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Original articles

Dysphonia, arterial hypertension, diabetes mellitus, thyroid diseases, and noise complaints as probable factors associated with hearing loss among teachers

Caroline Luiz Meneses-Barriviera[1]
https://orcid.org/0000-0001-8135-545X

Ana Carolina Marcotti Dias[1]
https://orcid.org/0000-0001-7503-7850

Rodrigo Antonio Carvalho Andraus[1]
https://orcid.org/0000-0002-3849-0872

Luciana Lozza de Moraes Marchiori[1,2]
https://orcid.org/0000-0002-9026-0468

[1] Universidade Estadual de Londrina - UEL, Universidade Norte do Paraná - UNOPAR, Programa de Pós-Graduação Stricto Sensu em Ciências da Reabilitação, Londrina, Paraná, Brasil.

[2] Universidade Cesumar - UniCesumar, Maringá, Paraná, Brasil.

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Corresponding address:
Ana Carolina Marcotti Dias
Rua Paris, 675
CEP: 86041-120 - Londrina - Paraná
E-mail: acmarcotti@hotmail.com

ABSTRACT

Objective: to verify a possible association between hearing loss and dysphonia, arterial hypertension, diabetes mellitus, thyroid diseases, and noise complaints.

Methods: a cross-sectional study involving 60 teachers, mean age 47.05 years. Pure-tone threshold audiometry was used to assess hearing, the voice questionnaire and voice acoustic evaluation were used for voice perception and quality, and the standardized questionnaire verified noise complaint and comorbidities. The statistical analysis was conducted with Mann-Whitney and Fisher's exact tests and multivariate linear regression.

Results: there was a significant association between hearing loss and diabetes mellitus, hypertension, and thyroid disease (both $p < 0.0001$), but there was no association between noise complaints and hearing loss in this population. The regression showed that dysphonia ($p = 0.0311$) and diabetes mellitus ($p = 0.0302$) are independent risk factors for hearing loss. A correlation was found between hearing loss and voice characteristics: roughness, breathiness, tension, and resonance.

Conclusion: this study showed that hypertension and thyroid diseases are factors associated with hearing loss. In addition, dysphonia and diabetes mellitus are independent factors associated with hearing loss in teachers. These results show the need for policies aimed at promoting teachers' health.

Keywords: Hearing Loss; Dysphonia; Diabetes Mellitus; Hypertension; Thyroid; Teacher

INTRODUCTION

The teaching career is distinguished from all other activities in its nature and social value. The teacher has a complex function, considering that each student has unique characteristics and peculiar needs. As knowledge grows and the world is transformed through technological innovations and globalized communication, difficulties accumulate for teachers who need to adapt to new demands to promote the learning of their students[1].

Currently, the teacher's role has gone beyond mediating the student's knowledge acquisition process, which used to be commonly expected. This professional's mission, in addition to that of classroom, was expanded to ensure a connection between the school and the community. The teacher, besides teaching, must participate in school management and planning, which means a more intense dedication, extending to families and community. The study of the relationship between the teaching work process, the real conditions in which it is developed, and possible physical and mental illnesses constitute a challenge, highlighting the need to understand the teachers' health-illness process, and to seek new associations[2-4].

Although teachers often report discomfort due to excessive classroom noise, as well as hearing symptoms, noise level measurements are not routinely performed[5]. Also, these professionals are frequently affected by hypertension – a multifactorial clinical condition, characterized by high and sustained blood pressure levels, often associated with functional and/or structural changes. Diabetes Mellitus (DM), which is also common in this population, is a heterogeneous group of metabolic disorders characterized by hyperglycemia, which in turn results from defects in cell receptors or insulin secretion, or both[6]. Thyroid diseases are common in the context of primary health care and are among the 25 conditions most commonly diagnosed by family doctors. Of these, primary hypothyroidism is the main thyroid hormone dysfunction, characterized by decreased thyroid hormone production and secretion[7,8]. Some studies have demonstrated an association between hearing loss, environmental noise, and metabolic, circulatory, and hormonal comorbidities, such as hypertension, DM, and thyroid diseases. However, there is a scarcity of studies that address this issue in relation to teachers[9-12].

Studies have shown, though, that teachers are at a high risk of developing dysphonia and presenting negative vocal signals to a greater or lesser degree. This change may be related to hearing and environmental noise, since the signal-to-noise ratio is inadequate in most classrooms[13-18].

Given the above, this study aimed to verify a possible association between hearing loss and dysphonia, hypertension, DM, thyroid diseases, and noise complaints in teachers.

