International Clinical and Medical Case Reports Journal
Original Research Article (ISSN: 2832-5788)

# A Study of Assessment of Auditory Dysfunction in Prediabetes and Type 2 Diabetes Mellitus

**Kuldeep Gurjar[1], Bharat Malhotra[2], Priyank Dhiman[3], Ritu Grewal[4], Neel Kanth Issar[5*], Manasvi Kalra[6], Abhay Rajpurohit[7], Nishchay Dhiman[8], Nidhi Sharma[9], Riddhima Juneja[10]**

[1]Senior Resident, Department of Gastroenterology and Transplant Hepatology, Army Hospital (R&R), Delhi, India

[2]Associate Professor, Department of Internal Medicine, Army Hospital (R&R), Delhi, India

[3]Associate Professor, Department of Gastroenterology and Transplant Hepatology, Army Hospital (R&R), Delhi, India

[4]Associate Professor, Department of Anesthesiology, Base Hospital, Delhi Cantt

[5]Senior Resident, Department of Gastroenterology and Transplant Hepatology, Army Hospital (R&R), Delhi, India

[6]Senior Resident, Department of Gastroenterology and Transplant Hepatology, Army Hospital (R&R), Delhi, India

[7]Senior Resident, Department of Gastroenterology and Transplant Hepatology, Army Hospital (R&R), Delhi, India

[8]Research Fellow, Delhi Technical University, Delhi, India

[9]Consultant, BLK Max, Delhi, India

[10]Consultant, SGRH, Delhi, India

**Citation:** *Kuldeep Gurjar, Bharat Malhotra, Priyank Dhiman, Ritu Grewal, Neel Kanth Issar, Manasvi Kalra, et al. A Study of Assessment of Auditory Dysfunction in Prediabetes and Type 2 Diabetes Mellitus. Int Clinc Med Case Rep Jour. 2025;4(10):1-12.*

**Received Date:** 29 September 2025**; Accepted Date:** 01 October 2025**; Published Date:** 02 October 2025

***Corresponding author:** Neel Kanth Issar (*Senior Resident, Department of Gastroenterology and Transplant Hepatology, Army Hospital (R&R), Delhi, India



'ICMCRJ is indexed in Google Scholar, Crossref, DOI, ResearchGate, Open AIRE and ISI'

## ABSTRACT

**Background:** Diabetes is associated with various macrovascular and microvascular complications. Current data suggest both type 1 and type 2 diabetes are associated with sensorineural hearing loss as a microvascular complication. On the other hand, data on prediabetes causing sensorineural hearing loss is limited and not conclusive. In this study, we aimed to investigate the prevalence of auditory dysfunction in type 2 diabetes mellitus and prediabetes. It also aimed to correlate the association between auditory dysfunction and various clinical and laboratory parameters.

**Methodology:** The study was conducted at the tertiary care hospital in Delhi aimed to assess auditory dysfunction in prediabetes and type 2 diabetes mellitus. 89 subjects were included in the study after screening and consent. Out of 89 subjects, 45 were categorized as pre-diabetes and 44 were diabetes. Clinical and

laboratory parameters used to detect macro and microvascular complications and auditory dysfunction assessed by using pure tone audiometry (PTA) and distortion product otoacoustic emissions (DPOAES).

**Results:** Out of 45 prediabetes subjects, one subject (2.22%) had sensorineural hearing loss on pure tone audiometry and out of 44 diabetes patients five (11.36%) had sensorineural hearing loss on pure tone audiometry. Similar results also obtained on DPOAE, one prediabetic subject (2.22%) had auditory dysfunction on DPOAE, five diabetic patients (11.36%) had auditory dysfunction on DPOAE. On DPOAE higher frequencies were more affected in both prediabetes and diabetes patients. Out of the 44 diabetics in our study, seven (15.91%) were found to have diabetic retinopathy; six (13.64%) had diabetic nephropathy; thirteen (29.55%) were diagnosed with diabetic retinopathy and four (9.09%) had evidence of coronary artery disease.

**Conclusion:** In this study, auditory dysfunction in diabetes patients was significantly higher than prediabetic subjects. In diabetic patients prevalence of auditory dysfunction was lower than the existing literature probably due to lower sample size and sampling methods. In the study diabetic patients who had deranged BMI, various associated microvascular complications associated with diabetes, and poor glycaemic control (higher HbA1c) had abnormal PTA and abnormal DPOAE. Further studies with a larger sample size are required to establish the association between prediabetes and auditory dysfunction.

