



Audiological implications of diabetes mellitus and arterial hypertension: a systematic review

Implicações audiológicas do diabetes mellitus e da hipertensão arterial: uma revisão sistemática

Implicaciones audiológicas de la diabetes mellitus y la hipertensión arterial: una revisión sistemática

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Abstract

Introduction: Among the most prevalent chronic non-communicable diseases (NCDs), Diabetes Mellitus (DM) and Systemic Arterial Hypertension (SAH) stand out. These NCDs are related to lifestyle, age and gender, and may be associated with audiological changes. **Objective:** To highlight the studies that already exist in the literature regarding DM and SAH and their relationship with hearing loss. **Research strategy:** Searches for scientific articles occurred in the electronic databases Medline (Pubmed), LILACS and SciELO. **Selection criteria:** Studies on the relationship between hearing loss and DM and SAH published in the last five years were included, and literature reviews, systematic reviews and meta-analysis were excluded. **Results:** Nine studies were selected showing that DM and / or SAH may be possible risk factors for the development of hearing loss. For this purpose, evaluations and comparisons of groups of people with and without such risk factors were carried out. Other comorbidities can be determinant for

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hearing loss. After the analysis, it was found that there is a relationship between SAH, DM and hearing loss, especially at high frequencies. No difference was observed between the ears. **Conclusion:** There is a relationship between DM and SAH with hearing loss, both in adults and in the elderly. Auditory impairment was shown to be greater in subjects with associated DM and SAH, suggesting a synergistic effect of the two chronic diseases on hearing. The hearing loss of the sensorineural type prevailed.

Keywords: Diabetes Mellitus; Hypertension; Hearing Loss.

Resumo

Introdução: Dentre as doenças crônicas não transmissíveis (DCNT) mais prevalentes, destacam-se o Diabetes Mellitus (DM) e a Hipertensão Arterial Sistêmica (HAS). Estas DCNT se relacionam ao estilo de vida, idade e gênero, e podem estar associadas a alterações audiológicas. **Objetivo:** Evidenciar os estudos já existentes na literatura a respeito da DM e a HAS e a sua relação com a perda auditiva. **Estratégia de pesquisa:** As buscas por artigos científicos ocorreram nas bases de dados eletrônicos Medline (Pubmed), LILACS e SciELO. **Critério de seleção:** Foram incluídos estudos sobre a relação da perda auditiva com a DM e HAS publicados nos últimos cinco anos, e, excluídas revisões de literatura, revisões sistemáticas e meta-análises. **Resultados:** Foram selecionados nove estudos evidenciando que a DM e/ou a HAS podem ser possíveis fatores de risco para o desenvolvimento da perda auditiva; para isso foram realizadas avaliações e comparações de grupos de pessoas com e sem tais fatores de risco. Outras comorbidades podem ser determinantes para a perda auditiva. Após a análise, verificou-se que existe uma relação entre a HAS, DM e a perda auditiva, principalmente em altas frequências. Não foi observada nenhuma diferença entre as orelhas. **Conclusão:** Existe relação entre DM e HAS com a perda auditiva, tanto em adultos quanto em idosos. O comprometimento auditivo mostrou-se maior nos sujeitos que apresentavam DM e HAS associados, sugerindo um efeito sinérgico das duas doenças crônicas sobre a audição. A alteração auditiva do tipo neurossensorial prevaleceu.

Palavras-chave: Diabetes Mellitus; Hipertensão; Perda Auditiva.

Resumen

Introducción: Entre las enfermedades crónicas no transmisibles (ENT) más prevalentes, destacan la diabetes mellitus (DM) y la hipertensión arterial sistémica (HSA). Estas ENT están relacionadas con el estilo de vida, la edad y el género, y pueden estar asociadas con cambios audiológicos. **Objetivo:** destacar los estudios que ya existen en la literatura sobre DM y SAH y su relación con la pérdida auditiva. **Estrategia de investigación:** Se realizaron búsquedas de artículos científicos en las bases de datos electrónicas Medline (Pubmed), LILACS y SciELO. **Criterios de selección:** Se incluyeron los estudios sobre la relación entre la pérdida auditiva y la DM y la HSA publicados en los últimos cinco años, y se excluyeron las revisiones de literatura, revisiones sistemáticas y metanálisis. **Resultados:** Se seleccionaron nueve estudios que demuestran que la DM y / o la HSA pueden ser posibles factores de riesgo para el desarrollo de la pérdida auditiva, para lo cual se llevaron a cabo evaluaciones y comparaciones de grupos de personas con y sin dichos factores de riesgo. Otras comorbilidades pueden ser determinantes para la pérdida auditiva. Después del análisis, se encontró que existe una relación entre SAH, DM y pérdida de audición, especialmente a altas frecuencias. No se observó diferencia entre las orejas. **Conclusión:** Existe una relación entre DM y SAH con pérdida auditiva, tanto en adultos como en ancianos. Se demostró que la deficiencia auditiva era mayor en sujetos con DM y SAH asociadas, lo que sugiere un efecto sinérgico de las dos enfermedades crónicas en la audición. La pérdida auditiva del tipo neurossensorial prevaleció.