METHODS

A cross-sectional study whose convenience sample was selected from an interdisciplinary project, called *Pró-Mestre*. It aimed to verify the relationships between the public-school teachers' health status and lifestyle and relate them to aspects of their work process. It was developed at the *Universidade Estadual de Londrina* and *Universidade Norte do Paraná*, Brazil, after approval by the Research Ethics Committee of the *Universidade Estadual de Londrina*, Paraná, Brazil, under evaluation report number 742.355. Additional information is available at http://www.uel.br/projetos/promestre/.

The evaluations of this broad research project took place in three stages, the present study being part of the third one. The flowchart regarding the process of forming teacher samples for the study and their respective particularities are shown in Figure 1.

The third stage of the study had 427 teachers selected in the follow-up study. Of these, 341 considered the possibility of continuing with the evaluations within the project. Thus, between September 2015 and June 2017, they were invited to participate in hearing and voice assessments, in addition to factors related to comorbidities such as metabolic and circulatory changes and lifestyle.

As inclusion criteria, all public elementary, middle, and high school classroom teachers working in the municipality, of both sexes, aged 18 to 60 years, working in the classroom and responsible for a subject for more than 12 months, who had not been out of their duties for more than 30 days in the previous 12 months, who performed pure-tone audiometry and voice assessment, answered the comorbidity questionnaire and signed the informed consent form were selected. Those who had undergone previous thyroid or laryngeal surgery, or were older than 60 years were excluded from the study.

It was not possible to include three teachers, as they lived in other regions, two that retired, 11 that were away from work, three that did not attend after scheduling for the third time, 57 that had no time available to participate, 42 that were not interested in participating

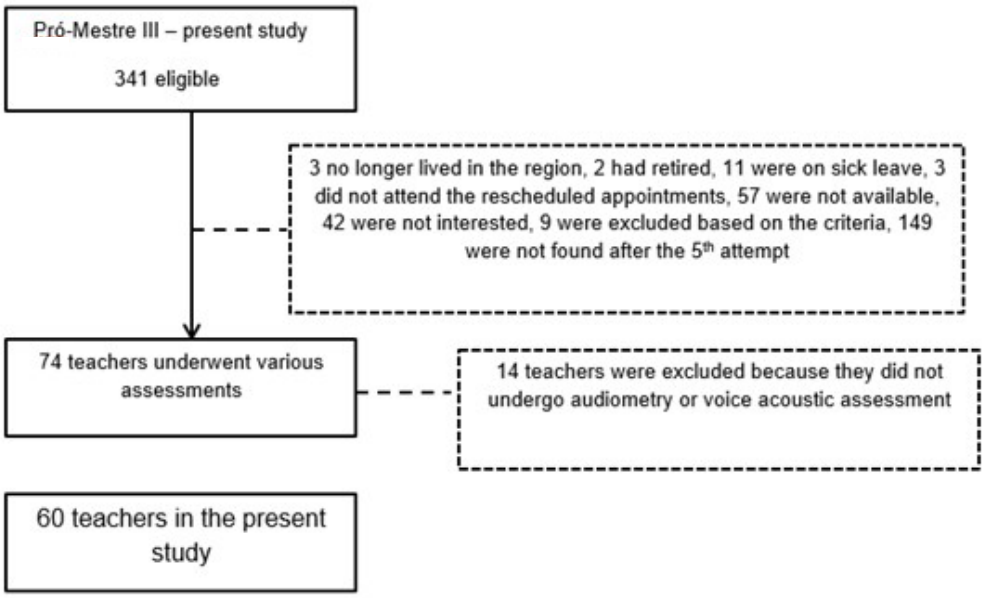

Figure 1. Sample of teachers in *Pró-Mestre* III – Present Study

in all assessments, 140 that were not found after the fifth attempt, nine by exclusion criteria, and 14 that were excluded for not participating in the audiological or voice assessment.

The audiological anamnesis (including a question regarding the complaint of working in a noisy environment) was carried out by the researcher[6] to investigate the hearing loss. Also, otoscopy was performed to measure the external auditory canal and tympanic membrane. The pure-tone threshold audiometry (considered the gold standard for assessing hearing thresholds in adults) was conducted in a sound booth, at frequencies from 250 to 8000Hz. The pure tones were presented, initially using 30 dB HL at 1000 Hz, to exclude those with hearing loss. It was entered into the database with the Winaudio program to be stored and printed to the patient. As for classification, individuals without hearing loss had a mean up to 25 dB, and those with hearing loss had a three-frequency mean above 26 dB[9]. The means of I and II were considered, in which the frequencies of 500 Hz, 1 kHz, and 2 kHz were used for frequencies I and II, those of 4 kHz, 6 kHz, and 8 kHz for the mean II[9], as occupational hearing loss usually starts at high frequencies. Hypertension, DM, and thyroid diseases were also verified during anamnesis.