## INTRODUCTION

Diabetes mellitus is a widespread metabolic disease that affects approximately 537 million adults aged 20 to 79 globally.[1] In India, the disease is particularly prevalent, with around 10% of the population affected. Recent studies estimate that there were around 77 million diabetic patients in 2019, a number expected to double to over 150 million by 2045.[2] A survey[3] found that nearly 9% of individuals were diabetic, while 24% were pre-diabetic, with many cases remaining undiagnosed for years. Contributing factors to the increasing burden of diabetes in countries like India include rising rates of overweight/obesity, sedentary lifestyles, and poor dietary habits, compounded by genetic predispositions. Diagnosis can be made through various criteria including fasting plasma glucose, oral glucose tolerance tests, or A1C levels.

Regardless of diabetes type, chronic hyperglycemia leads to systemic complications that affect multiple organs, categorized into microvascular and macrovascular types. These complications significantly increase morbidity and mortality rates among diabetic individuals, reducing life expectancy and increasing the burden on the healthcare system. Recent advancements in diabetes management have led to the recognition of lesser-known complications beyond vascular issues, including malignancies, cognitive dysfunction, and hepatic dysfunction.[4-6] Sensorineural hearing loss is also increasingly recognized as a complication of Type 2 diabetes mellitus (T2DM), with studies indicating a higher risk for T2DM patients compared to the general population.[7] The mechanism behind this auditory impairment is attributed to microangiopathic complications affecting the organ of Corti and its nerve supply, resulting in reduced blood flow and structural changes such as thickening of capillary basement membranes and decreased outer and inner hair cell count.[8] While numerous studies have explored hearing loss in diabetic patients, research on prediabetic individuals remains limited. Since the pre-diabetic state is just a precursor to the full-blown diabetic phenotype, it is likely that similar auditory complications might be present in prediabetics as well.

The objective of this study was to compare the extent of auditory dysfunction in individuals with diabetes and prediabetes. To achieve these objectives, a comprehensive assessment was conducted using various methods. Firstly, a detailed medical history was obtained from each participant to gather information about the duration and severity of diabetes or prediabetes. Additionally, any previous diagnoses of peripheral neuropathy or retinopathy were noted, as studies[9] showed that these conditions have been associated with an increased risk of hearing loss in diabetics. Following the medical history, a thorough clinical examination was performed to evaluate the overall health of the participants, with a specific focus on the auditory system. Pure audiometry and otoacoustic emission tests were conducted to assess inner ear auditory function. These tests were used to measure the thresholds at which participants could detect different frequencies of sound and to evaluate the health and functioning of the cochlea.

By examining both diabetic and prediabetic individuals, this study aimed to provide a comprehensive understanding of the continuum of auditory impairment to glucose metabolism, which could help facilitate early intervention and management to prevent further deterioration.

## MATERIALS AND METHODS

The study was conducted at the Department of Medicine, Tertiary Care Hospital in New Delhi. It employed an observational, cross-sectional study design. The study population consisted of patients who had attended the Medicine Outpatient Department (OPD). The study lasted for one year. Ethical approval for the study was obtained from the Institutional Ethics Committee (IEC). Subjects meeting specific inclusion and exclusion criteria were enrolled after screening.

Inclusion criteria for the study comprised Patients of either sex having T2DM (as per ADA criteria 2021) for more than 5 years of age <50 years. Pre-diabetic patients (as per ADA criteria 2021) HbA1c 5.7-6.4 and FBS 100-125 mg/dl (4/5). Exclusion criteria included patients who have Congenital hearing loss, a history of CSOM, a history of sudden sensorineural deafness or noise trauma-induced hearing loss, Trauma to the ear, patients on ototoxic drugs, and patients who have serious clinical illness like ESRD, Disseminated Koch, and malignancies.

The sample size calculation was based on a previous study by Friedman et al, which reported prevalence of hearing impairment (mild to severe) in the diabetic population varies from 38% to 55%. Using a formula for sample size calculation, considering a 95% confidence interval, standard deviation, and a 10% margin of error, the estimated sample size was 90. However, a sample size of 89 patients was chosen for this study.