Palabras clave: Diabetes Mellitus; Hipertensión; Pérdida auditiva.

Introduction

Currently, about one third of global deaths occur due to chronic non-communicable diseases (CNCDs), which are associated with unfavorable living conditions, such as poor education, low per capita family income and unhealthy lifestyle such as smoking, alcoholism, physical inactivity, and stress^{1,2}.

The CNCDs have multiple etiology, long latency periods, non-infectious origin and are also associated with functional deficiencies and disabilities. Among the most well-known and prevalent CNCDs are Diabetes Mellitus (DM) and Systemic Arterial Hypertension (SAH)³.

DM is known as a metabolic disease characterized by hyperglycemia and is associated with complications, dysfunctions and insufficiency of different organs, including eyes, kidneys, nerves, brain, heart and blood vessels. Defects in the secretion and/or action of insulin and even destruction of cells producing this hormone may occur⁴.

One of the audiological implications in individuals with diabetes is believed to be angiopathy, which can interfere with the supply of nutrients and oxygen to the cochlea. In addition to cochlear changes, DM can also cause secondary degeneration of the eighth cranial nerve (VIII), causing neural hearing loss^{1,5}.

Regarding SAH, there are other risk factors that are concomitant that increase the likelihood of the individual developing cardiovascular disease^{1,6}, such as age, gender, family history, smoking, alcoholism and physical inactivity. According to the World Health Organization (WHO) (2015)⁷, the prevalence increase of SAH may be associated with aging, which may be its main determining factor since many of these factors are modifiable.

Hypertension is one of the most common vascular disorders, which can facilitate structural changes of the heart and blood vessels. High pressure in the vascular system can result in hemorrhages in the inner ear, which, like other parts of the body, receives a blood supply derived from the anterior inferior cerebellar artery, which divides and supports other branches of the ear, which can

culminate in sudden or progressive hearing loss^{1,8}. This investigation aims to highlight studies on Diabetes Mellitus and Systemic Arterial Hypertension and its relationship with hearing loss, in a current perspective.

Research strategy

This is a systematic review, conducted according to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)⁹. The search for the articles was carried out in the following databases: MEDLINE (via PubMed) (<https://www.ncbi.nlm.nih.gov/pubmed/>), Scientific Electronic Library Online (SciELO) (<http://www.Scielo.br/>) and Latin American and Caribbean Literature in Health Sciences (LILACS) (<http://lilacs.bvsalud.org/>). The search strategy for MEDLINE was as follows: (“diabetes mellitus” [Mesh]) AND (“hypertension” [Mesh]) AND (“hearingloss” [Mesh]). For the Scopus, SciELO and LILACS databases, a combination of words/terms was used: (“diabetes mellitus” [DeCS] AND “hypertension” [DeCS] AND “hearing loss” [DeCS]). The survey period covered articles published between the year 2014 and 2019. The articles included in this systematic review were selected by two independent authors, and the articles were retrieved in four stages.

In the first stage, the articles were identified through electronic search, organized and reviewed for duplication by the two authors independently. In the second stage, the titles of the articles were independently analyzed. Articles that did not meet some of the inclusion criteria were excluded. In the third stage, the abstracts of the articles selected in the second stage were examined. Articles that did not contain characteristics of the studied population were excluded. If there was insufficient data, the summary was left for the next evaluation stage. In the fourth stage, the full articles were retrieved and reviewed. Those that presented data regarding the relationship between DM and SAH with hearing loss were selected.

The investigation was structured and organized in the form PICOS (Chart 1), which is an acronym for the target Population, Intervention, Comparison and Outcomes, Study.

Chart 1. PICOS strategy description.

Acronym	Definition	Description
P	Patient or problem	Relationship between diabetes mellitus and systemic arterial hypertension and hearing loss
I	Intervention	Patients with hearing loss
C	Control or Comparison	Patients with hearing loss due to chronic non-communicable diseases
O	Outcomes	Hearing loss related to diabetes mellitus and systemic arterial hypertension
S	Study types	Cross-sectional, multicenter cohort, comparative prospective, case control and retrospective

Selection criteria

The articles selected for this review were those that met the following inclusion criteria: individuals with hearing loss due to chronic non-communicable diseases such as diabetes and hypertension; Portuguese, English and Spanish languages without localization restrictions, but with publication period restrictions, covering studies published from 2014 to 2019.

