ratio of hearing loss in exposed children was calculated. **Results:** Children exposed to smoking had fourfold odds of hearing loss compared to their non-exposed peers (OR 4.2, 95%CI 1.584 to 11.138). A significant association was also observed between exposure to smoking and sensorineural hearing loss (OR 5.60, 95%CI 1.783 to 17.591, p=0.002). No association was found between severity of exposure and intensity of hearing loss. **Conclusion:** This study suggest that sensorineural hearing loss occurs more frequently in children exposed to smoking then in their age-matched peers not so exposed. However, we cannot state conclusively whether there is an association between passive smoke exposure and conductive hearing loss, nor between the degree of hearing loss and the level of exposure to nicotine as assessed by the Fagerström test.

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INTRODUCTION

Nonsmoking individuals who live with indoor smokers[1] are included among those at higher risk of hearing loss, as the inner ear is a structure very sensitive to systemic abnormalities, especially vascular, metabolic, and autoimmune changes[2,3].

The present study was designed to investigate whether there is an association between passive smoking and hearing loss in preschoolers and school-aged children.

MATERIAL AND METHODS

This retrospective, descriptive, case-control study was carried out at "Associação de Pais e Amigos dos Deficientes Auditivos" (APADA) from January 2016 to December 2018. The study population comprised children aged 2 to 10 years who underwent audiometric evaluation (Beta 6000®, Beta Medical and Electronic Devices LTDs). All examinations were performed by a single operator (a specialized pediatric audiologist). APADA is a registered charity, affiliated with the Brazilian Unified Health System, which helps approximately 700 children with hearing loss each year, providing occupational therapy, speech therapy, audiology, social care, and otolaryngology services.

A passive smoker is defined as a nonsmoking individual who lives with one or more indoor smokers[1].

Each child's severity of exposure to smoking was identified by their parents' degree of nicotine dependence, as measured by the Fagerström test score (4). This test is a screening instrument for physical dependence[4]. Dependence was classified as low to moderate (scores 0 to 4), moderate (scores 5 to 7), or high (scores 8 to 10).

The audiometric evaluation classified hearing loss as: conductive, when the outer and/or middle ears were affected; sensorineural, when the inner ear (auditory nerve and/or cochlea) was affected; and mixed when there was concomitant presence of sensorineural (SHL) and conductive hearing loss (CHL)[5].

All children who had risk factors for neonatal and/or post-neonatal hearing loss according to the Joint Committee on Infant Hearing[6] were excluded from the study.

The included children were divided into two groups: passively exposed to tobacco (PET), forming the case group, and not exposed to tobacco (NET), forming the control group. The PET group consisted of children who underwent hearing assessment and were passive smokers. The NET group was formed by children who underwent hearing assessment, but whose parents were nonsmokers.

The study variables collected from parents were duration of smoking time and severity of nicotine dependence as measured by the Fagerström scale, while the only variables collected from children were age, sex, and type of hearing loss,

Once the research project had been approved by the relevant ethics committee (CEP-FacMed-UFF, CAAE: 66917.4.0000.5243, n. 2.080.907), data collection was begun. All data were entered into a Microsoft Excel® spreadsheet.

Age-related data were summarized in both study groups, computed and presented as means and standard deviations (mean ± SD). These were compared using Student's t-test after the assumption of normality of data distribution had been confirmed by the Kolmogorov–Smirnov test. Data on the sex of participants were presented as frequencies.

To evaluate the association between exposure to passive smoking and abnormal audiometry findings, Fisher's exact test was used. When significant, odds ratios (OR) between tobacco exposure and the occurrence of hearing impairment were calculated. Statistical calculations were performed in MedCalc® version 20.006 (64-bit) (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2021)[7].

RESULTS

Among the 76 children included in the study, 35 were female and 41 were male, with a mean (SD) age of 6.6 (±2.17) years and 6.6 (±1.79) years, respectively (p>0.05). There were 35 (46.1%) in the PET group and 41 (53.9%) children in the NET group (p=0.5007), demonstrating sample homogeneity.

Using Fagerström test scores of parental nicotine dependence as a surrogate measure of the degree of exposure to smoking, we found that 41 children (54%) were not exposed, 12 (15.8%) were mildly exposed, 14 (18.4%) were moderately exposed and 9 (11.8%) were highly exposed.

Of the 76 children observed overall, 45 (59.2%) had no hearing loss and 31 (40.8%) had evidence of hearing loss. Table 1 summarizes the joint distribution of the two variables.

The odds ratio (OR) of hearing loss in the PET group compared to the NET group was 4.2 (95% CI: 1.58 to 11,14), indicating that passive exposure to tobacco smoking meets the requirements to be classified as a risk factor for hearing loss in children.

Regarding the type of hearing loss, none of the children included in the sample presented with *mixed hearing loss*. The distribution of hearing loss in the 31 children in whom it was detected is shown in Table 2.

Considering the dichotomous outcome observed for type of hearing loss, the binomial test was used to evaluate the hypothesis that the proportions of both categories could be considered homogeneous, i.e., that there was no statistically significant difference in the proportions of cases between the two categories of hearing loss sensorineural (S and conductive), at the 5% significance level ($\alpha = 0.05$). Fisher's exact test indicated a statistically significant association (p=0.002) between the degree of exposure to smoking and SHL. There was no association between the degree of exposure to smoking and CHL (p=1.000) (Table 3).