## METHODOLOGY

Patients were included or excluded in the study based on predetermined criteria following informed consent. Detailed medical history was taken at enrollment, including age at onset, symptom duration, and diabetes-related complications. Clinical examinations and anthropometric measurements were conducted at enrollment including height, weight, BMI, waist circumference, neuropathy assessment using the monofilament test, and fundus examination. Blood investigations included complete blood counts, kidney and liver function tests, HbA1c, fasting blood sugar, lipid profile, urine albumin, and estimated glomerular filtration rate (eGFR) assessment. Complications such as nephropathy were diagnosed based on albuminuria levels and CKD staging,

while retinopathy was assessed through fundus examination. Patients meeting inclusion criteria underwent pure tone audiometry and distortion product otoacoustic emission tests in the ENT OPD audiometry room, and outcome variables were used for statistical analysis.

## STATISTICAL ANALYSIS

The data was entered in a Microsoft Excel spreadsheet and analyzed using Epi-Info, JASP, and Statistical Package for Social Sciences (SPSS) version 25.0. Continuous variables are represented as mean ± SD or medians with the Interquartile range. Categorical variables are represented as numbers and percentages (%). The variables were tested for normality with the Kolmogorov-Smirnov test for normality, Q- Q plots, visual inspection of the histograms, and the z-scores for the degree of skewness and kurtosis. The Spearman Rank correlation test was used to assess the correlation between continuous quantitative variables. All tests of significance were two-tailed and statistical significance was defined as $P < 0.05$. Not all variables met the assumptions required for parametric; therefore, non-parametric tests (i.e., Mann-Whitney test, Spearman correlation) were used for all analyses for consistency. Appropriate graphs such as pie charts, bar diagrams, and histograms have been constructed.

## RESULTS

Our observations were categorized into Demographic parameters, including age and gender distribution, Anthropometric parameters such as weight, height, and BMI, Laboratory parameters, including lipid profile and renal function tests and Clinical characteristics like the duration of the disease and diabetic complications. Glycemic control was measured by fasting blood sugar and HbA1c levels. Audiometric parameters were assessed through Pure Tone Audiometry, and DPOAE. We assessed the association between the duration of illness and audiometric parameters, eg. by Pure Tone Audiometry and DPOAE. The association between Pure Tone Audiometry parameters and glycemic control, focusing on fasting blood sugar, HbA1c levels, and complications of diabetes was also assessed.

**Table 1:** shows various demographic, anthropometric and lab parameters;

| | Pre-Diabetic | Diabetic | p-Value |
|---|---|---|---|
| | | | |
| Age , Mean(SD) | 45.18 (3.0) | 44.86 (3.70) | 0.84 |
| Gender, Male (N%) | **22 (48.89%)** | **20 (45.45%)** | 0.746 |
| BMI, mean (SD) | **27.32 (1.57)** | **26.24 (3.15)** | 0.043 |
| Duration of diabetes, Median (SD), years | - | 7.2 (0.29) | - |
| FBS, mean (SD), mg/Dl | **114.93 (7.09)** | **148.8 (37.86)** | <0.001 |
| HbA1c, mean (SD), gm/dL | 6.8 (0.25) | 7.57 (0.94) | <0.001 |
| Retinopathy, N % | - | 7 (15.91%) | - |
| Nephropathy, N% | - | 6 (13.64%) | - |
| Neuropathy, N% | - | 13(29.55%) | - |
| Coronary artery disease, N% | - | 4 (9.09%) | - |

The age of subjects in the pre-diabetic group ranged from values 40.0 to a maximum of 50.0. The Median (IQR) age was 45.0 (43.0 - 48.0) and the Mean ± Standard Deviation was 45.18 ± 3.0. In the Diabetic group, it ranged from a minimum value of 35.0 to a maximum of 50.0. The Median (IQR) was 45.0 (42.0 - 48.0) and the Mean ± Standard Deviation was 44.86 ± 3.7. The vast majority of the Pre-diabetic (n = 23, 51.1%) as well as Diabetic (n = 21, 47.7%) subjects belonged to the age group 45 to 49 years. Of the 45 subjects in the pre-diabetic group, 23 (51.11%) were female and the remaining 22 (48.89%) were male. A similar distribution was present in the Diabetic group with 24 (54.55%) females and 20 (45.45%) males. In the pre-diabetic group, the subjects' median (IQR) BMI was 27.41 (26.22-28.26) and the Mean ± Standard Deviation was 27.32 ± 1.57. On the other hand, the median (IQR) BMI of subjects in the Diabetic group was 26.28 (23.72 - 28.42), and the Mean ± Standard The deviation was 26.24 ± 3.15. In general, vascular complications tend to become more common as the disease progresses. Therefore, complications tend to increase as the duration of the disease increases. The average duration of illness for the diabetics in our study was 7.2 ± 0.29 years.

