

Association between Diabetes Mellitus and Sensorineural Hearing Loss: An Exposure-Based Cross-Sectional Study

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Abstract

Diabetes mellitus is a chronic metabolic disorder associated with microvascular and neuropathic complications, and emerging evidence suggests that auditory dysfunction may be one of its under-recognised consequences. This exposure-based cross-sectional study investigated the association between diabetes mellitus and sensorineural hearing loss by comparing auditory function in diabetic patients and age- and sex-frequency-matched non-diabetic comparison participants. A total of 120 participants were included, comprising 60 diabetic patients and 60 non-diabetic participants. Clinical information, diabetes-related variables, and pure-tone audiometric findings were assessed. Sensorineural hearing loss was more prevalent among diabetic patients than non-diabetic participants on unadjusted analysis (43.3% versus 8.3%). Multivariable logistic regression showed that diabetes status remained independently associated with sensorineural hearing loss after adjustment for controlled hypertension and age (adjusted odds ratio = 11.61, 95% confidence interval: 3.78 - 35.63, $p < 0.001$). In the diabetic subgroup, each 1-year increase in diabetes duration was independently associated with higher odds of sensorineural hearing loss (adjusted odds ratio = 2.09, 95% confidence interval: 1.46 - 2.98, $p < 0.001$). Bilateral involvement was more common than unilateral loss, and mild sensorineural hearing loss was the most frequent severity category. These findings support an independent association between diabetes mellitus and sensorineural hearing impairment, with longer disease duration associated with a higher likelihood of sensorineural hearing loss among diabetic patients.

Keywords

Diabetes Mellitus, Sensorineural Hearing Loss, Hearing Impairment, Pure-Tone Audiometry, HbA1c, Exposure-Based Cross-Sectional Study

1. Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Its global burden is rising rapidly, especially in low- and middle-income countries, and it is associated with multiple microvascular and neuropathic complications [1] [2]. Hearing impairment is also a major public health concern and can adversely affect communication, social participation, and quality of life [3] [4].

Diabetes-related hearing loss is typically described as progressive, bilateral, and sensorineural, with early involvement of higher frequencies [5] [6]. Proposed mechanisms include cochlear microangiopathy, oxidative stress, inflammatory endothelial dysfunction, degeneration of the stria vascularis, injury to outer hair cells, and secondary involvement of the eighth cranial nerve [7]-[9]. Because sensorineural hearing loss (SNHL) is usually irreversible, early detection among patients with diabetes may have practical value for counseling, auditory rehabilitation, and better communication during clinical care [10].

Several studies and systematic reviews have reported a higher frequency of hearing impairment in diabetic patients than in non-diabetic controls, although findings are not completely consistent across populations and study designs [11] [12]. Dalton *et al.* found only a modest association after adjustment [13], while Horikawa *et al.* reported a pooled odds ratio of 2.15 for hearing impairment among diabetic adults [14]. Other studies have linked diabetes, glycaemic control, and duration of disease with new-onset hearing loss or high-frequency SNHL [15]-[21]. Conversely, some longitudinal data have not shown a consistent association between diabetes and the rate of hearing decline [22].

In Bangladesh and similar resource-limited settings, both diabetes and untreated hearing impairment may be under-recognised in routine care. This study, therefore, aimed to investigate the association between diabetes mellitus and sensorineural hearing loss by comparing pure-tone audiometric findings between diabetic patients and age- and sex-frequency-matched non-diabetic comparison participants, and by assessing whether diabetes remained associated with SNHL after adjustment for age and controlled hypertension.

2. Methods

2.1. Study Design and Setting

This was an exposure-based cross-sectional study comparing diabetic patients with age- and sex-frequency-matched non-diabetic comparison participants. The study was conducted in the Department of ENT and Head-Neck Surgery and the Department of Endocrinology at Cumilla Medical College Hospital, Cumilla. The study period was six months, from 1 October 2025 to 31 March 2026.

2.2. Study Population and Sampling

The study population consisted of diabetic patients attending the Department of

Endocrinology and non-diabetic comparison participants recruited from patients and attendants in the Department of General Medicine. A consecutive sampling method was used in both groups. Matching was frequency-based rather than individual pair matching; the comparison group was recruited to achieve an age and sex distribution comparable to the diabetic group. Eligible diabetic patients and non-diabetic comparison participants were invited to participate until the target sample size was reached.