The voice assessment diagnostic research consisted of the voice anamnesis proposed by Behlau[19] and voice recording-based on the CAPE-V protocol[19,20], with psychoacoustic voice analysis performed by a trained and skilled researcher, in a silent room. It was recorded and analyzed with VoxMetria 4.0 software. Then, the acoustic and auditory-perceptual analysis was performed, with emphasis on the analysis of characteristics (roughness, breathiness, tension, loudness, and vocal resonance), with an operating system for VoxMetria 4.0 and a portable computer equipped with an omnidirectional stereo microphone. The research participants performed the voice tests in a standing position, in a quiet environment, with the microphone at a 90º directional pickup angle.

Statistical analysis was performed using the IBM SPSS program (version 20 for Windows). The parametric data distribution was verified with the D'agostino-Pearson test, using Fisher's exact test and Mann-Whitney test for independent samples. To compare the performance means between the groups, $p < 0.05$ was used. To investigate the independent risk factors for hearing loss, the multivariate linear regression test was used with the following variables: voice, DM, hypertension, thyroid disease, noise, age, and sex. For the dependent variable – hearing loss – mean I was used and then hearing mean II.

RESULTS

Of the 60 teachers who attended all the assessments, 24 (40%) were men, and 36 (60%), women. The mean age was 47.05 years. The presence of hearing loss was observed in 28.33% of the individuals; 42 (70%) presented dysphonia according to the CAPE-V

protocol, while 18 (30%) did not; 15 (25%) of the research participants had hypertension and 45 (75%) did not; nine (15%) had thyroid changes and 51 (85%) did not; six (10%) had DM and 54 (90%) did not. Of the 17 participants with hearing loss based on mean I, 52.94% had hypertension, 35.29% had thyroid disorders, and 29.41% had DM. Of the 43 participants with normal hearing thresholds, 13.95% had arterial hypertension, 6.97% had thyroid disorders, and 2.32%, DM.

A total of 35.71% of the dysphonic participants, as well as 11.11% of the euphonic participants, presented hearing loss based on mean I. Of the participants with hearing loss, all presented changes in resonance, which was also presented by 81.39% of the 43 participants with normal hearing thresholds. A total of 35.71% of dysphonic participants, as well as 11.11% of euphonic participants, had hearing loss. Of the participants with hearing loss, all presented changes in resonance, which was also presented by 81.39% of the 43 participants with normal hearing thresholds.

The statistical analysis showed that hypertension, DM, thyroid disease, and dysphonia correlated with hearing loss in both the dichotomous analysis (Table 1) and the auditory means I and II (Table 2). Table 2 also shows the results between dysphonia and auditory means I and II in both ears, as well as between auditory mean and voice characteristics (roughness, breathiness, tension, loudness, and vocal resonance).

Table 1. Association between hearing loss and comorbidities

		HEARING LOSS			
		YES	%	NO	%
HYPERTENSION	YES	9	52.94	6	13.95
	NO	8	47.05	37	86.04
Fisher's exact p = 0.0032*					
DIABETES MELLITUS	YES	5	29.41	1	2.32
	NO	12	70.58	42	97.67
Fisher's exact p = 0.0056*					
THYROID DISEASE	YES	6	35.29	3	6.97
	NO	11	64.7	40	93.02
Fisher's exact p = 0.0116*					
DYSPHONIA	YES	15	35.71	27	64.28
	NO	2	11.11	16	88.88
Fisher's exact p = 0.0474*					

Caption: * = significant p-value ($p < 0.05$)

Table 2. Correlation between the hearing means, comorbidities, and voice characteristics

	Hearing Loss I/ right ear	Hearing Loss II/ right ear	Hearing Loss I/ left ear	Hearing Loss II/ left ear
Hypertension	p < 0.0001*	p < 0.0001*	p < 0.0001*	p < 0.0001*
Diabetes mellitus	p < 0.0001*	p < 0.0001*	p < 0.0001*	p < 0.0001*
Thyroid diseases	p < 0.0001*	p < 0.0001*	p < 0.0001*	p < 0.0001*
Dysphonia	p < 0.0001*	p < 0.0001*	p < 0.0001*	p < 0.0001*
Roughness	p < 0.0001*	p < 0.0001*	p < 0.0001*	p < 0.0001*
Breathiness	p < 0.0001*	p < 0.0001*	p < 0.0001*	p < 0.0001*
Tension	p < 0.0001*	p = 0.0244*	p < 0.0001*	p = 0.0429*
Loudness	p = 0.4437	p = 0.1411	p = 0.228	p = 0.1328
Resonance	p < 0.0001*	p < 0.0001*	p < 0.0001*	p < 0.0001*