All the diabetics in our study were screened for presence of microvascular and macrovascular complications. out of the 44 diabetics in our study, 7 (15.91%) were found to have evidence of diabetic retinopathy; 6 (13.64%) had diabetic nephropathy; 13 (29.55%) were diagnosed with diabetic retinopathy and 4 (9.09%) had evidence of coronary artery disease.

The Fasting Blood Sugar in the Pre-Diabetic group ranged from a minimum value of 101.0 to a maximum of 125.0. The Median (IQR) FBS was 116.0 (109.0 - 121.0) and the Mean ± Standard Deviation was 114.93 ± 7.09. In the Diabetic group, it ranged from a minimum value of 97.0 to a maximum of 284.0. The Median (IQR) was 140.5 (120.5 - 163.5) and the Mean ± standard Deviation was 148.8 ± 37.86. Thus, the Fasting Blood Sugar was significantly lower in the pre-diabetic group as compared to the Diabetic group (Median 116.0 versus 140.5). The median (IQR) HbA1c in the pre-diabetic subjects was 5.90 (5.90 – 6.30). On the other hand, the median (IQR) in the Diabetic group was 7.30 (6.80 – 8.13).

## Pure Tone Audiometry

Hearing thresholds were assessed for all subjects at various frequencies using pure tone audiometry. Subjects were said to have a hearing loss if PTA identified a hearing loss of more than 25 dB at any frequency. 1 (2.22%) subject in the pre-diabetic group and 5 subjects (11.36%) in the diabetic group were found to have SNHL. None of the subjects were found to have conductive hearing loss on PTA.

**Table 2:** shows the distribution of subjects based on PTA;

| Pure Tone Audiometry | GROUP | | | |
|---|---|---|---|---|
| | Pre-Diabetic | Diabetic | Total | P Value |
| NORMAL | 44 (97.78%) | 39 (88.64%) | 83 (93.26%) | 0.11 |
| SNHL | 1 (2.22%) | 5 (11.36%) | 6 (6.74%) | |
| Total | 45 (100.0%) | 44 (100.0%) | 89 (100.0%) | |

**Distortion Product Otoacoustic Emissions (DPOAE)**

In this study, we investigated the differences in Distortion Product Otoacoustic Emissions (DPOAE) between pre-diabetic and diabetic groups across various frequencies. In DPOAE for each given frequency SNR was measured. patients who had SNR less than 6 were considered failed on DPOAE test and subjects who had SNR greater than 6 were considered passed on the DPOAE test. 1 (2.22%) subject in the pre-diabetic group and 5 subjects (11.36%) in the diabetic group failed the DPOAE test.

On further analysis study revealed notable disparities in mean values between the two groups, particularly evident at higher frequencies. At 5 and 7 kHz, the mean DPOAE amplitude was notably higher in the pre-diabetic group compared to the diabetic group, with a significant p-value. This suggests a potential impact of diabetic status on DPOAE amplitudes at this frequency.

Overall, our findings suggest that diabetic status may influence DPOAE amplitudes, particularly at higher frequencies, with diabetic individuals demonstrating lower mean amplitudes compared to their pre-diabetic counterparts.

**Table 3:** shows distribution of subjects based on DPOAE;

| DPOAE | GROUP | | | |
|---|---|---|---|---|
| | Pre-Diabetic | Diabetic | Total | p-Value |
| NORMAL | 44 (97.78%) | 39 (88.64%) | 83 (93.26%) | 0.11 |
| FAILED | 1 (2.22%) | 5 (11.36%) | 6 (6.74%) | |
| Total | 45 (100.0%) | 44 (100.0%) | 89 (100.0%) | |

Table shows the findings with respect to DPOAE in pre-diabetic and diabetic groups

| | Frequency | GROUP | | | | P Value |
|---|---|---|---|---|---|---|
| | | Pre-Diabetic | | Diabetic | | |
| | | Mean | Standard Deviation | Mean | Standard Deviation | |
| DPOAE SNR | 0.5 KHZ | 8.86 | 2.20 | 9.27 | 2.86 | 0.081 |
| | 1 KHZ | 9.11 | 2.42 | 8.91 | 2.69 | 0.657 |
| | 2 KHZ | 9.61 | 1.54 | 8.31 | 2.64 | 0.009 |
| | 3KHZ | 9.02 | 2.37 | 7.18 | 2.31 | <0.001 |
| | 5KHZ | 8.55 | 1.97 | 7.49 | 2.19 | 0.048 |
| | 7KHZ | 9.27 | 2.31 | 7.62 | 2.47 | 0.003 |