2.3. Sample Size

The sample size was calculated using proportions of sensorineural hearing loss reported by Mozaffari *et al.* [23], where p_1 was 45% among diabetic patients and p_2 was 20% among non-diabetic participants. With $Z\alpha = 1.96$, $Z\beta = 0.84$, and a 1:1 exposure-group ratio, the calculated sample size was 55.03 per group. After allowing for 10% dropout, the adjusted sample size was approximately 60 participants per group. Therefore, 120 participants were included: 60 diabetic and 60 non-diabetic participants.

2.4. Eligibility Criteria

Diabetic patients were included if they had a confirmed diagnosis of diabetes mellitus, were aged below 60 years, were willing to participate and undergo relevant investigations, and had only well-controlled comorbid conditions when present. For this study, diabetes in the diabetic group was confirmed from a documented physician diagnosis and/or current antidiabetic medication history, supported by review of available medical records; HbA1c was recorded as part of the diabetes profile. Fasting plasma glucose was not used as a study screening criterion. Non-diabetic comparison participants were age- and sex-frequency matched, below 60 years of age, apparently healthy without diabetes, and willing to participate; non-diabetic status was based on no known history of diabetes mellitus, no current antidiabetic medication use, and review of available records when present.

Participants were excluded if they had uncontrolled hypertension, chronic renal failure, current or past use of known ototoxic medications, active ear infection or discharge, chronic ear disease such as chronic suppurative otitis media, otitis media with effusion or otosclerosis, previous ear surgery, congenital ear anomalies, occupational noise exposure, acoustic trauma, significant ear trauma, or persistent ear discharge.

2.5. Data Collection and Audiological Assessment

After history taking and clinical examination, participants were allocated into Group A, consisting of diabetic patients, and Group B, consisting of non-diabetic comparison participants. Data were recorded in a semi-structured questionnaire. Demographic information, diabetes type, duration of diabetes, HbA1c, comorbidities including hypertension and dyslipidemia, auditory symptoms, ototoxic drug history, and relevant ENT examination findings were recorded. Hearing assess-

ment was performed using pure-tone audiometry (PTA), with PTA calculated from thresholds at 0.5, 1, 2, and 4 kHz. Occupational noise exposure and acoustic trauma were assessed for exclusion and were not analysed as independent exposures.

Hearing impairment was classified using the World Health Organization better-ear PTA grading system (**Table 1**) [24]. At the ear level, SNHL was defined as an average hearing threshold of at least 20 dB HL at 0.5, 1, 2, and 4 kHz, with a sensorineural audiometric pattern and no conductive or mixed hearing loss after ENT examination. At the participant level, SNHL was classified as present when either ear met this criterion. Unilateral SNHL was defined as SNHL in one ear only, whereas bilateral SNHL was defined as SNHL in both ears. Severity grading was based on the better-ear PTA according to the WHO categories shown in **Table 1**.

Table 1. WHO grades of hearing impairment based on better-ear pure-tone average.

Grade	Average Hearing Threshold (dB HL)	Impairment Description
0 - No Impairment	≤19 dB	No or very slight hearing problems
1 - Mild	20 - 34 dB	Difficulty hearing soft speech
2 - Moderate	35 - 49 dB	Difficulty following conversation in noise
3 - Moderately Severe	50 - 64 dB	Requires a raised voice at 1 m
4 - Severe	65 - 79 dB	Understands only shouted words close to the ear
5 - Profound	≥80 dB	Unable to understand the shouted voice

Note: Hearing impairment grades are based on the better-ear pure-tone average at 0.5, 1, 2, and 4 kHz.