Studies with the following characteristics were excluded: literature reviews, systematic reviews, meta-analyses, interventions or randomization process, observational studies, letters to the editor, guidelines and abstracts. Studies that were poorly described or that were unclear or unavailable were also rejected for this investigation. Below, inclusion and exclusion criteria of the present review are reported (Chart 2).

Chart 2. Inclusion and exclusion criteria.

Inclusion Criteria	
Design	Case studies, longitudinal studies, cross-sectional studies and prevalence studies
Location	No restriction
Language	No restriction
Year	From 2014 to 2019
Exclusion Criteria	
Design	Literature reviews, systematic reviews and meta-analyses
Studies	Unclear or poorly described or inadequate studies
Form of publication	Only abstracts

Data analysis

Two independent investigators reviewed the survey results to find potentially eligible studies. Initially, 137 articles were found; later, repeated articles were excluded, leaving 127 articles; the titles were analyzed and excluded when they did not fit the criteria, reducing the list to 30 articles;

successively the abstracts were reviewed and only those that were *potentially eligible were selected, totaling 18 articles. Based on the abstracts, the articles* were selected for full reading, leaving only nine articles that met all predetermined criteria (Figure 1).

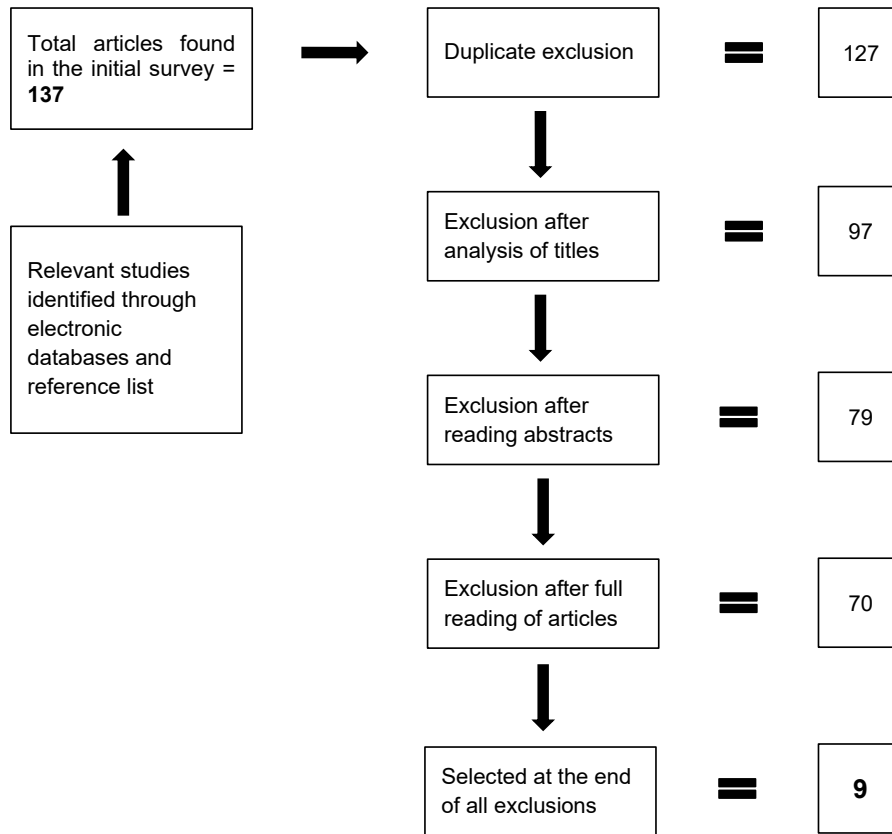


Figure 1. Search and analysis of articles.

Results

The survey performed yielded nine articles that met all the inclusion criteria (Table 1). The selected studies showed DM and SAH as possible risk factors for the development of hearing loss¹⁰⁻¹². Patients with DM have a higher risk of developing sensorineural hearing loss^{12,1,12,14,16}. Some studies indicated that smoking¹², high body mass index (BMI)¹⁰, exposure to noise and older age¹⁴ can also be determinants for hearing loss (Table1).

Regarding the methodology adopted by the investigators, cross-sectional studies stand out^{10,13,14,15,16,18}, but also multicentric¹⁷, case-control¹² and retrospective¹¹ design investigations were found. As for the public studied, in six surveys the authors chose to evaluate adults and/or elderly aged 20 to 87 years^{10,12,13,15,16,18}, while another three studies conducted the investigation only with the elderly population (age ≥ 60 years)^{11,14,17}. The number of subjects selected for the investigation

ranged from 80 to 37,773^{10-12,14-18}; one study did not mention the number of individuals included¹³. Regarding the gender of the participants, the female gender stands out^{10,13,14,16}, however, not all the authors mentioned the gender of the individuals studied^{11,17,18}. One study showed a very similar distribution between genders¹² and one showed a prevalence of male participants¹⁵.

