Cureus
Part of SPRINGER NATURE

Open Access Original Article

Associations of Age, Sex, and Diabetes Duration With Sensorineural Hearing Loss Severity in Patients With Type 2 Diabetes Mellitus: A Retrospective Study

Review began 10/20/2026
Review ended 10/26/2026
Published 10/30/2026

© **Copyright** 2026
Sindhu et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

DOI: 10.7759/cureus.118852

Mangde Anata Sindhu [1], Agus Santosa [2], Made Gita Ratnasari [2], I Made Wiranadha [3]

1. Faculty of Medicine and Health Sciences, Universitas Warmadewa, Denpasar, IDN 2. Department of Otolaryngology - Head and Neck Surgery, Faculty of Medicine and Health Sciences, Universitas Warmadewa, Denpasar, IDN 3. Division of Neurotology, Department of Otolaryngology - Head and Neck Surgery, Prof. Dr. I.G.N.G. Ngoerah General Hospital, Denpasar, IDN

Corresponding author: Mangde Anata Sindhu, f.anatasindhu.32@gmail.com

Abstract

Background

This study examined the unadjusted associations of age, sex, and diabetes duration with sensorineural hearing loss (SNHL) severity among patients with type 2 diabetes mellitus (T2DM) and established SNHL.

Materials and methods

This observational cross-sectional study retrospectively reviewed medical records of patients who underwent pure-tone audiometry at an otolaryngology outpatient clinic between January 2024 and December 2025. All 112 eligible patients with T2DM and SNHL who had complete study data were included. Hearing loss severity was extracted from categories documented in medical records or audiometry reports, without recalculating hearing thresholds. Severity was grouped as mild to moderate or moderately severe to profound. Age was categorized as ≤46 or >46 years, and diabetes duration as <5 or ≥5 years. Associations were assessed separately using Pearson's chi-square test, with $p < 0.05$ considered statistically significant.

Results

Of the 112 patients, 92 (82.1%) were aged >46 years, 66 (58.9%) were male, and 69 (61.6%) had a diabetes duration of ≥5 years. Moderate SNHL was the most frequent category, affecting 44 patients (39.3%). Mild to moderate SNHL occurred in 78 patients (69.6%), while moderately severe to profound SNHL occurred in 34 (30.4%). Pearson's chi-square tests showed that the proportion with moderately severe to profound SNHL was higher among patients aged >46 years than those aged ≤46 years (35.9% versus 5.0%; $\chi^2(1) = 7.405$, $p = 0.0065$), among males than females (40.9% versus 15.2%; $\chi^2(1) = 8.463$, $p = 0.0036$), and among patients with diabetes duration ≥5 years than those with duration <5 years (42.0% versus 11.6%; $\chi^2(1) = 11.581$, $p = 0.0007$).

Conclusions

Age >46 years, male sex, and diabetes duration ≥5 years were associated with greater SNHL severity in this sample of patients with T2DM and established SNHL. These associations were unadjusted for potential confounders and should be confirmed in studies incorporating multivariable analysis.

Categories: Otolaryngology, Endocrinology/Diabetes/Metabolism
Keywords: age, diabetes duration, hearing loss severity, sensorineural hearing loss, sex, type 2 diabetes mellitus

Introduction

Diabetes mellitus has been associated with hearing impairment in both population-based and clinical studies. An analysis of the National Health and Nutrition Examination Survey found a higher prevalence of audiometric hearing impairment among adults with diabetes than among those without diabetes [1]. A large prospective cohort study also reported an association between diabetes and the subsequent development of bilateral hearing loss [2]. These findings support further investigation of auditory function in patients with type 2 diabetes mellitus (T2DM), including the characteristics associated with hearing loss severity.

Structural changes in the cochlea provide a biological basis for this association. A human temporal bone study identified thickening of cochlear vessel walls, atrophy of the stria vascularis, and greater outer hair cell loss in patients with T2DM compared with controls [3]. These findings suggest that diabetes-related vascular and cochlear abnormalities may contribute to sensorineural hearing loss (SNHL). However, the presence of these abnormalities does not establish that diabetes alone accounts for the degree of hearing

impairment in an individual patient.

