

Effect of HbA1c Level on Hearing Sensitivity Among Patients with Diabetic Mellitus

G. Tamil Selvan¹, Kala Samayan¹, J.S. Kumar², P. Venkataraman³,
G. Muthukumaran¹, S. Ambethkar¹ and D. Balakrishnan¹

¹Department of Audiology and Speech-Language Pathology, SRM IST,
Kattankulathur, Chengalpattu (Dt), Tamil Nadu, India.

²Department of General Medicine, SRM IST, Kattankulathur, Chengalpattu (Dt), Tamil Nadu, India.

³Department of Research, SRM IST, Kattankulathur, Chengalpattu (Dt), Tamil Nadu, India.

*Corresponding Author E-mail: kalas1@srmist.edu.in

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Diabetes Mellitus (DM) appears to be a risk factor for hearing loss. Meta-analyses of cross-sectional studies reported that diabetes had a greater risk of hearing impairment. Hearing loss and hemoglobin A1c (HbA1c), a glycemic management biomarker, have been linked in a few studies. HbA1c and hearing impairment as measured by a pure-tone average threshold of frequencies (500 Hz, 1 kHz, and 2 kHz), while the other two found a link between HbA1c and high-frequency hearing impairment. The goal of this study is to see if the amount of HbA1c level is linked to the occurrence of hearing loss. Participants were 430 of both genders between the ages of 21 to 60 years and based on the duration of HbA1c level. Results indicated that the higher HbA1c level patient had high-frequency hearing loss when compared to speech frequencies in both ears. As the HbA1c level increases an increase in the high-frequency hearing loss was also noticed. A positive correlation exists between the duration of diabetics and high-frequency hearing loss. Moreover, when diabetic duration increases, the hearing loss is more affected in extended high frequency, high frequency followed by speech frequency among uncontrolled DM than controlled DM in both ears. These findings suggest that proper glycemic management might help avoid diabetic hearing loss.

Keywords: Diabetic Mellitus; Duration; High-Frequency Hearing Loss; HbA1c.

Hearing is an essential element of everyday living, and its loss has a major impact on quality of life owing to decreased communication and functional abilities (Lin FR et al., 2011; Wilson et al., 2017)^{1,2}. According to WHO estimates, around 360 million individuals, or 5% of the world population suffer from hearing loss, and this incidence is rising due to the growing older Adults (Deafness and Hearing Loss, 2020)³.

Hearing loss in adults can be caused by a variety of reasons, including age, genetics, neurological illnesses, vascular causes, metabolic problems, ototoxic medicines, noise, and diabetes mellitus. But age-related hearing loss cannot be reversed, it is critical to identify factors that may be avoided. Diabetes mellitus (DM) is a non-communicable endocrine condition that causes significant damage throughout the body.

Diabetes is a chronic illness that, in its advanced stages, produces a variety of organ malfunctions or impairments in individuals with DM. Among the long-term consequences of diabetes include cardiovascular and peripheral vascular illnesses, neuropathy, nephropathy, retinopathy, and cerebrovascular problems (International Diabetes Federation, 2019)⁴.

Diabetes mellitus appears to be a risk factor for hearing loss, according to research. Subjects with diabetes had a greater risk of hearing impairment, according to meta-analyses of cross-sectional studies (Horikawa *et al.*, 2013)⁵. Hearing impairment and hemoglobin A1c (HbA1c), a glycemic management measure, have been linked in three studies. (Michikawa *et al.*, 2014; Kang *et al.*, 2016)^{6,7}. One of these studies found a positive dose-response connection between HbA1c and hearing impairment as measured by a pure-tone average threshold of mostly low frequencies, (Kim *et al.*, 2017)⁸. Whereas the other two found that HbA1c was linked to high-frequency hearing impairment (Michikawa *et al.*, 2014; Kang *et al.*, 2016)^{6,7}.

Hemoglobin A1c (HbA1c) is a non-enzymatic and slow glycolysis product of hemoglobin in the blood that is used to monitor long-term glycemic management in diabetics and to diagnose non-diabetic people. It's also thought to represent the quality of patient follow-up control and suggest the danger of diabetic complications. Although HbA1c is less than 6% in those without diabetes, it can rise to more than 10% in people with uncontrolled diabetes (Schnell *et al.*, 2017)⁹.