In order to assess the physical and hearing health conditions of the participants in each of the studies selected for this literature review, a series of assessments was carried out. There was a difference between the procedures used by the different authors, among which we can point out the development and application of a sociodemographic questionnaire¹³, tests to measure blood pressure¹⁵, blood tests^{15,18}, physical tests¹³, glucose¹⁸, assessment of the Body Mass Index (BMI)^{10,13,16}, magnetic resonance¹², otoscopic examination^{10,14,16}, meatoscopy¹⁷, pure tone audiometry¹⁰⁻¹⁸, logaudiometry^{11,12,17,18},

immittance audiometry^{11,12,17,18} and brainstem auditory evoked potential¹².

Most of the studies selected for this review followed up two or more groups to measure whether there is a relationship between these risk factors and hearing loss. Some studies were composed of at least one group with DM or SAH, and /or a group with subjects who had the two associated factors (DM + SAH), as well as a group without these variables, called, by the authors, as control group^{11,16-18}. Another study, in which the main focus was to evidence hearing loss related to DM, separated a group with hearing loss and another without hearing loss¹².

Other aspects reviewed were the previous diagnosis of the pathologies^{13,15-18} and the time since the participants had received this diagnosis^{17,18}. Five studies described procedures and parameters for making the diagnosis^{13,15-18} and one of these carefully divided subgroups, separating these individuals according to the age when they received the diagnosis¹⁷. The time of diagnosis of these pathologies varied, being six years for DM, for SAH 16 years and DM + SAH 14 years¹⁷.

After audiological follow-up, some studies have shown a significant relationship between SAH

and/or DM and hearing loss^{10,14,15,17}, especially at high frequencies^{14,15,17}; nevertheless, the impairment of medium and low frequencies has also been observed^{11,17}. One study found hearing thresholds and speech test results significantly worse in the group with DM than in the group without DM; however, this difference was not maintained after adjusting for age, gender and the presence of hypertension, as well as no association was found between the duration of diabetes and hearing thresholds after said adjustment¹⁸. A greater auditory impairment in the groups whose subjects had associated DM and SAH was evidenced in some publications, suggesting a synergistic effect of the two chronic diseases on hearing^{11,13,16,17}. Hearing loss in patients with type 2 DM was worsened by hypertension and low glycemic control¹⁶.

As for the type and degree of hearing loss, there is a sensorineural hearing loss^{11,14,16}, bilateral¹⁴, mild¹⁴ or moderate¹⁶, increasing progressively with age^{13,14,15} and the presence of other factors^{9,15}. There was no statistical difference in relation to age, gender of participants¹⁰⁻¹⁸ and/or in relation to the right and left ear^{11,14}.

Table 1. Summary of the articles included in the review.

Author/ Year	Title	Objective	Methodology	Results
Stephen Semen Yikawe; Kufre Robert Iseh; Anas Ahmad Sabir; Mfon Ime Inoh; Joseph Hassan Solomon; Nasiru Aliyu/ 2018	Cardiovascular risk factors and hearing loss among adults in a tertiary center of Northwestern Nigeria ¹⁰	To evaluate the effect of cardiovascular risk factors on hearing loss.	Cross-sectional study, involving 220 subjects with an average age of 45.24 (\pm 12.21) years, carried out between December 2015 and April 2016. A pre-tested questionnaire was used to obtain information about the biographical data and participants' doctors, after which they were examined and had their hearing thresholds measured. DM and SAH were considered cardiovascular risk factors, and the diagnosis of these pathologies was performed by a doctor. The mean audiometric thresholds of 500, 1000, 2000 and 4000 Hz were determined and categorized according to the degrees of hearing impairment proposed by the World Health Organization as follows: normal hearing (<25 dB), mild hearing loss (26 and 40 dB), moderate hearing loss (41 and 60 dB), severe hearing loss (61e80 dB), profound hearing loss (81 dB or higher).	The average hearing thresholds for pure tone was 19.15 (\pm 9.28) dBHL. Thirty-six (16.4%) participants had some degree of hearing loss. In addition, 30 of them (13.6%) had SAH, while 23 (10.5%) had DM. In addition, 43 participants (19.5%) had a BMI \geq 25 kg / m ² . Nine of the 220 participants (4.1%) had a smoking history. Thus, SAH, DM, BMI \geq 25 kg / m ² and aging were significantly associated with the risk of hearing loss, while smoking and gender were not.