Age, sex, and diabetes duration are readily available clinical characteristics that may help describe variation in auditory impairment. Srinivas et al. reported higher hearing thresholds with increasing age and longer diabetes duration, but found no significant difference according to sex [4]. Other research has shown that associations between hearing impairment and diabetes-related characteristics are not consistently demonstrated across populations [5]. This variation supports examining these characteristics within specific clinical settings, while recognizing that age, metabolic status, comorbidities, and environmental exposures may overlap in their associations with hearing function.

Evidence concerning the occurrence of hearing loss in diabetes does not directly explain differences in severity among patients who already have SNHL. Examining severity within this group may provide clinically relevant information about the distribution of auditory impairment. Therefore, this study aimed to assess the unadjusted associations of age, sex, and documented diabetes duration with SNHL severity among patients with T2DM and established SNHL attending an otolaryngology outpatient clinic, using retrospectively collected medical records from January 2024 to December 2025.

Materials And Methods

Study design and setting

This analytical observational study used a cross-sectional design with retrospective review of medical records. The study examined the associations of age, sex, and diabetes duration with SNHL severity among patients with T2DM. Records were obtained from an otolaryngology outpatient clinic in Denpasar, Indonesia, and covered examinations performed between January 2024 and December 2025. Data extraction was conducted in 2026 after ethical review and institutional research permission had been obtained.

Study population and sampling

Total sampling was used to include all eligible patients within the study period. Patients were eligible for the primary analysis if they had documented T2DM, pure SNHL established in the clinical record and pure-tone audiometry report, and complete information on age, sex, diabetes duration, and recorded SNHL severity.

Exclusion criteria were conductive or mixed hearing loss; documented congenital or genetic hearing disorders; chronic noise exposure or acoustic trauma; use of potentially ototoxic medications; head or ear trauma; head and neck malignancy; chronic kidney disease, autoimmune disease, or neurological disorders that could affect hearing; and previous ear surgery that could influence audiometric findings. Records with missing information on the required study variables were also excluded. These criteria were applied using the information documented in the medical records.

The minimum sample size was estimated during study planning using a single-proportion formula, with a 95% confidence level, an assumed proportion of 0.50, and an absolute precision of 0.10, yielding a minimum of 97 patients. This calculation was intended for proportion estimation rather than specifically determining statistical power for the association analyses. The primary analysis included 112 eligible patients with T2DM and pure SNHL.

A broader dataset of 170 patients with T2DM and available audiometric classifications was used solely to describe the distribution of hearing loss types. This dataset included the 112 patients with pure SNHL, 35 with mixed hearing loss, and 23 with conductive hearing loss. Patients with mixed or conductive hearing loss were not included in the analyses of SNHL severity.

Study variables and outcome assessment

Age was defined as the patient's age at the reference audiometric examination and categorized as ⩽46 or >46 years. Sex was obtained from the medical record and categorized as male or female. Diabetes duration was defined as the documented interval between T2DM diagnosis and the reference audiometric examination and categorized as <5 or ⩾5 years. This measure represented time since documented diagnosis rather than the actual onset of hyperglycemia.

The primary outcome was SNHL severity, extracted directly from the category documented in the medical record or audiometry report. Recorded categories were mild, moderate, moderately severe, severe, and profound. For the association analyses, these categories were combined into mild-moderate and moderately severe-profound groups. The grouped outcome distinguished patients with recorded mild or moderate SNHL from those with recorded moderately severe, severe, or profound SNHL.

The outcome represented the clinical severity classification documented in routine care rather than a classification independently reconstructed by the investigators. Severity categories were not reassigned through recalculation of frequency-specific hearing thresholds or converted into estimated numerical pure-tone averages. The patient was the unit of analysis, with one observation representing each patient.