2.6. Statistical Analysis

Data were checked, cleaned, and entered into SPSS version 16.0 for analysis. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were expressed as frequency and percentage. Independent-sample t-tests were used for continuous variables and Chi-square tests for categorical variables. Because matching was frequency-based rather than individual pair matching, conditional logistic regression was not required; therefore, multivariable binary logistic regression was used with SNHL status as the dependent variable. Diabetes status, controlled hypertension, and age were entered as independent variables in the full-sample model. Sex was not entered because the sex distribution was identical between the diabetic and non-diabetic groups. Because diabetes duration was applicable only to diabetic participants, a separate diabetic-subgroup logistic regression model was performed using diabetes duration, controlled hypertension,

and age as covariates. Diabetes duration was measured in years; therefore, the aOR for diabetes duration represents the change in odds for each 1-year increase. HbA1c and dyslipidemia were recorded but were not entered into the diabetic-subgroup model because the limited number of SNHL events would have made a model with additional covariates unstable and potentially overfit. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported. A p-value < 0.05 was considered statistically significant.

2.7. Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of Cumilla Medical College Hospital, and permission was obtained from the relevant departments. All participants were informed about the objectives, benefits, and potential risks of the study, and written consent was obtained. Confidentiality was maintained, and participants retained the right to withdraw at any stage. Necessary treatment was provided for any complication arising in relation to the study.

3. Results

A total of 120 participants were included, comprising 60 diabetic patients and 60 non-diabetic comparison participants. Participants were aged between 30 and 59 years. Baseline characteristics are shown in **Table 2**. Age and sex distribution were similar between groups, whereas controlled hypertension was significantly more frequent among diabetic patients.

Table 2. Comparison of baseline characteristics between diabetic patients and non-diabetic comparison participants.

Variable	Diabetic (n = 60)	Non-Diabetic (n = 60)	Test	p Value
Age, Mean $\pm$ SD (Years)	45.67 $\pm$ 8.59	45.50 $\pm$ 8.79	t = 0.11	0.915
Male Sex	28 (46.7%)	28 (46.7%)	$\chi^2 = 0.00$	1.000
Controlled Hypertension	20 (33.3%)	7 (11.7%)	$\chi^2 = 8.08$	0.004

Note: Student's t-test was used for age; the Chi-square test was used for categorical variables.

Among the 60 diabetic patients, 48 (80.0%) had type 2 diabetes mellitus and 12 (20.0%) had type 1 diabetes mellitus. The mean duration of diabetes was 7.56 years $\pm$ 3.53 years among type 1 diabetic patients and 6.40 years $\pm$ 3.20 years among type 2 diabetic patients. Mean HbA1c values were 7.48% $\pm$ 0.50% and 7.27% $\pm$ 0.65%, respectively.

The unadjusted association between diabetes status and SNHL is shown in **Table 3**. SNHL was detected in 26 diabetic patients (43.3%) and 5 non-diabetic comparison participants (8.3%), showing a statistically significant difference between groups ($\chi^2 = 19.18$, p < 0.001).

Table 3. Association between diabetes status and sensorineural hearing loss.

SNHL	Diabetic (n = 60)	Non-Diabetic (n = 60)	χ^2	p Value
Present	26 (43.3%)	5 (8.3%)	19.18	<0.001
Absent	34 (56.7%)	55 (91.7%)		

Note: Chi-square test was used for the unadjusted association. Adjusted logistic regression results are shown in **Table 4**.

In the adjusted full-sample logistic regression model, diabetes status remained independently associated with SNHL after adjustment for controlled hypertension and age (**Table 4**). Diabetic participants had 11.61 times higher adjusted odds of SNHL than non-diabetic comparison participants (aOR = 11.61, 95% CI: 3.78 - 35.63, $p < 0.001$). Controlled hypertension and age were not independently associated with SNHL in this model.

Table 4. Multivariable logistic regression model for factors associated with sensorineural hearing loss.

Covariate	aOR	95% CI	p Value
Diabetes Status	11.61	3.78 - 35.63	<0.001
Controlled Hypertension	0.34	0.11 - 1.08	0.067
Age	1.05	0.99 - 1.11	0.085

Note: SNHL = sensorineural hearing loss; CI = confidence interval; aOR = adjusted odds ratio. Diabetes duration was excluded from the full-sample model because it was not applicable to non-diabetic comparison participants.

Because diabetes duration was applicable only to diabetic participants, a separate diabetic-subgroup logistic regression model was performed (**Table 5**). Diabetes duration was measured in years. Each 1-year increase in diabetes duration was independently associated with higher odds of SNHL (aOR = 2.09, 95% CI: 1.46 - 2.98, $p < 0.001$), while controlled hypertension and age were not independently associated with SNHL in this model.