Author/ Year	Title	Objective	Methodology	Results
Laurie Penha Rolim; Camila Maia Rabelo; Ivone Ferreira Neves Lobo; Renata Rodrigues Moreira; Alessandra Giannella Samelli / 2015	Interaction between diabetes mellitus and hypertension in the hearing of the elderly11	Compare the hearing thresholds of elderly people with DM, SAH and DM + SAH with a control group (CG).	Retrospective study carried out by collecting data from the medical records of 80 elderly people with complete hearing assessment (anamnesis, pure tone audiometry, vocal audiometry and immittance testing), between the years 2008 and 2012. The individuals were divided into four groups, with 20 subjects each: DM, SAH, DM + SAH and with no known chronic diseases (CG).	There was no statistically significant difference between the ears, and these results were grouped. Comparisons between the mean auditory thresholds of the CG and the DM or SAH did not show statistically significant differences. However, a statistically significant difference was observed in the comparison between these three groups and the DM + SAH group for several of the evaluated frequencies, suggesting a synergistic effect of the two chronic diseases on hearing.
Chen-Yu Chien; Shu-Yu Tai; Ling-Feng Wang; Edward Hsi; Ning-Chia Chang; Ming-Tsang Wu; and Kuen-Yao Ho / 2015	Metabolic Syndrome Increases the Risk of Sudden Sensorineural Hearing Loss in Taiwan: A Case-Control Study12	Examine whether metabolic syndrome increases the risk of sudden sensorineural hearing loss in Taiwan.	Retrospectively investigated 181 cases of sudden sensorineural hearing loss and 181 control cases from 2010 to 2012, comparing their clinical variables. The relationship between metabolic syndrome and sudden sensorineural hearing loss was analyzed. Metabolic syndrome was defined according to the National Cholesterol Education Program III Adult Treatment Panel. The audiological evaluation included initial and follow-up pure tone audiometry, vocal audiometry, immittance testing, brainstem auditory evoked potential and magnetic resonance imaging. Audiograms were categorized into four patterns: low-pitched, high-pitched, flat and total hearing loss. The severity of hearing loss was assessed with the average hearing threshold in 5 frequencies (250, 500, 1000, 2000 and 4000 Hz) in the pure tone audiogram performed when the sudden sensorineural hearing loss was diagnosed. Severity was then categorized into 1 of 4 degrees, based on the initial audiogram, which included mild (hearing loss less than 40 dB), moderate (hearing loss greater than 40 dB, but not greater than 70 dB), severe (hearing loss greater than 70 dB, but not greater than 90 dB) and profound (hearing loss greater than 90 dB). Hearing improvement was assessed by comparing the last patient's follow-up audiogram with the audiogram performed when sudden hearing loss was diagnosed. All patients were followed up for at least 3 months.	Individuals with metabolic syndrome had a 3.54-fold increased risk (95% confidence interval [CI] = 2.00-6.43, P <0.01) of having sudden sensorineural hearing loss compared to those without metabolic syndrome. With the increase in the number of components of the metabolic syndrome, the risk of sudden sensorineural hearing loss increased. Vertigo was associated with a poor result (P = 0.02; 95% CI = 1.13 to 5.13, adjusted odds ratio = 2.39). The pattern of hearing loss can influence the result of sensorineural hearing loss (P <0.01).

Author/ Year	Title	Objective	Methodology	Results
Abdulbari Bener; Abdulla OAA Al-Hamaq; Khalid Abdulhadi; Ahmed H. Salahaldin; Loida Gansan/2017	Interaction between diabetes mellitus and hypertension on risk of hearing loss in highly endogamous population ¹³	To determine the prevalence of hearing loss and its association with DM2 in a highly inbred population.	During the study period (January 2013 to July 2014), prevalence, hearing, audiological testing, family history and medical problems associated with hearing loss in middle-aged patients were recorded. Hearing was assessed using pure tone audiometry and considered normal when the thresholds were up to 25 dB, with hearing loss classified as mild (26 to 40 dB), moderate (41 to 55 dB), severe (56 to 70 dB), very severe (71 to 90 dB), profound (91-120 dB) and deaf (without hearing).	Most cases of hearing loss were observed over the age of 45 (44.8% vs 51.7%, $p = 0.05$). Consanguineous marriages were more observed in hearing loss (32.1%) than in normal hearing (21.8%) ($p = 0.028$). The average duration of the onset of diabetes (7.8 ± 4.12 years), sleep disturbance (5.81 ± 1.29 h), obese individuals (38% vs 27.4%); family history of diabetes (30.6 vs 23.1%) was higher among the hearing impaired. The associated risk factors were significantly higher in DM2 with BP, than in DM with normal hearing. There was a difference between hearing loss and normal hearing in DM2 regarding the frequency of hearing ($p < 0.001$). Adults with associated DM and hypertension had greater hearing impairment in highly endogamous populations.
Caroline Luiz Meneses-Barriviera ; Jéssica Aparecida Bazoni ; Marcelo Yugi Doi ; Luciana Lozza de Moraes Marchiori / 2018	Probable Association of Hearing Loss, Hypertension and Diabetes Mellitus in the Elderly ¹⁴	To assess the prevalence of hearing loss and its possible association with SAH and DM in the elderly.	Cross-sectional study with 519 elderly people over 60 years of age, submitted to audiological evaluation, and answered a questionnaire of comorbidities. The dependent variable was the presence of hearing loss. The independent variables were age, gender, DM and hypertension. The variables were presented in absolute numbers and proportions and made it possible to estimate the prevalence. The audiological evaluation consisted of anamnesis, otoscopy and pure tone audiometry. To classify hearing loss, the Davis and Silverman (1970) classification was used to analyze the auditory average I (500 Hz, 1000 Hz and 2000 Hz) and the classification of the National Committee on Noise and the study by Amorim et al. (2008) to analyze the auditory average II (3000 Hz, 4000 Hz and 6000 Hz). The degrees of hearing loss were classified as: mild (26 to 40 dB), moderate (41 to 70 dB), severe (71 to 90 dB) and profound (> 91 dB).	Sensorineural hearing loss was more prevalent (66.26%), being frequently bilateral (91.56%) and mild (26.50%). DM was associated with hearing loss at high frequencies in the elderly and, according to multiple logistic regression, risk factors are independent of hearing loss only for age and exposure to occupational noise.