Microangiopathy is thought to be the primary cause of diabetic retinopathy, nephropathy, and neuropathy (Sen *et al.*, 2015; Ooley *et al.*, 2018; & Nemati *et al.*, 2018)^{10,11,12}. Microangiopathy is also thought to be a major cause of hearing loss in diabetics (Cohen Atsmoni *et al.*, 2018)¹³. There is a link between HbA1c and hearing loss, according to research (Nagahama *et al.*, 2018)¹⁴. By comparing the audiometric characteristics of the two groups, we were able to discover a link between HbA1c and hearing loss.

Sharma *et al.* (2022)¹⁵ Hearing loss was reported on higher frequencies, according to There was a link between hearing loss and HbA1c, which was strongest in the 10-13.9 percent

range, although not statistically significant. While some studies found that diabetic people had a higher risk of hearing loss, others found no link between diabetes and hearing loss. By comparing the audiometric characteristics of the groups, we were able to discover a link between HbA1c and hearing loss. In HbA1c and auditory systems has been a lack in literature. Based on a few pieces of literature we aimed, to be a there is any relationship between the HbA1c and the degree of hearing loss among the controlled and uncontrolled DM.

MATERIALS AND METHODS

In this study, 430 individuals had their HbA1c test values monitored and were taken for an audiological examination. The study excluded individuals with chronic otitis, ototoxicity, acoustic damage, cancer, prior ear surgery, neurological illness, and mental development abnormalities. Patients included in the age range of 21 to 60 years. Participants more than 60 years old were excluded from the research to rule out presbycusis and genetic predisposing factors. The research population of 430 participants was separated into two groups based on their HbA1c levels. Subjects with HbA1c levels of >5.5 to 6.9 were classified as Group 1 (Controlled Diabetes Mellitus); those with values of 7.0 and above were classified as Group 2 (Uncontrolled DM). The correlation between HbA1c blood test results and pure tone audiological test findings was statistically analyzed.

The Piano Inventies audiometer was used to conduct pure tone audiometry tests with frequency ranges of 250Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, 9 kHz, 10 kHz, 12 kHz, 14 kHz, and 16 kHz. The right and left ear threshold levels were tested individually. Pure tone averages of the subjects were determined for both ears. For each criterion, such as age and duration of DM, it was determined if there was a significant difference between the HbA1c groups of controlled DM and Uncontrolled DM.

RESULTS AND DISCUSSION

The present aimed to study the relationship between the HbA1c level and the degree of hearing loss among controlled and uncontrolled diabetic

Mellitus. The results have been discussed with HbA1c level, duration, and severity of the hearing loss.

Controlled DM

Figure 1 shows that when the diabetic age increases the severity of hearing loss also increases among controlled DM

The present study found that to be a relationship between the length of the diabetic Mellitus and hearing loss, those with diabetes who have had the disease for longer than 10 years have higher hearing loss, particularly of the sensorineural variety. Contrarily, some other writers hypothesized that the length of the DM is

substantially connected with hearing loss, meaning that the longer diabetes is present, the greater the risk of hearing loss stated by Uju IM *et al.* (2021)¹⁶.

Table 1 shows that there is a significant age difference ($p < 0.05$) and duration (months) of controlled DM ($p < 0.05$) in the Right high frequency. On the other hand, there is no significant difference between age and diabetic duration of Right speech frequency. But there is a significant difference in the age of the participants. There is no significant difference between age and diabetic duration of the left speech and high frequency among controlled DM. The present finding concurrent with past findings done by Horikawa *et al.* (2013)⁵ that the

Table 1. Pearson Chi-Square Tests of speech frequency and high frequency of both ears in controlled DM