Table 5. Multivariable logistic regression model for factors associated with sensorineural hearing loss among diabetic patients.

Covariate	aOR	95% CI	p Value
Diabetes Duration (per 1-Year Increase)	2.09	1.46 - 2.98	<0.001
Controlled Hypertension	0.19	0.03 - 1.10	0.063
Age	0.98	0.89 - 1.07	0.626

Note: This model included diabetic patients only (n = 60). Diabetes duration was measured in years; the aOR for diabetes duration represents the change in odds for each 1-year increase.

The severity distribution of SNHL is presented in **Table 6**. Mild SNHL was the most common severity category. Among diabetic patients with SNHL, 16 (61.5%) had mild and 10 (38.5%) had moderate SNHL, whereas all affected non-diabetic participants had mild SNHL.

Table 6. Severity of sensorineural hearing loss among affected participants.

Severity	Diabetic SNHL (n = 26)	Non-Diabetic SNHL (n = 5)	χ^2	P Value
Mild	16 (61.5%)	5 (100.0%)	2.84	0.092
Moderate	10 (38.5%)	0 (0.0%)		

Note: Chi-square test was used. SNHL = sensorineural hearing loss.

The exploratory distribution of SNHL by type of diabetes is shown in **Table 7**. SNHL was observed in 66.7% of type 1 diabetic patients and 37.5% of type 2 diabetic patients; however, this comparison should be interpreted cautiously because only 12 participants had type 1 diabetes.

Table 7. Exploratory distribution of sensorineural hearing loss by type of diabetes mellitus.

Type of Diabetes	SNHL Present	SNHL Absent	χ^2	p Value
Type 1 Diabetes Mellitus (n = 12)	8 (66.7%)	4 (33.3%)	3.33	0.068
Type 2 Diabetes Mellitus (n = 48)	18 (37.5%)	30 (62.5%)		

Note: Chi-square test was used. SNHL = sensorineural hearing loss.

Bilateral SNHL was more common than unilateral involvement. Among diabetic patients with SNHL, 69.2% had bilateral loss and 30.8% had unilateral loss. SNHL was more frequent among patients with longer diabetes duration; among diabetic patients with SNHL, 7.7% had diabetes for 0 - 5 years, 53.8% for 6 - 10 years, and 38.5% for more than 10 years.

4. Discussion

This exposure-based cross-sectional study found that SNHL was substantially more frequent among diabetic patients than among age- and sex-frequency-matched non-diabetic comparison participants. The association remained statistically significant after adjustment for controlled hypertension and age, suggesting that diabetes status was independently associated with SNHL in this study population. Longer diabetes duration was also independently associated with higher odds of SNHL among diabetic patients.

The prevalence of SNHL among diabetic patients in the present study was 43.3%, compared with 8.3% among non-diabetic participants. This finding is con-

sistent with studies reporting higher frequencies of auditory impairment among diabetic patients. Al-Hameed reported hearing loss in 72.3% of diabetic participants compared with 27.7% of controls [21], while Kanabi and Dzayii observed SNHL in 52% of diabetic participants and 20% of non-diabetic participants [25]. Al-Rubeaan *et al.* also identified hearing impairment as an under-recognised comorbidity of type 2 diabetes mellitus [17].

The present adjusted model showed an aOR of 11.61 for the association between diabetes status and SNHL. This estimate is higher than pooled estimates from some systematic reviews, including Horikawa *et al.*, who reported a pooled odds ratio of 2.15 [14]. The higher estimate in the present study may reflect differences in sample characteristics, hospital-based recruitment, exclusion of major alternative causes of hearing loss, local population factors, or the relatively low prevalence of SNHL in the non-diabetic comparison group. The confidence interval was wide, indicating that the effect estimate should be interpreted cautiously.

The finding that longer diabetes duration was independently associated with SNHL supports the biological plausibility of cumulative metabolic and microvascular injury to the auditory system. Similar observations have been reported by Al-Rubeaan *et al.* [17] and Vyas and Ranga [26], who described relationships between duration of diabetes, glycaemic control, and the severity of hearing impairment. Chronic hyperglycemia may contribute to microangiopathy, oxidative stress, and neural dysfunction within the cochlea and auditory pathway [7]-[9]. Although HbA1c and dyslipidemia were recorded, they were not included in the diabetic-subgroup regression model because the number of SNHL events was limited, and adding further covariates could have produced an unstable, overfitted model. Therefore, the discussion of glycaemic control should be interpreted as biologically relevant and descriptive rather than as an independently adjusted effect in this dataset.