Data collection and management

Extracted information included coded patient identifiers, age at audiometric examination, sex, documented diabetes duration, hearing loss type, and SNHL severity. Data were checked for completeness, coded, entered, and cleaned before analysis. Only records with complete information on the required variables were included in the primary analysis.

Statistical analysis

Analyses were performed using the Statistical Package for the Social Sciences (SPSS) (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY). Categorical variables were summarized as frequencies and percentages. Patient characteristics and SNHL severity were described using the 112-patient analytical sample, whereas hearing loss types were described separately using the 170-patient descriptive dataset.

Associations between each explanatory variable and the two-category SNHL severity outcome were evaluated separately using Pearson's chi-square test without continuity correction when all expected cell frequencies were ⩾5. A two-sided Fisher's exact test was specified for comparisons that did not meet this requirement. Statistical significance was defined as $p < 0.05$. Percentages in association tables were calculated within rows.

The analyses were bivariate, and no multivariable adjustment was performed. Consequently, the findings were interpreted as unadjusted associations. Potential confounders, including glycemic control, hypertension, dyslipidemia, smoking, and other relevant exposures, were not jointly controlled because these data were not consistently available.

Results

Study sample

The descriptive dataset comprised 170 patients with T2DM and documented audiometric classifications. Of these, 112 (65.9%) had pure SNHL, 35 (20.6%) had mixed hearing loss, and 23 (13.5%) had conductive hearing loss. The 112 eligible patients with pure SNHL constituted the analytical sample. Patients with mixed or conductive hearing loss were excluded from the analyses of SNHL severity. The distribution of hearing loss types in the descriptive dataset is presented in Table *1*.

Hearing loss type	Patients, n	Percentage (%)
Pure sensorineural hearing loss	112	65.9
Mixed hearing loss	35	20.6
Conductive hearing loss	23	13.5
Total	170	100.0

TABLE 1: Distribution of hearing loss types in the descriptive dataset

Percentages were calculated using the descriptive dataset of 170 patients. Only the 112 eligible patients with pure sensorineural hearing loss were included in the primary association analyses.

Patient characteristics and hearing loss severity

Among the 112 patients in the analytical sample, 92 (82.1%) were aged >46 years, 66 (58.9%) were male, and 69 (61.6%) had a documented diabetes duration of ⩾5 years. Moderate SNHL was the most frequently recorded severity category, affecting 44 patients (39.3%), followed by mild SNHL in 34 (30.4%), severe SNHL in 25 (22.3%), and profound SNHL in nine (8.0%). No patients were classified as having moderately severe SNHL. After grouping the recorded severity categories for analysis, 78 patients (69.6%) had mild-moderate SNHL and 34 (30.4%) had moderately severe-profound SNHL. Patient characteristics and severity distributions are summarized in Table *2*.

Characteristic	Category	Patients, n (%)
Age	≤46 years	20 (17.9)
	>46 years	92 (82.1)
Sex	Male	66 (58.9)
	Female	46 (41.1)
Diabetes duration	<5 years	43 (38.4)
	≥5 years	69 (61.6)
Recorded SNHL severity	Mild	34 (30.4)
	Moderate	44 (39.3)
	Moderately severe	0 (0.0)
	Severe	25 (22.3)
	Profound	9 (8.0)
Grouped SNHL severity	Mild-moderate	78 (69.6)
	Moderately severe-profound	34 (30.4)

TABLE 2: Characteristics and recorded hearing loss severity of patients in the analytical sample

Values are presented as n (%), with percentages calculated using the analytical sample of 112 patients. Severity categories were extracted from existing medical records or audiometry reports. The grouped categories represent the same patients and were used for the association analyses.

SNHL: sensorineural hearing loss

Associations with sensorineural hearing loss severity

The proportion of patients with moderately severe-profound SNHL was higher among those aged >46 years than among those aged ⩽46 years (35.9% versus 5.0%). Age was significantly associated with SNHL severity ($\chi^2(1) = 7.405$; $p = 0.0065$).