	Pearson Chi-Square Tests				
		Gender	Severity	Age	DM age (months)
Right Speech Frequency (RSF) 500 Hz, 1kHz & 2kHz	Chi-square	1.128	2.497	22.995	16.276
	Df	4	4	12	12
	Sig.	.890 ^{a,b}	.645 ^{a,b}	.028 ^{a,b,*}	.179 ^{a,b}
Right High & Extended High Frequency (RHF) 4kHz – 16 kHz	Chi-square	2.494	5.864	29.335	25.537
	Df	5	5	15	15
	Sig.	.777 ^a	.320 ^a	.015 ^{a,b,*}	.043 ^{a,b,*}
Left Speech Frequency (LSF) 500 Hz, 1kHz & 2kHz	Chi-square	.456	6.301	8.749	7.573
	df	4	4	12	12
	Sig.	.978 ^a	.178 ^a	.724 ^a	.818 ^{a,b}
Left High & Extended High Frequency (LHF)4kH - 16 kHz	Chi-square	4.894	5.067	16.724	11.268
	df	5	5	15	15
	Sig.	.429 ^{a,b}	.408 ^{a,b}	.336 ^{a,b}	.733 ^{a,b}

Table 2. Pearson Chi-Square Tests of speech frequency and high frequency of both ears in Uncontrolled DM

	Pearson Chi-Square Tests				
		Sex	Severity of HbA1c	Age	Diabetic Months
Right Speech Frequency (RSF) 500 Hz, 1kHz & 2kHz	Chi-square	10.367	146.892	33.360	28.494
	Df	5	10	15	15
	Sig.	.065	.000 ^{a,b,*}	.004 [*]	.001 ^{a,b,*}
Right High & Extended High Frequency (RHF) 4kHz – 16 kHz	Chi-square	6.583	6.092	38.499	58.594
	Df	6	12	18	18
	Sig.	.361 ^{a,b}	.004 ^{a,b}	.003 ^{a,b,*}	.000 ^{a,b,*}
Left Speech Frequency (LSF) 500 Hz, 1kHz & 2kHz	Chi-square	5.239	20.262	31.078	12.685
	Df	4	8	12	12
	Sig.	.264	.005 ^{a,b,*}	.002 ^{a,*}	0.003 ^{a,b}
Left High & Extended High Frequency (LHF)4kH - 16 kHz	Chi-square	8.192	12.326	37.778	18.034
	Df	6	12	18	18
	Sig.	.224 ^{a,b}	.004 ^{a,b}	.003 ^{a,b,*}	.004 ^{a,b}

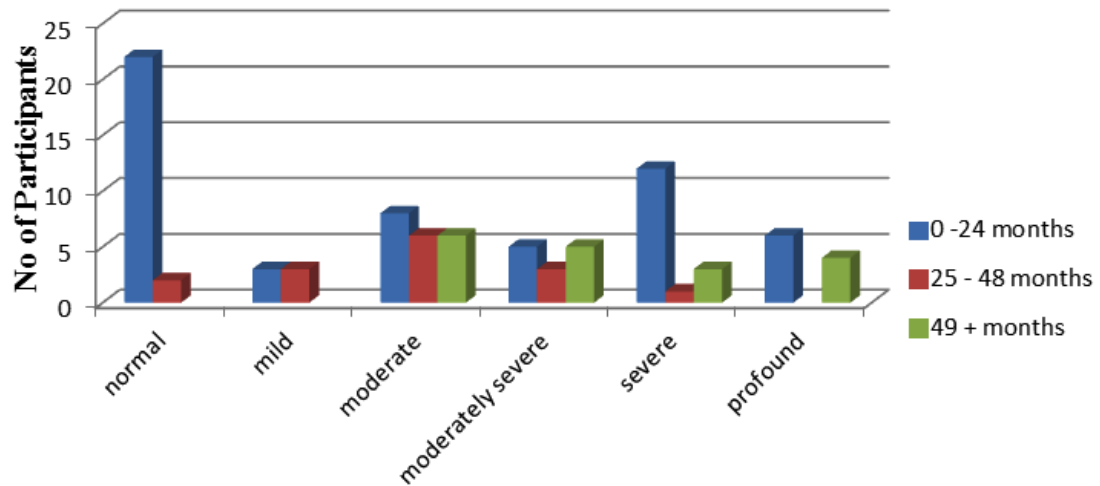
relationship between HbA1c level and diabetes problems, as well as a link between hypoglycemia and its diabetic complications. Moreover, diabetics who have adequate glycemic management may prevent diabetic-related hearing loss.