Author/ Year	Title	Objective	Methodology	Results
Em-Hwan Oh; Jong Hoon Lee; Park Dong Choon; Myung Gu Kim; Ji Hyung Chung; Sang Hoon Kim; Seung Geun Yeon / 2014	Hearing Loss as a Function of Aging and Diabetes Mellitus: A Cross Sectional Study ¹⁵	Evaluate the contributions of DM and SAH, chronic diseases associated with aging, as well as aging itself, for hearing loss in health screening tests.	This study included 37,773 individuals who underwent health screening exams from 2009 to 2012. The relationships between hearing threshold and age, hearing threshold at each frequency were assessed based on age group, degree of hearing loss and presence or absence of SAH and DM. Hearing thresholds were assessed at frequencies of 500, 1000, 2000, 3000, 4000 and 6000 Hz. An average hearing threshold ≥ 26 dB was defined as hearing loss and the degree of hearing loss was classified as mild (26.40 dB), moderate (41.55 dB), moderately severe (56.70 dB) and severe (71.90 dB) based on the ISO standard. The average auditory threshold in each age group and the auditory threshold in each frequency were also determined.	The prevalence of hearing loss increased with age, with 1.6%, 1.8%, 4.6%, 14.0%, 30.8% and 49.2% in individuals aged 20, 30, 40, 60, and 70 years, respectively ($p < 0.05$). The value of hearing by frequency showed changes based on aging, in the order of 6000, 4000, 2000, 1000 and 500 Hz, indicating greater hearing losses at high frequencies. The degree of hearing loss varied from mild to severe. Aging and DM were correlated with the prevalence of hearing loss ($p < 0.05$). There was no statistically significant association between hearing loss and hypertension after adjustment for age and DM.
Stephen Oluwatosin Adebola; Micheal A. Olamoyegun; Olusola A. Sogebi; Sandra O. Iwuala; John A. Babarinde; Abayomi O. Oyelakin / 2016	Otologic and audiologic characteristics of type 2 diabetics in a tertiary health institution in Nigeria ¹⁶	Describe the pattern of ear diseases and hearing acuity in patients with type 2 DM (DM2), comparing these patterns with that of non-diabetics, and also explore their determinants.	Ninety-seven patients with a clinical diagnosis of diabetes mellitus (DM2), were matched for sex and age with 90 non-diabetic patients (180 ears). These patients were evaluated using otoscopy and pure tone audiometry, over a period of 6 months.	The study reported a prevalence rate of 21.6% of hearing loss (BP) in patients with DM2. The most common type of ear disease that showed a significant association with patients with DM2 was otitis media with effusion ($p = 0.027$). DM2 was significantly associated with altered audiometric findings ($p = 0.022$), mainly sensorineural BP ($p = 0.012$), of moderate degree ($p = 0.057$). Coexisting hypertension and poor glycemic control were significantly associated with worsening hearing in patients with DM2 ($p < 0.001$ and $p = 0.009$, respectively).
Laurie Penha Rolim; Alessandra Giannella Samelli; Renata Rodrigues Moreira; Carla Gentile Matas; Itamar de Souza Santos; Isabela Martins Bensor; Paulo Andrade Lotufo / 2017	Effects of diabetes mellitus and systemic arterial hypertension on elderly patients' hearing ¹⁷	Compare the initial audiometry (A1) with a subsequent audiometry (A2) performed after an interval of 3 to 4 years in an elderly population with diabetes mellitus and/or systemic arterial hypertension,	The study included 100 elderly people diagnosed with DM and / or SAH, divided into four groups: DM Group ($n = 20$); SAH groups ($n = 20$); DM / SAH group ($n = 20$); Control group ($n = 40$). All participants should have a previous complete audiological evaluation (A1). A new audiological evaluation (A2) was performed 3-4 years after the first. The audiological evaluations consisted of anamnesis, meatoscopy, immittance testing, pure tone audiometry and vocal audiometry. Participants with DM and/or SAH were paired in a 1:1 ratio with participants of the same sex and age, without these clinical conditions. To compare the auditory thresholds of A1 with A2 between the study groups and their respective control, the average increase in auditory thresholds per year was considered.	When comparing the average annual increase in the hearing thresholds of A1 with A2, considering each study group and its respective control, it can be observed that there was no statistically significant difference for any of the frequencies for the DM group; for the group with SAH, significant differences were observed after 4 kHz. For the group with DM and SAH, significant differences were observed in the frequencies of 500, 2 kHz, 3 kHz and 8 kHz.