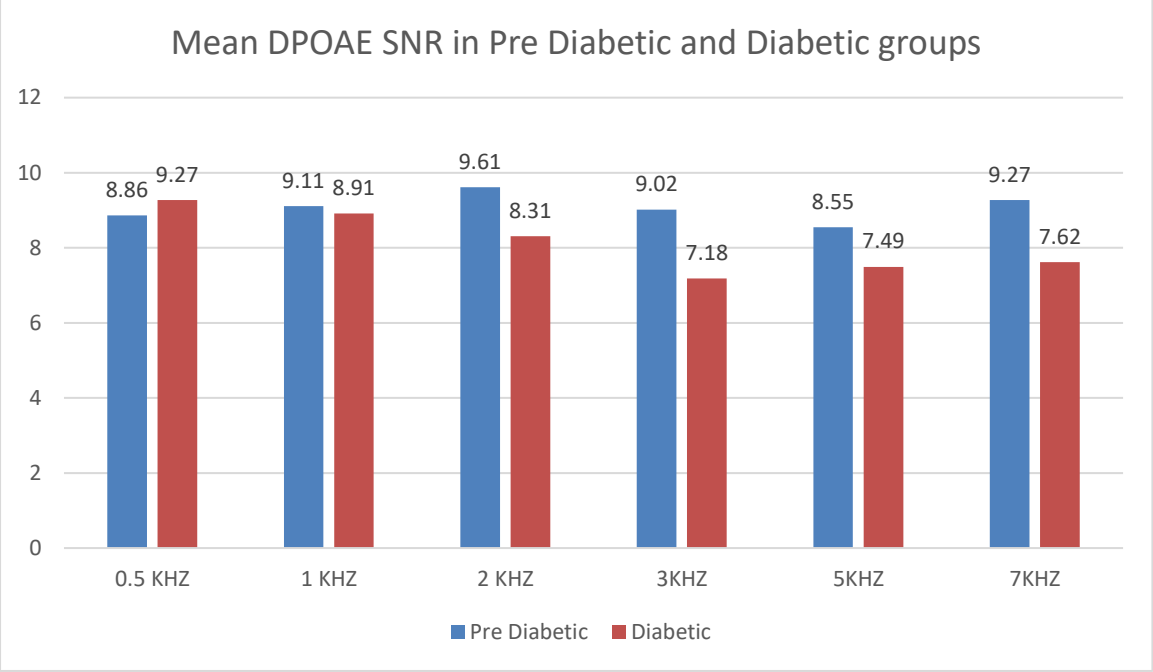


**Figure 1:** shows the findings with respect to DPOAE in pre-diabetic and diabetic groups

**Pure Tone Audiometry versus Duration of Illness**

In the subjects with Normal PTA, the average duration of illness was 7.28 ± 2.0 years and the median (IQR) was 7.0 (6.0 - 8.0). On the other hand, the mean duration of illness in the subjects with SNHL on PTA was 6.6 ± 1.34 years and the median was 6.0 (6.0 - 8.0) years.

**FBS Versus PTA and DPOAE**

In the subjects with SNHL on PTA and abnormal DPOAE, the mean FBS was 135.5 ± 24 and the median (IQR) was 135.5 (117 - 159). On the other hand, the mean FBS in the subjects without SNHL on PTA and normal DPAOE was 131.4 ± 32.5 and the Median (IQR) was 121 (112 - 139).

Table comparing FBS between those with SNHL and abnormal DPOAE and those without

| FBS (mg/dL) | GROUP | | |
|---|---|---|---|
| | Normal | SNHL And Abnormal DPOAE | P Value |
| Mean (SD) | 131.4 ± 32.5 | 135.5 (24) | 0.408 |
| Median (IQR) | 121 (112 - 139) | 133.5 (117 - 159) | |
| Min-Max | 97 – 284 | 105 – 165 | |

Association Diabetic complications between and PTA

Neuropathy and PTA

Of the subjects with SNHL, 2 (40%) of subjects were found to have diabetic neuropathy. The corresponding number in the subjects with normal PTA was 11 (28.2%).

Diabetic Nephropathy and PTA

In the subjects with SNHL, 1 (20%) of subjects were found to have diabetic nephropathy. The corresponding number in the subjects with normal PTA was 5 (12.8%).