Moderately severe-profound SNHL was recorded in 40.9% of male patients and 15.2% of female patients. Sex was significantly associated with SNHL severity ($\chi^2(1) = 8.463$; $p = 0.0036$).

Among patients with a diabetes duration of ⩾5 years, 42.0% had moderately severe-profound SNHL, compared with 11.6% of those with a duration of <5 years. Diabetes duration was significantly associated with SNHL severity ($\chi^2(1) = 11.581$; $p = 0.0007$). All three comparisons used Pearson's chi-square test, and all expected cell frequencies were ⩾5. The unadjusted associations are presented in Table *3*.

Variable	Category	Mild-moderate, n (%)	Moderately severe-profound, n (%)	Total, n	χ^2	df	p-value
Age	≤46 years	19 (95.0)	1 (5.0)	20	7.405	1	0.0065
	>46 years	59 (64.1)	33 (35.9)	92	-	-	-
Sex	Male	39 (59.1)	27 (40.9)	66	8.463	1	0.0036
	Female	39 (84.8)	7 (15.2)	46	-	-	-
Diabetes duration	<5 years	38 (88.4)	5 (11.6)	43	11.581	1	0.0007
	≥5 years	40 (58.0)	29 (42.0)	69	-	-	-

TABLE 3: Associations of age, sex, and diabetes duration with sensorineural hearing loss severity (N = 112)

Values are presented as n (%), with percentages calculated within each row. Associations were evaluated using Pearson's chi-square test without continuity correction. Each χ^2 statistic and p-value applies to the comparison between the two categories of the corresponding explanatory variable. All comparisons had one degree of freedom, and all expected cell frequencies were ≥5. Analyses were bivariate and unadjusted for potential confounders. Dashes indicate that the same comparison is not reported twice.

df: degrees of freedom; SNHL: sensorineural hearing loss; χ^2: chi-square statistic

Discussion

Principal findings

This study identified significant associations of age, sex, and diabetes duration with SNHL severity among 112 patients with T2DM and documented pure SNHL. The proportion with moderately severe-profound SNHL was higher among patients aged >46 years, men, and those with a diabetes duration of ⩾5 years. These findings describe differences in severity within a population that already had SNHL. Because the analyses were bivariate, they do not establish that these characteristics were independently associated with severity after adjustment for other factors.

Biological context and comparison with previous research

Diabetes-related cochlear abnormalities provide a possible biological context for the observed findings. Fukushima et al. demonstrated cochlear vessel wall thickening, stria vascularis atrophy, and outer hair cell loss in human temporal bones from patients with T2DM [3]. Such abnormalities could contribute to impaired auditory function, although the present study did not directly assess cochlear pathology or establish the mechanisms responsible for individual patients' hearing loss.

Metabolic and vascular characteristics may also contribute to variation in hearing impairment. In an Indonesian case-control study, Santosa et al. reported associations of elevated low-density lipoprotein cholesterol and reduced high-density lipoprotein cholesterol with SNHL among patients with T2DM [6]. That study examined the presence of SNHL rather than severity among patients already affected. Nevertheless, its findings highlight potentially relevant metabolic factors that were not consistently available for adjustment in the present analysis.

Association between age and hearing loss severity

Patients aged >46 years had a higher proportion of moderately severe-profound SNHL than those aged ⩽46 years (35.9% versus 5.0%). This finding is consistent with Srinivas et al., who reported increasing hearing thresholds with advancing age among patients with T2DM [4]. Bainbridge et al. also found that adults with diabetes and hearing impairment were older than those without hearing impairment [5]. Differences in populations and outcome definitions, however, limit direct comparison with the present severity-based analysis.