Mann-Whitney test
Caption: * = significant p-value ($p < 0.05$)

For the multivariate linear regression test, the following variables were included: sex, age, and complaints of excessive classroom noise. According to this test, the independent risk factors for hearing loss are dysphonia and DM (Table 3). When comparing the coefficients, a statistically significant difference can be observed between dysphonia and DM; hypertension and DM; DM and sex; DM and age (Table 3).

Table 3. Variables associated with hearing loss in the multivariate linear regression

Multivariate linear regression/ F = 1.8601	p-value
Intercept (hearing loss) =	0.3456
Partial Correlation Coefficient (b1 - dysphonia) =	**0.0311***
Partial Correlation Coefficient (b2 - noise) =	0.1949
Partial Correlation Coefficient (b3 - hypertension) =	0.2683
Partial Correlation Coefficient (b4 - thyroid diseases) =	0.6204
Partial Correlation Coefficient (b5 - diabetes mellitus) =	**0.0302***
Partial Correlation Coefficient (b6 - sex) =	0.3036
Partial Correlation Coefficient (b7 - age) =	0.9445
Comparison Coefficient. (b1 - dysphonia) and Coeff. (b2 - noise) =	0.1777
Comparison Coefficient. (b1 - dysphonia) and Coeff. (b3 - hypertension) =	0.2512
Comparison Coefficient. (b1 - dysphonia) and Coeff. (b4 - thyroid diseases) =	0.5891
Comparison Coefficient. (b1 - dysphonia) and Coeff. (b5 - diabetes mellitus) =	**0.0321***
Comparison Coefficient. (b1 - dysphonia) and Coeff. (b6 - sex) =	0.2806
Comparison Coefficient. (b1 - dysphonia) and Coeff. (b7 - age) =	0.4433
Comparison Coefficient. (b2 - noise) and Coeff. (b3 - hypertension) =	0.9933
Comparison Coefficient. (b2 - noise) and Coeff. (b4 - thyroid diseases) =	0.5641
Comparison Coefficient. (b2 - noise) and Coeff. (b5 - diabetes mellitus) =	0.0107*
Comparison Coefficient. (b2 - noise) and Coeff. (b6 - sex) =	0.7214
Comparison Coefficient. (b2 - noise) and Coeff. (b7 - age) =	0.1940
Comparison Coefficient. (b3 - hypertension) and Coeff. (b4 - thyroid diseases) =	0.6415
Comparison Coefficient. (b3 - hypertension) and Coeff. (b5 - diabetes mellitus) =	0.0366*
Comparison Coefficient. (b3 - hypertension) and Coeff. (b6 - sex) =	0.7639
Comparison Coefficient. (b3 - hypertension) and Coeff. (b7 - age) =	0.2769
Comparison Coefficient. (b4 - thyroid diseases) and Coeff. (b5 - diabetes mellitus) =	0.0586
Comparison Coefficient. (b4 - thyroid diseases) and Coeff. (b6 - sex) =	0.8005
Comparison Coefficient. (b4 - thyroid diseases) and Coeff. (b7 - age) =	0.6189
Comparison Coefficient. (b5 - diabetes mellitus) aand Coeff. (b6 - sex) =	0.0348*
Comparison Coefficient. (b5 - diabetes mellitus) and Coeff. (b7 - age) =	0.0316*
Comparison Coefficient. (b6 - sex) and Coeff. (b7 - age) =	0.2929

Caption: * = significant p-value ($p < 0.05$)

DISCUSSION

In this study, there was a significant association between hearing loss and DM, and between hypertension and thyroid disease (both, $p < 0.0001$), but there was no association between noise complaints and hearing loss in this population. The logistic regression showed that dysphonia ($p = 0.0311$) and DM ($p = 0.0302$) are independent risk factors for hearing loss considering both means I and II. Such findings agree with the literature that shows an association between hearing loss and hypertension, DM, and thyroid diseases among elementary, middle, and high school teachers[9-11]. It also shows the need for further studies with teachers since they constitute a population at risk for both hearing loss and other studied comorbidities. Working conditions – that is, the circumstances under which teachers put their physical, cognitive, and effective capacities into practice to achieve the goals of school production – can lead to overload or excessive demand for their psychophysiological functions. If there is no time for recovery, clinical symptoms are triggered

or precipitated[4]. The demands of the job force teachers to make great efforts and can compromise their balance and health. The anxiety that arises from stressors may lead to severe levels of insomnia and chronic disorders, which can include disrupted sleep, recurrently waking up, and difficulty falling back asleep. This leads to an imbalance in behavior and health[1], contributing to the onset of comorbidities such as hypertension, DM, and changes in the thyroid.