Diabetic Retinopathy and PTA

In the subjects with SNHL, 1 (20%) of subjects were found to have diabetic retinopathy. The corresponding number in the subjects with normal PTA was only 6 (15.4%).

Coronary Artery Disease and PTA

None of the subjects with SNHL were found to have coronary artery disease. The corresponding number in the subjects with normal PTA was 4 (10.3%).

The table shows the association between diabetic neuropathy and PTA findings

| | Normal | SNHL | Total | P Value |
|---|---|---|---|---|
| Diabetic Neuropathy | | | | |
| Absent | 28 (71.8%) | 3 (60.0%) | 31 (70.5%) | 0.179 |
| Present | 11 (28.2%) | 2 (40.0%) | 13 (29.5%) | |
| Diabetic Nephropathy | | | | |
| Absent | 34 (87.2%) | 4 (80.0%) | 38 (86.4%) | 0.66 |
| Present | 5 (12.8%) | 1 (20.0%) | 6 (13.6%) | |
| Diabetic Retinopathy | | | | |
| Absent | 33 (84.6%) | 4 (80.0%) | 37 (84.1%) | 0.791 |
| Present | 6 (15.4%) | 1 (20.0%) | 7 (15.9%) | |
| Coronary Artery Disease | | | | |
| Absent | 35 (89.7%) | 5 (100.0%) | 40 (90.9%) | 0.453 |
| Present | 4 (10.3%) | 0 (0.0%) | 4 (9.1%) | |

## DISCUSSION

Our main aims were to study whether there exists any association between diabetes and sensorineural hearing loss and the prevalence of auditory dysfunction in prediabetes. With these aims in mind, we conducted an observational cross-sectional to compare the diabetic and pre-diabetic subjects with respect to the level of auditory dysfunction.

The subjects in our study were mostly middle-aged (Mean 45.02 ± 3.34 years) between the ages of 45 and 50 years (n = 44, 49.44%). Both the groups were well matched with respect to the median age (p value 0.84) as well as the distribution (p value 0.264). This result is consistent with the fact that diabetes is more common in the middle and elderly aged people, as compared to younger age group. Our results are consistent with the results of the previous studies as well. For instance, Abraham et al[10] reported a mean age of 49 years. The average age was 51 years in the study by Al-Rubean et al[11,12]. Li et al[13] reported an average age of 56.1 years in the diabetic group and 54 years in the pre-diabetic group. The article by Ren et al[14] included only diabetics and had a mean age of 50.6 years. Kim et al[15] reported similar values for the diabetics (Mean age of 46.1

years). However, the pre-diabetics were relatively younger as compared to our study (39.4 years). This difference could be due to a sampling bias, differences in sample size as well as differences in the health-seeking behaviors of people in different countries.

Both males (n = 42, 47.2%) as well as females (n = 47, 52.8%) were well represented in our study. Both the groups were comparable (p value 0.746) with respect to gender distribution. Our results are counter to the results of some studies[16] which have found that the prevalence of diabetes is higher in males, as compared to females, at least in the Indian population. However, most other studies reported a similar gender distribution. The study by Abraham et al[10] included 50% females; the proportion of females was 47.8% in the study by Al-rubean et al [12]. Li et al[13] also reported 47.1% females in the diabetic group and 45.5% in the pre-diabetic group. However, some studies had a much higher number of males. For instance, the study by Kim et al[15] had 76% males in the diabetic groups and 73.6% males in the pre-diabetic group; Ren et al[14] reported These differences could be explained due to sampling biases as well as differences in sample sizes of the various studies. For instance, the study by Kim et[15] had 6250 diabetic subjects and 46,000 pre-diabetic subjects. Yet another reason for the difference could be due to geographical differences. For instance, the study by Kim et al was conducted in South Korea, whose genetic as well as ethnic heritage is quite different from those in our study. Finally, these differences could be secondary to the various study designs. For instance, most of the studies conducted along these lines have been cross-sectional studies whereas cohort studies (such as Kim et al) are relatively few.