The age association should be interpreted with particular attention to overlapping causes of auditory impairment. Age-related changes may coexist with diabetes-related cochlear abnormalities, and their respective contributions cannot be separated using the present data. Furthermore, the >46-year category is an analytical grouping and should not be interpreted as a diagnostic threshold for presbycusis. Without adjustment for diabetes duration, glycemic control, and other relevant factors, the observed association cannot be attributed specifically to aging or diabetes-related injury.

Association between sex and hearing loss severity

The proportion with moderately severe-profound SNHL was higher in men than in women (40.9% versus 15.2%). Previous findings concerning sex differences have varied. Bainbridge et al. observed a greater proportion of men among diabetic adults with high-frequency hearing impairment, but did not identify a corresponding sex difference for low/mid-frequency impairment [5]. Conversely, Srinivas et al. reported no significant sex difference in their clinical sample [4]. These studies assessed different auditory outcomes and therefore provide contextual comparisons rather than direct replication.

The present study cannot determine why severity differed between men and women. Differences in age, diabetes duration, metabolic status, or exposure histories could contribute to the observed pattern. Although documented alternative causes of hearing loss were addressed through the exclusion criteria, incomplete records cannot establish the absence of previous exposures. Hormonal, occupational, and behavioral explanations consequently remain hypotheses rather than demonstrated mechanisms in this sample.

Association between diabetes duration and hearing loss severity

Moderately severe-profound SNHL was more frequent among patients with a diabetes duration of ⩾5 years than among those with a duration of <5 years (42.0% versus 11.6%). This pattern is consistent with the association between longer diabetes duration and higher hearing thresholds reported by Srinivas et al. [4]. However, Bainbridge et al. did not find an association between diabetes duration and hearing impairment [5], indicating that the relationship is not consistently demonstrated across study settings.

Longer documented diabetes duration may reflect a longer opportunity for metabolic and vascular injury, but it does not directly measure cumulative hyperglycemic exposure. Diabetes may also remain undiagnosed for some time, making the interval since recorded diagnosis shorter than the actual disease duration. Because longitudinal glycemic measurements were unavailable, this study could not distinguish the contribution of disease duration from glycemic control. Age and diabetes duration were also not jointly adjusted.

Clinical implications

These findings suggest that hearing loss severity merits attention when evaluating patients with T2DM who already have SNHL. In this clinical sample, older age, male sex, and longer documented diabetes duration characterized groups with a greater proportion of more severe impairment. These characteristics may inform clinical assessment, but they are not validated prediction criteria. The study did not evaluate screening effectiveness, treatment response, or whether improved glycemic control prevents hearing deterioration.

Strengths and limitations

A strength of this study was its focus on severity among patients with documented pure SNHL, with mixed and conductive hearing loss excluded from the primary analysis. The separate presentation of the broader descriptive dataset also maintained a clear distinction between hearing loss type and SNHL severity.

Several limitations should be considered. First, the retrospective cross-sectional design prevented assessment of hearing deterioration over time or establishment of temporal and causal relationships. Second, data completeness depended on routine clinical documentation. Glycemic control, hypertension, dyslipidemia, smoking, noise exposure, and other potentially relevant factors were not consistently available. Applying exclusion criteria to documented histories could not eliminate residual confounding.

Third, severity was extracted from existing medical records or audiometry reports without repeat audiometric testing or recalculation of frequency-specific thresholds. Incomplete ear-specific and frequency-specific information prevented systematic evaluation of asymmetry and audiometric configuration. Reliance on recorded severity categories also limited independent verification of the consistency of classification across patients. Any variation in the original clinical classification could have introduced outcome misclassification, and its potential influence on the observed associations could not be quantified.

Combining severity into two categories simplified the analysis but reduced information about differences within each group. Categorizing age and diabetes duration similarly limited assessment of continuous relationships and dose-response patterns. The selected age and diabetes-duration cutoffs should not be interpreted as biological thresholds at which hearing impairment begins or worsens. The findings may differ when alternative cutoffs or continuous-variable analyses are used.

Fourth, the bivariate analyses did not establish independent associations. The relatively small younger-age subgroup, including only one patient with moderately severe-profound SNHL, also warrants cautious interpretation.