Mild SNHL was the most common severity category in this study. This pattern is clinically important because mild hearing loss may be overlooked during routine diabetic follow-up, despite its effect on communication and quality of life. The predominance of bilateral involvement also supports the concept that diabetes-related SNHL may reflect systemic vascular or metabolic pathology rather than isolated local ear disease. Routine or periodic hearing screening may therefore be useful, particularly in patients with longer duration of diabetes or poor glycaemic control.

The exploratory comparison between type 1 and type 2 diabetes showed a higher proportion of SNHL among type 1 diabetic patients. However, the type 1 subgroup included only 12 participants, making this analysis underpowered. The non-significant p-value should not be interpreted as evidence of equivalence or comparability between diabetes types. Larger studies with adequate numbers of both type 1 and type 2 diabetic patients are needed to clarify whether hearing outcomes differ by diabetes type.

The findings should be interpreted within the context of the exposure-based

cross-sectional design. Participants were selected according to diabetes exposure status rather than hearing-loss status. Therefore, the study can estimate association and support adjusted analysis, but it cannot establish temporality or prove causality. Longitudinal studies are needed to determine whether diabetes precedes progressive hearing impairment and how auditory risk changes over time.

4.1. Limitations

- Previous audiometric records were not available, so it was not possible to determine whether hearing impairment developed before or after the diagnosis of diabetes.
- Hearing assessment was mainly based on pure-tone audiometry. Tests that could detect early cochlear or neural changes, such as otoacoustic emission, auditory brainstem response, and high-frequency audiometry, were not included.
- Glycaemic status was assessed by HbA1c at the time of the study, but long-term diabetic control over several years could not be evaluated.
- The non-diabetic comparison group was hospital-based and may not represent the general non-diabetic population. Because hospital attendees may differ from community controls in comorbidity burden or health-seeking behaviour, the observed diabetes-SNHL association could be influenced by selection bias, and the findings may not be fully generalisable to the wider population.
- The type 1 diabetes subgroup was small, making the study underpowered to compare SNHL frequency, laterality, or severity between type 1 and type 2 diabetes.
- Although multivariable logistic regression was performed, the number of SNHL events was limited, resulting in relatively wide confidence intervals for some adjusted estimates.

4.2. Recommendations

- Periodic pure-tone audiometry may be considered for diabetic patients, particularly those with longer disease duration or poor glycaemic control.
- Future studies should include larger samples with community-based comparison groups and balanced cardiovascular risk profiles.
- Studies with sufficient numbers of both type 1 and type 2 diabetic patients are needed to compare hearing outcomes between diabetes types.
- Future researchers should include otoacoustic emission, auditory brainstem response, and high-frequency audiometry to detect early auditory involvement in diabetes.
- Longitudinal follow-up is recommended to clarify temporality, causal pathways, and the progression of diabetes-related hearing impairment.

5. Conclusions

This exposure-based cross-sectional study demonstrated an independent associa-

tion between diabetes mellitus and sensorineural hearing impairment. SNHL was substantially more frequent among diabetic patients than among age- and sex-frequency-matched non-diabetic comparison participants. After adjustment for controlled hypertension and age, diabetes status remained significantly associated with SNHL (aOR = 11.61, 95% CI: 3.78 - 35.63, $p < 0.001$). Among diabetic patients, each 1-year increase in diabetes duration was also independently associated with higher odds of SNHL (aOR = 2.09, 95% CI: 1.46 - 2.98, $p < 0.001$).

These findings support the view that auditory dysfunction should be considered an important but often under-recognised concern in patients with diabetes mellitus. Incorporating routine hearing screening into diabetic care may help identify hearing impairment earlier, allow timely counseling and intervention, and improve communication-related quality of life. Further, larger, preferably community-based and longitudinal studies are recommended to clarify temporality and the progression of diabetes-related hearing impairment.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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