Author/ Year	Title	Objective	Methodology	Results
Alessandra G. Samelli; Itamar S. Santos; Renata R. Moreira; Camila M. Rabelo; Laurie P. Rolim; Isabela J. Bensenõr; Paulo A. Lotufo / 2017	Diabetes mellitus and sensorineural hearing loss: Is there an association? Baseline of the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil) ¹⁸	To investigate the association between diabetes and sensorineural hearing loss. We evaluated the influence of the time of diagnosis of diabetes in this association after the control for diagnosis of age, gender and hypertension and excluded individuals with exposure to noise.	This cross-sectional study evaluated 901 adults and elderly people participating in the Estudo Longitudinal de Saúde do Adulto (ELSA, Longitudinal Study on Adult Health - Brazil). The audiological evaluation consisted of pure tone audiometry, vocal audiometry and immittance testing. No significant differences were found between the left and right ears, and they were grouped. The average values for each audiometric frequency (threshold per frequency) were calculated; low to medium range frequencies (250 to 2000 Hz); high-range frequencies (3000–8000 Hz); speech recognition threshold and speech recognition index. The normality pattern considered for the thresholds by frequency was 25 dBHL.	Hearing thresholds and speech test results were significantly worse in the group with diabetes than in the group without diabetes. However, no significant differences were found between participants with and without diabetes after adjusting for age, gender and the presence of hypertension. Hearing thresholds were not affected by occupational noise exposure in groups with and without diabetes. In addition, no association between the duration of diabetes and hearing thresholds was observed after adjusting for age, gender and hypertension.

Legend: DM = Diabetes Mellitus; SAH = Systemic Arterial Hypertension; BMI = Body Mass Index; CG = Control Group; DM2 = Diabetes Mellitus type 2.

Discussion

In this investigation it was found that DM and SAH are considered risk factors for hearing loss¹⁰⁻¹⁷. In addition to the CNCs surveyed, other risk factors were cited as related to the onset of hearing loss, such as smoking and high BMI^{7,10,12}.

Although there was great variability in relation to the age of the subjects in the screened studies^{10,13,15,16,18} it was possible to observe the predominance of the elderly, since practically all studies included individuals aged 60 years or older in their samples^{10-12,14-18}. This can be justified by the fact that SAH is a highly prevalent disease among elderly people, affecting about 50 to 70% of people in this age group, as well as DM, which is one of the most common chronic diseases in this age group¹⁹. In addition, aging is directly associated with the increase in hearing thresholds, resulting in a greater degree of hearing loss in older individuals^{14,15,20-22}. Thus, the age investigated is an extremely relevant factor in the analysis of the results.

A recently published study is consistent with the aforementioned findings, as the elderly who presented DM and HA as the main comorbidities complained more often of hypoacusis (40.3%) and tinnitus (36.6%), with sensorineural hearing loss being the most common in this population²². To measure the degree/level of DM, SAH and the presence or absence of hearing loss, some procedures were

implemented, such as pure tone audiometry¹⁰⁻¹⁸, logoaudiometry and immittanciometry^{11,12,17,18}, blood test^{13,15, 16,18} for confirmation of DM and, finally, blood pressure measurement¹⁰⁻¹⁸ procedures that partially corroborate those performed in other studies compiled in the literature^{8,20,23}.