Finally, selection was restricted to patients attending a single otolaryngology outpatient clinic who underwent audiometry and had complete information on the required study variables. These patients may

differ from those who were not referred for audiometry or had incomplete records, introducing potential referral and complete-case selection bias. The findings therefore concern severity among selected patients with established SNHL and cannot estimate the occurrence or risk of SNHL in the broader population with T2DM. The descriptive proportion of pure SNHL among 170 patients should not be interpreted as its prevalence in the general population with T2DM. Prospective studies with standardized audiometry, longitudinal glycemic measurements, and multivariable analyses are needed to clarify these relationships.

Conclusions

Age, sex, and diabetes duration were significantly associated with SNHL severity among patients with T2DM in this study. The proportion with moderately severe-profound hearing loss was higher among patients aged >46 years, men, and those with a documented diabetes duration of ⩾5 years. These findings represent unadjusted associations within a single-center sample of patients who already had SNHL and do not establish independent or causal effects. Prospective studies incorporating standardized audiometric assessment, glycemic control measurements, and multivariable adjustment are needed to clarify these relationships.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Mangde Anata Sindhu, Agus Santosa, Made Gita Ratnasari

Acquisition, analysis, or interpretation of data: Mangde Anata Sindhu, Agus Santosa, Made Gita Ratnasari, I Made Wiranadha

Drafting of the manuscript: Mangde Anata Sindhu

Critical review of the manuscript for important intellectual content: Mangde Anata Sindhu, Agus Santosa, Made Gita Ratnasari, I Made Wiranadha

Supervision: Agus Santosa, Made Gita Ratnasari, I Made Wiranadha

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Health Research Ethics Committee of Prof. Dr. I.G.N.G. Ngoerah General Hospital issued approval PS.02.03/D.XVI.17.4/0009/2026. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements

ChatGPT (OpenAI, San Francisco, CA) was used to assist with English translation, manuscript organization, and drafting of manuscript sections based on the authors' thesis and study findings. The authors retain responsibility for the accuracy, interpretation, references, and final content of the manuscript.

References

1. Bainbridge KE, Hoffman HJ, Cowie CC: Diabetes and hearing impairment in the United States: audiometric evidence from the National Health and Nutrition Examination Survey, 1999 to 2004. Ann Intern Med. 2008, 149:1-10. 10.7326/0003-4819-149-1-200807010-00231
2. Kim MB, Zhang Y, Chang Y, et al.: Diabetes mellitus and the incidence of hearing loss: a cohort study . Int J Epidemiol. 2017, 46:717-26. 10.1093/ije/dyw243
3. Fukushima H, Cureoglu S, Schachern PA, Paparella MM, Harada T, Oktay MF: Effects of type 2 diabetes mellitus on cochlear structure in humans. Arch Otolaryngol Head Neck Surg. 2006, 132:934-8. 10.1001/archotol.132.9.934
4. Srinivas CV, Shyamala V, Shiva Kumar BR: Clinical study to evaluate the association between sensorineural hearing loss and diabetes mellitus in poorly controlled patients whose HbA1c >8. Indian J Otolaryngol Head Neck Surg. 2016, 68:191-5. 10.1007/s12070-016-0973-5
5. Bainbridge KE, Hoffman HJ, Cowie CC: Risk factors for hearing impairment among U.S. adults with diabetes: National Health and Nutrition Examination Survey 1999-2004. Diabetes Care. 2011, 34:1540-5.

10.2337/dc10-2161

6. Santosa A, Saraswati MR, Suastika K, Sulistiawan IW, Laksmi PP, Devinta MRS: Pengaruh profil lipid terhadap gangguan pendengaran sensorineural pada pasien Diabetes Mellitus Tipe II di Poli Diabetic Centre RSUP Prof. Ngoerah. Ngoerah Intisari Sains Medis. 2023, 14:1222-6. 10.15562/ism.v14i3.1834