We also calculated the odds ratio (OR) of sensorineural hearing loss occurring between the PET and

Table 1: Joint distribution of children according to passive tobacco exposure and hearing loss.

Exposure to passive smoking	Hearing loss		Overall
	Yes	Não	
PET	21 (67.7%)	15 (33.3%)	36 (47.4%)
NET	10 (32.3%)	30 (66.7%)	40 (52.6%)
Overall	31 (100.0%)	45 (100.0%)	76 (100.0%)

OR = 4.2 (IC 95%: 1.58 a 11,14) p = 0,0039

Table 2. Children with hearing loss, stratified by type.

Children with hearing loss	Children with hearing loss	
	n	%
Sensorineural	21	67.7
Conductive	10	32.3
Overall	31	100.0

Table 3. Association among children exposed to passive smoking, SHL and CHL

Exposure to passive smoking	SHL*		CHL**	
	Yes	No	Yes	No
PET	16 (21.1%)	20 (26.3%)	5 (6.6%)	31 (40.8%)
NET	5 (6.6%)	35 (46.1%)	5 (6.6%)	35 (46.1%)

*SHL (p=0.002) OR = 5.60 (95% CI: 1.783 to 17.591) p = 0,0032
**CHL (p= 1.000)

Table 4. Association among severity of exposure to smoking, SHL and CHL.

Severity of exposure to tobacco	SHL*		CHL**	
	Yes	No	Yes	No
Mild	4 (11.1)	8 (22.2)	3 (8.3)	9 (25.0)
Moderate	8 (22.2)	7 (19.4)	1 (2.8)	14 (38.9)
Severe	4 (11.1)	5 (13.9)	1 (2.8)	8 (22.2)

*SHL ($\chi2$ = 1.119 p=0.637). **CHL ($\chi2$ = 1.847 p=0.410)

NET groups. The odds of sensorineural hearing loss among children exposed to tobacco were approximately five and a half times greater than among those not exposed to tobacco: OR = 5.60 (95% CI: 1.783 to 17.591).

Neither SHL nor CHL was associated with the severity of exposure (χ^2 = 1.119; p=0.637 and χ^2 = 1.847; p=0.410, respectively) (Table 4).

DISCUSSION

In recent years, some studies[8-11] have evaluated the association between tobacco exposure and the risk of hearing loss in smokers, but few have addressed the relationship between passive smoking and hearing loss in children[12-15]. In the present study, we analyzed the results of audiometric tests performed in children 2-10 years of age, exposed or unexposed to passive smoking, and assessed their degree of exposure by applying the Fagerström scale to parents or guardians. Other studies have assessed the correlation between hearing loss and passive smoking, but major differences from ours must be noted. Lalwani et al. (2011)[14], in a study of adolescents between 12 and 19 years of age, analyzed exposure to smoking through a review of medical records and measurement of cotinine levels (with serum levels between 0.05 ng/mL and 3 ng/mL considered indicative of passive smoking) and correlated these findings with audiometric tests. They concluded that passive smokers had an increased risk of developing low-frequency hearing loss. Other studies[15,16] have had children as their target population. Durante et al. (2013)[16], in a study of Brazilian schoolchildren, evaluated urinary nicotine levels and otoacoustic emissions as a measure of cochlear physiology. The authors found lower response levels in those exposed to smoke, especially at 2.8-kHz frequencies, suggesting that, in this group of children exposed to passive smoking, changes in cochlear physiology could increase the future risk of hearing loss. Considering that the mixed type of hearing loss did not occur in the studied sample, the study focused on the other two types (sensorineural and conductive). Talaat et al. (2014)[15], in a study of children aged 5 to 11 years, analyzed the relationship between passive smoking and sensorineural hearing loss and

found that all children had minimal sensorineural hearing loss. Experimental studies have shown that exposure to nicotine can decrease the function of cortical nicotinic acetylcholine receptors, leading to lower latency in stimulus detection and changes in the responsiveness of acetylcholine pathways in the cerebral cortex[17,18]. It can also interfere with the development of the auditory cortex through overstimulation of glutamatergic synapses[19]. In addition, passive smoking increases the risk of common respiratory infections, such as acute otitis media, which can lead to hearing loss[20,21]. In our study, we found a positive association between passive smoking and sensorineural hearing loss. The higher probability (0.677) of sensorineural hearing loss in relation to conductive hearing loss (0.323) observed (see Table 2) is attributable to the small sample size, considering that the binomial test did not show a statistically significant difference between the two.

This association is biologically plausible, as nicotine has a direct ototoxic effect on the outer hair cells, as well as inducing vasospasm and arteriosclerosis in cochlear blood vessels[13]. Both the direct ototoxic effect of nicotine and the induction of cochlear ischemia through the production of carboxyhemoglobin[22], vasospasm, increased blood viscosity, and arteriosclerosis seem to interact with other ototoxic exposures (such as noise and a variety of chemicals), leading to synergistic adverse effects on the auditory system[23,24]. Although noise exposure is a contributing factor to hearing loss, we did not include it in our analysis. We conclude that the findings of this study suggest that sensorineural hearing loss occurs more frequently in children exposed to smoking than in their age-matched peers not so exposed. However, we cannot state conclusively whether there is an association between passive smoke exposure and conductive hearing loss, nor between the degree of hearing loss and the level of exposure to nicotine as assessed by the Fagerström test.

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