The average BMI was significantly (p Value 0.043) higher in the Pre-Diabetic (27.32 ± 1.57) subjects as compared to the Diabetic subjects (26.24 ± 3.15). In the study by Al-Rubeaan et al[12], subjects had a mean BMI of 32.46 kg/m2. Li et al[13] also reported a BMI of 24 kg/m2 in diabetic group, 25.8 kg/m2 in the pre-diabetic group. The average BMI was 23.3 kg/m2 in study by Kim et al[15] and 25.13 kg/m2 as reported by Ren et al.[14]

The average duration of disease in our study was 7.2 ± 0.29 years. The average duration of disease was relatively lower as compared to the number reported by other studies. For instance, the average duration was 12.9 years in study by Al-Rubeaan et al[12], Li et al[13] reported an average duration of 10.9 years. However, some studies included subjects with relatively lower disease duration as well. Ren et al[14] reported an average disease duration of 4 years. An important point to note is that studies with higher duration of illness are likely to have higher prevalence of diabetic complications.

Out of the 44 diabetics, 13 (29.55%) subjects had diabetic neuropathy, 7 (15.9%) had diabetic retinopathy, 6 (13.64%) had diabetic nephropathy and 4 (9.09%) had coronary artery disease. Some studies have reported much higher prevalence of diabetic complications. For instance, of the 200 subjects in the study by Abraham et al (10/37), 47 (23.5%) had mild neuropathy and 105 (52.5%) had moderate to severe neuropathy. In the study by Al-Rubeaan[12], 26.8% had neuropathy, 21.7% had retinopathy, 3.8% had nephropathy and 3.8% had coronary artery disease. In the study by Li et al (14), 31.4% of diabetics had retinopathy, 23.5% had peripheral neuropathy and 21.6% had diabetic nephropathy.

The Fasting Blood Sugar was significantly (p Value <0.001) lower in the Pre-Diabetic group (Mean 114.93 ± 7.09) as compared to the Diabetic group (Mean 148.8 ± 37.86). In the study by Al-Rubeaan et al[12], subjects had a mean FBS of 172.8 mg/dL; Ren et al[14] reported a mean FBS of 182.5 mg/dL.

The HbA1c was significantly (p Value <0.001) lower in the Pre-Diabetic group (Mean 6.0 ± 0.25) as compared to the Diabetic group (Mean 7.57 ± 0.94). Comparable values were reported by other studies. The subjects in the study by Al-Rubeaan[12] had an average HbA1c of 8.6 %; Li et al[13] reported a mean HbA1c of 8.5%; Ren et al [14] reported a mean HbA1c of 9 %. Thus, there was a wide variation in the HbA1c level of subjects in various studies. This variation could be due to differences in sample sizes, geographic and ethnic differences in the study populations as well as differences in the treatments of the subjects in various studies.

Thus, the glycemic control of subjects in our study was relatively better as compared to other studies, which could be due to a sampling bias. Moreover, since the subjects in our study were all taken from those presenting to the Medicine OPD, they were more likely to be receiving adequate medical care and might be more motivated to take treatment. However, some studies were population based and included subjects from the community as well, who may not be as motivated to take pharmacological therapy.

Audiometric parameters of subjects were assessed using Pure Tone Audiometry and DPOAEs. On PTA and DPOAE 1 subject (2.22%) in prediabetic group had SNHL and abnormal DPOAE. PTA and DPOAE was abnormal specially in obese prediabetic and these individuals had higher HbA1C in pre diabetic range. Out of 44 type 2 diabetes patients 5 patients (11.36%) having SNHL on PTA and abnormal DPOAE, which indicated higher audiological impairment in diabetic patients than prediabetes. In a study by Li et al[11] 45.1% individual had abnormal results on PTA. Similar results were seen in a study by R Meena et al[17] abnormal PTA in 58% diabetic patients. These difference between various studies could be due to older individuals in selection criteria and longer duration of illness of diabetes. On DPOAE patients who have uncontrolled glycemia has hearing loss for higher frequencies specially 5Khz and more. A study by Mitchell et al[18] also showed there were absent DPOAE responses for higher frequencies in diabetes.

We compared the duration of illness in the different groups based on PTA. The duration of illness was comparable irrespective of status of PTA (Mean 7.28 ± 2.0 in normal and 6.6 ± 1.34 in SNHL, p value 0.544. In our study diabetic patients who are having SNHL have lesser duration of illness but they had poor glycemic control, their HbA1c was higher (Mean 7.33 ± 0.86) in contrast to patients were having normal PTA (mean,6.77 ± 1.02, p value 0.067). So, our study shows status of glycemic control has profound effect on cochlea and leads to early auditory dysfunction in diabetes. These individuals more likely to be associated with other microvascular complication like retinopathy, neuropathy and nephropathy. A study by Ashish et al[17] showed similar results in which patients who has poor glycemic control and longer duration of diabetes had abnormal PTA and abnormal DPOAE.