Regarding the audiological evaluation, there is a consensus in the literature as to the ideal way to perform pure tone audiometry, with the recommendations being followed in most of the studies selected^{11,13,14,16-18}, as well as evidenced in other studies surveyed in the literature^{20,23}. On the other hand, there was a study whose authors chose to evaluate the frequencies from 500 to 6000 kHz¹⁵, and two others that did not make clear the range of frequencies assessed, although in one of them there is a reference that the average for the classification of hearing loss was based on the hearing thresholds from 500 to 4000 Hz¹⁰ and the other mentioned that five frequencies (250, 500, 1000, 2000 and 4000 Hz) were used in the assessment of the severity of hearing loss.¹² On the other hand, the performance of logoaudiometry and immittance testing was not a consensus, as observed in the papers that show that these tests were performed in a smaller proportion.

Two procedures that were not performed in any of the screened studies and are extremely important (taking into account the findings obtained by some studies, which found hearing loss mainly at high frequencies^{14,15,17}), include high frequency audiometry

etry and otoacoustic emissions. Such tests help in the early diagnosis, that is, before the impairment reaches the frequencies used in the detection and understanding of speech. In addition to DM and SAH, other risk factors were mentioned, such as noise exposure^{14,18}, family history of diabetes and predisposition to develop other diseases¹³. In this regard, it is worth emphasizing the importance of preventing these risk factors through preventive health actions, reducing the risk of hearing loss^{2,7,9,10}.

Regarding the time the patients were already diagnosed with SAH and/or DM, an average of five to 16 years for both comorbidities was found^{16,17}. As for the age at which the subjects received the diagnosis, it ranged from 30 to 72 years of age in one of the studies focusing on DM¹⁸, while in another study, DM patients were diagnosed with an average of 61.75 years of age and the diagnosis of SAH was given at 52.65 years of age, on average¹⁷, with no relationship between age and time of diagnosis of SAH and/or DM with hearing loss. However, it is important to emphasize that both DM and SAH are diseases that can be asymptomatic and, therefore, the time of onset of the disease may be longer than that reported by individuals.

Hypertensive individuals were significantly more likely to develop hearing loss, when compared to non-hypertensive individuals¹⁰, possibly due to the fact that hypertension can cause micro-circulatory insufficiency that can lead to a greater or lesser deterioration of the peripheral auditory system, which may cause sudden or progressive hearing loss.

Comparing the group of DM patients to the control group, in three different studies one can see that participants with DM had elevated hearing thresholds^{11,16,17}. Confirming these findings, a similar study found a worsening in the hearing thresholds of the subjects with DM, and these findings were significant when compared to the control group, indicating the correlation between DM and hearing loss²⁴. Thus, it is estimated that patients with DM have a predisposition to hearing loss²². It is believed that one of the implications of DM is angiopathy, which can interfere with the supply of nutrients and oxygen from the cochlea. In addition to cochlear changes, DM can also cause secondary degeneration of the eighth cranial nerve (CN VIII), causing neural hearing loss^{1,5}.

Two studies^{11,17} compared a group with SAH and DM associated with a control group and found that the group with SAH and DM was the one with the most altered hearing thresholds, in line with what was found in a study developed in a highly endogamous population that concluded that adults with DM and associated SAH had greater hearing impairment¹³. Thus, it can be said that individuals who have SAH and DM are more susceptible to developing hearing loss. In another study¹⁶, hearing loss in patients with DM2 was worsened by coexisting hypertension and inadequate glycemic control.

According to the analysis of the studies, individuals showed more changes in high frequencies^{14,15,17}, with bilateral hearing loss¹⁴ being mild¹⁴ or moderate¹⁶. The association of DM and SAH with the degree of hearing loss is an aspect little addressed in current publications, requiring the development of studies that assess a wider range of frequencies and determine the degree of change, both for low and medium and high frequencies.

Thus, there is no consensus and details on the real factors that contribute to the risk of hearing loss in subjects with DM and SAH, requiring further research. It is suggested to develop studies that evaluate high frequencies (>8000 Hz) and study otoacoustic emissions (OAE), as well as the brainstem auditory evoked potential (BAEP) of these patients, since it is believed that DM and SAH can cause cochlear as well as central changes.

Conclusion

From the studies reviewed, it can be concluded that there is a relationship between DM and SAH with hearing loss, both in adults and in the elderly, who represent the fastest growing portion in the Brazilian population today. Auditory impairment has been shown to be greater in subjects with associated DM and SAH, suggesting a synergistic effect of the two chronic diseases on hearing. The hearing loss of the sensorineural type prevailed.

In addition, in view of the results presented in these individuals who have such risk factors, it is necessary to implement public policies and preventive measures in order to minimize the prevalence and implications of hearing loss in the health of this population, as well as expanding access to health services available to the population, so that they receive adequate care.

Although there are many studies on this subject, it has not yet been possible to establish the existence of a cause and effect relationship between DM and/or SAH and hearing loss. It is suggested to perform new studies in order to establish this relationship, to be developed with the evaluation of a wider range of frequencies, as well as with the use of procedures such as OAE and BAEP.

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