Uncontrolled DM

The above Figure 2 shows that the high-frequency hearing loss increased when compared to speech frequency in both ears. When the diabetic duration has increased the severity of hearing loss (moderate to profound) is also increased among Uncontrolled DM in both ears. The present finding agrees with past findings were done by Kurien *et al.*

(1989); Tay *et al.* (1995); Panchu *et al.* (2018);^{17,18,19} that the considerable link between HbA1c level and hearing loss and those with poorly managed diabetes suffer severe hearing loss due to high HbA1c levels.

These findings reveal a link between HbA1c levels in the blood and sensorineural hearing loss. According to this concept, the degree of diabetes might be a deciding factor for hearing loss. We compared the effects of diabetes on the cochlear system by performing a complete blood HbA1c (uncontrolled DM) level and audiological examination.



Diabetic age & degree of hearing loss in Controlled DM

Fig. 1. Diabetic age & degree of hearing loss among control DM group

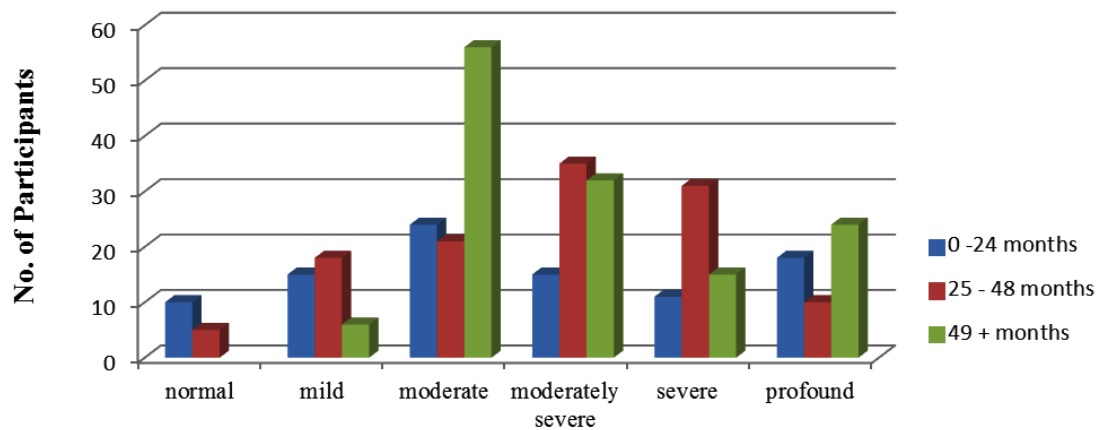


Fig. 2. Diabetic age & degree of hearing loss in Uncontrolled DM

Above table 2 shows that, a significance of age ($p = 0.004$), duration of DM (months) ($p 0.001$) and severity of HbA1c ($p 0.000$) in Right speech frequency and high frequency hearing loss highly significance of HbA1c ($p 0.004$), Age of the participant ($p 0.003$) & duration of DM ($p 0.000$) in right ear. In similar table shows that a significant difference was observed in age (p -value 0.002), duration of DM (months) ($p 0.003$), and severity of HbA1c ($p 0.005$) in left speech frequency and high-frequency hearing loss highly significance of HbA1c ($p0.004$), Age of the participant ($p 0.003$) & duration of DM ($p 0.004$) in the left ear of uncontrolled DM by using multiple comparisons (Pearson Chi-Square Tests).

There is a paucity of research on the relationship between diabetes and hearing impairment symptoms (Ooley C, *et al.* 2017; Nagahama S *et al* 2018)^{11,14}. There are studies documenting hearing loss in all frequencies. The current study shows that there is an association between the severity of HbA1C (controlled DM & uncontrolled DM) and hearing loss (speech frequency & high frequency) among diabetics Mellitus. In addition to research defining diabetes-related hearing loss as progressive, bilateral, and affecting high frequencies (Ren *et al.* 2017; Gupta *et al.* 2019)^{20,21}.

According to Cohen Atsmoni S *et al.* (2019)¹³, reported that diabetes-related hearing loss

would manifest itself mostly at high frequencies, as high-frequency specific parts of the cochlea may be more sensitive to ischemia alterations as a result of microvascular problems as well as this current study also found to be a similar finding of both speech frequency (500Hz, 1kHz & 2kHz), high-frequency hearing loss (4kHz & 8 kHz) and extended high-frequency hearing loss ((9kHz & 16 kHz)) among uncontrolled DM.