We compared the distribution of various diabetic complications in those with normal hearing on PTA and those with SNHL. We found no difference between the two groups in terms of distribution of Diabetic retinopathy (p

value 0.791), Diabetic neuropathy (p value 0.179), Diabetic nephropathy (p value 0.66) or coronary artery disease (p value 0.453). This could be explained by lower sample size.

In our study patient who had deranged BMI, various microvascular complications associated with diabetes and poor glycemic control (higher HbA1c) had abnormal PTA and loss of DPOAE.

## REFERENCES

1. Kumar A, Gangwar R, Ahmad Zargar A, Kumar R, Sharma A. Prevalence of diabetes in India: A review of IDF Diabetes Atlas 10th edition. Curr Diabetes Rev. 2024;20(1):e130423215752.
2. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol. 2021;69(11):2932–8.
3. Mathur P, Leburu S, Kulothungan V. Prevalence, Awareness, Treatment and Control of Diabetes in India From the Countrywide National NCD Monitoring Survey. Front Public Health. 2022;10:748157.
4. Chatterjee S, Peters SAE, W oodward M, Arango SM, Batty GD, Beckett N, et al. Type 2 Diabetes as a Risk Factor for Dementia in Women Compared With Men: A Pooled Analysis of 2.3 Million People Comprising More Than 100,000 Cases of Dementia. Diabetes Care. 2016;39(2):300.
5. Kk T, Jc K, Ds L, Ee N, Jp I. Type 2 diabetes and cancer: umbrella review of meta-analyses of observational studies. BMJ. 2015:350:g7607.
6. Jl H, Me P, Dj M, Je S, Ew G. Global trends in diabetes complications: a review of current evidence. Diabetologia. 2019;62(1):3-16.
7. K.D P, D.R S. Hearing loss in Diabetes Mellitus. International journal of collaborative research on internal medicine and public health. 2011.
8. 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(9):934-8.
9. Gioacchini FM, Pisani D, Viola P, Astorina A, Scarpa A, Libonati FA, et al. Diabetes Mellitus and Hearing Loss: A Complex Relationship. Medicina (Kaunas). 2023;59(2):269.
10. Li J, Zhang Y, Fu X, Bi J, Li Y, Liu B, et al. Alteration of auditory function in type 2 diabetic and pre-diabetic patients. Acta Otolaryngol. 2018;138(6):542–7.
11. Abraham AM, Jacob JJ, Varghese A. Prevalence of Hearing Loss in Type 2 Diabetes Mellitus and Its Association with Severity of Diabetic Neuropathy and Glycemic Control. J Assoc Physicians India. 2023;71(6):11–2.
12. Al-Rubeaan K, AlMomani M, AlGethami AK, Darandari J, Alsalhi A, AlNaqeeb D, et al. Hearing loss among patients with type 2 diabetes mellitus: a cross-sectional study. Ann Saudi Med. 2021;41(3):171–8.
13. Li J, Zhang Y, Fu X, Bi J, Li Y, Liu B, et al. Alteration of auditory function in type 2 diabetic and pre-diabetic patients. Acta Otolaryngol. 2018;138(6):542–7.
14. Ren H, Wang Z, Mao Z, Zhang P, Wang C, Liu A, et al. Hearing Loss in Type 2 Diabetes in Association with Diabetic Neuropathy. Arch Med Res. 2017;48(7):631–7.

15. Kim MB, Zhang Y, Chang Y, Ryu S, Choi Y, Kwon MJ, et al. Diabetes mellitus and the incidence of hearing loss: a cohort study. Int J Epidemiol. 2017;46(2):717–26.
16. Sujata, Thakur R. Unequal burden of equal risk factors of diabetes between different gender in India: a cross-sectional analysis. Sci Rep. 2021;11:22653.
17. Agarwal Ashish C, Pujary Kailesh, Ganapathy Kanaka, Balakrishnan R, Nayak Dipak R, Hasan, Faisal. Pure tone audiometry and otoacoustic emissions for the assessment of hearing loss in diabetic patients. Indian Journal of Otology. 2013;19(1):13-17.
18. Mitchell P, Gopinath, B, McMahon CM, Rochtchina E, Wang JJ, Boyages SC. et al. Relationship of Type 2 diabetes to the prevalence, incidence and progression of age-related hearing loss. Diabet Med . 2009;26(5):483-8.