In contrast to the present findings on the non-association between noise complaints and hearing disorders, two recent studies mention the relationship between school noise exposure and hearing disorders[21,22]. Such divergences may be related to the research methodology used since this research was based only on the teachers' self-reported data regarding the noise complaint. In addition, another study mentions that noise levels can contribute to vocal changes, although this paper associates such findings with the stress caused by the pedagogical method, pointing out that the structure and organization in a given activity can contribute to noise level[21].

Sensorineural hearing loss has been reported in several autoimmune diseases such as thyroiditis, which seems to have an important impact on the reduction of hearing capacity in these patients[23]. This study agrees with this premise since in the present research thyroid changes were shown to be independent risk factors for hearing loss in teachers.

The assessment of this risk is an important tool for actions that promote health in the school environment, which can raise awareness in those involved, as well as a change in habits and the environment, to improve their quality of life [24,25]. Also, the data from this survey is in line with a study that suggests that, although teachers have been reasonably satisfied with their vocal quality, they have also shown misperceptions about the health process and have highlighted neglected aspects of vocal quality and health needs that can impair the teachers' voice and vocal health[15]. The results of the present study confirm these data.

In this study involving Brazilian public school teachers, it was noted that the noise complaint, despite not being associated with hearing loss, was associated with these teachers' vocal problems. Although noise is neglected at school, public health actions must address it through methodological and environmental planning aiming to minimize it. Hence, the teacher's work environment is improved, reducing the likelihood of noise-related hearing and voice problems[25,26].

A previous study with the population of the first phase of the basic project of this research aimed to estimate the prevalence of self-reported vocal problems among elementary school teachers and to identify associated occupational factors, using a cross-sectional design and face-to-face interviews with 967 teachers. The prevalence of self-reported vocal problems was 25.7%. Adjusted analyses showed associations with employment-related characteristics (40 working hours and low perception of wages and health benefits), work environment characteristics (number of students per class and exposure to chalk dust and microorganisms), factional psychological factors (limited opportunities to express opinions, poor relationship with their superiors, and a poor balance between professional and personal life), and violence (insults and intimidation). Voice disorders affected one in four elementary school teachers and were associated with various teaching characteristics (both structural and work-related)[25].

Although a statistically significant association was found in this study between hearing loss and dysphonia, as well as a correlation between hearing loss and specific voice characteristics, such as roughness, breathiness, tension, and resonance, it was not possible to verify the real association of voice changes due to the sample size and the prevalence of milder hearing disorders in this population of teachers. This limitation can be corrected in studies with larger populations, in which the degree of hearing loss can be considered concerning each of the teacher's voice assessment variables.

However, this study brings relevant data for this population, since it points to the need to prevent comorbidities such as hypertension, DM, and thyroid disorders, as well as the early diagnosis of these changes in the population with hearing loss, aiming to minimize its effects on their hearing. It also draws attention to the association between hearing loss and dysphonia, showing that there is a need to investigate hearing in teachers with this change. In short, it is emphasized that hearing is a necessary condition for the daily work and functional activities of teachers and, therefore, it must be constantly analyzed, aiming at this population's well-being.

CONCLUSION

This study demonstrated that hypertension and thyroid diseases are factors associated with hearing loss in teachers and that dysphonia and DM are independent factors associated with hearing loss in

teachers. There was also a correlation between hearing loss and the voice characteristics studied: roughness, breathiness, tension, and resonance.

These results suggest a more in-depth exploration to determine this association in future studies, as well as the need for policies aimed at promoting teachers' health with early intervention, for hearing loss and hypertension, DM, and thyroid diseases, in order to reduce changes, symptoms, and comorbidities, present in this population.

Based on the association between hearing loss and voice parameters in teachers, the clinical importance of the results of hearing and voice assessment in this population is emphasized. The data collection parameters reported in this study, in many respects, are similar to those used in other clinical centers and could be implemented in similar studies.

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