A quadratic relationship between HbA1c and the occurrence of high-frequency hearing impairment in this investigation. HbA1c levels, in particular, have been linked to high-frequency hearing damage. A relationship between HbA1c and high-frequency hearing impairment. Findings suggest that maintaining proper glycemic management might help to avoid diabetic hearing loss.

According to Sharma, R *et al.* (2022)¹⁵, there is a substantial link between type 2 diabetes and hearing loss. Hearing loss was found to be sensorineural, bilateral, mild to severe, and involving high-frequency and extended high-frequency thresholds in diabetics. The prevalence of SNHL and HbA1c were shown to have been significant relationship among uncontrolled DM.

Figure 3 indicates that the degree of hearing loss is more in uncontrolled DM when compared to controlled DM. Moreover, if the diabetic duration is longer in diabetic patients,

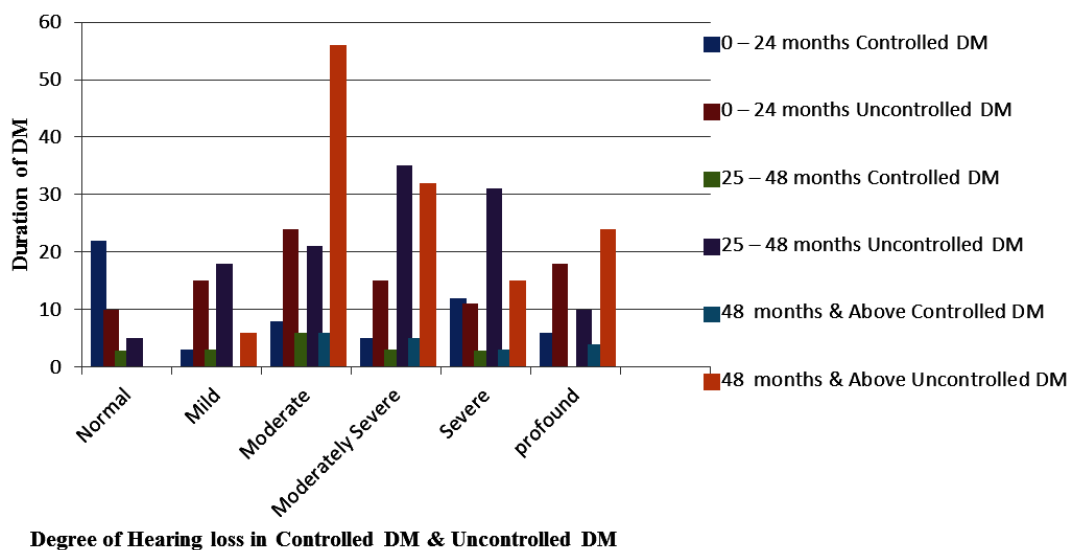


Fig. 3. Degree of Hearing Loss among Controlled & Uncontrolled DM

hearing loss is observed more in severity in both groups.

CONCLUSION

Diabetic Mellitus is a common metabolic disorder that affects several organs. The purpose of this study was to determine the level of hearing sensitivity in people with controlled and uncontrolled diabetes mellitus. The occurrence of bilateral mild to moderately severe high-frequency hearing loss was discovered to be an alarming indicator of the early start of hearing loss at the speech frequency spectrum in uncontrolled DM. As well, high-frequency and extended high-frequency audiometry (HFA) is an important diagnostic method for the early detection of hearing loss in patients with DM, according to the findings of this study. As a result, we urge the use of HFA as a standard Audiological test battery in patients with DM to track hearing sensitivity levels and progression.

Limitations of this study

Broader research that included people of all ages might result in a larger sample size and more data. However, because the sample size and age range were larger, we didn't focus on the study's age constraints. A higher sample size may not make a substantial difference in the conclusion. It may even make it more difficult to reach meaningful findings. A whole separate issue has to be addressed. Following the participants as a cohort for another five or 10 years can provide conclusive and uncontroversial findings. That is what the current investigators want to do at the next level of this study.

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