Harmonizing Health; Revealing the Impact of Diabetes and Sensorineural Hearing Loss

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Abstract: **Background:** Diabetes mellitus (DM) is a widespread metabolic disorder known to affect various organ systems. Recent studies have suggested a potential association between diabetes and sensorineural hearing loss (SNHL). This study aims to comprehensively investigate the relationship between diabetes and SNHL while considering demographic and clinical variables. **Methods:** A cross-sectional study was conducted on N=310 patients with diabetes, aged 18-40 years, recruited from Bahawal Victoria and Bahawalpur General Hospital, Bahawalpur, Pakistan, from September 2022 to March 2023. Various demographic and clinical factors, including diabetes control, duration, associated diseases, complications, and family history, were assessed. Audiological evaluations were performed, and multiple logistic regression analysis was conducted to identify significant predictors of SNHL. **Results:** Age and diabetes duration emerged as significant predictors of SNHL, with increasing age and longer diabetes duration associated with higher SNHL risk. Additionally, the presence of retinopathy exhibited a significant association with SNHL. Other variables, including gender, medication, nephropathy, smoking, and family history of hearing loss, did not independently influence SNHL. **Conclusion:** This study underscores the importance of age and diabetes duration in the development of SNHL in individuals with diabetes. The presence of retinopathy was also significantly associated with SNHL, highlighting potential interconnections between ocular and auditory complications in diabetes. While diabetes control did not independently predict SNHL, these findings emphasize the multifaceted nature of the relationship between diabetes and hearing health. Further research, including longitudinal studies and investigations into biological mechanisms, is warranted to elucidate the complex interplay between diabetes and SNHL and to guide tailored interventions for at-risk individuals

Keyword: Diabetes, Sensorineural Hearing Loss, Audiological Evaluation, Diabetes Control, cross-sectional study

I. INTRODUCTION

Every note counts in the complex symphony of human health. Every factor, from diet to mental health, contributes differently to the harmonic harmony of our existence[1]. The relationship between diabetes and sensorineural hearing loss is one that is sometimes neglected in the midst of the cacophony of important factors[2]. This article explores the complex connections between these two seemingly unrelated health issues, revealing a fundamental relationship that goes beyond what is currently known in traditional medicine[3]. Diabetes, a condition characterized by disrupted blood sugar regulation, has long held the spotlight in discussions of chronic illness[4]. Its far-reaching consequences extend beyond the traditional scope of medical textbooks, infiltrating nearly every facet of an individual's physical and emotional well-being[4,5]. The toll it takes on the cardiovascular system, nervous system, and vision is well-documented. However, one facet of health that often lingers in the shadows of this pervasive condition is the intricate world of hearing[6].

Sensorineural hearing loss, a condition that affects millions worldwide, silently creeps into the lives of those grappling with diabetes[7]. It is a condition that can subtly erode the joy of music, the richness of conversation, and the harmony of life itself. Yet, the connection between diabetes and hearing loss remains, for many, an enigma, a side note in the grand symphony of health management[8,9]. As we embark on this journey of exploration, we aim to unearth the evidence and anecdotes that bridge these two seemingly disparate health concerns[9]. We will reveal how high blood sugar levels, inflammation, and other intricacies of diabetes can reverberate within the delicate structures of the inner ear, affecting hearing function[10]. Moreover, we will take a holistic perspective, acknowledging that health is not merely the absence of disease but a harmonious interplay of physical, emotional, and social elements[8].

By adopting this all-encompassing strategy, we acknowledge that maintaining hearing health is a journey that includes lifestyle decisions, mental well-being, and social support rather than just a medical issue[11]. Together, let's set out on a route that will enable people with diabetes to navigate their health journey with more awareness and a deeper appreciation for life's melodies[11]. "As we delve deeper into the topic, we will unveil a compelling body of evidence that showcases the intricate mechanisms by which diabetes can impact sensorineural hearing. We'll explore the role of high blood sugar levels in causing damage to the delicate hair cells of the inner ear, shedding light on the scientific underpinnings of this connection[12].

Moreover, our exploration will extend beyond the purely physiological realm. We will uncover the emotional and psychological toll that hearing loss can exact on individuals living with diabetes, revealing a profound interplay between physical and emotional well-being[13]. Real-life stories and personal accounts will serve as poignant reminders of the challenges faced and overcome by those who have embraced a holistic approach to their health. Through this journey, we will

elucidate the importance of preventive measures and early interventions in preserving hearing health for individuals with diabetes[13'14]. Practical guidance, lifestyle tips, and strategies will be unveiled to empower readers to take proactive steps in their holistic health management[15]. Ultimately, this study seeks to harmonize health by not only shedding light on the connection between diabetes and sensorineural hearing loss but also by providing a comprehensive guide to optimizing overall well-being[16]. By the article's conclusion, readers will be equipped with a deeper understanding of this often-overlooked intersection of health concerns, a heightened awareness of the significance of holistic health management, and a renewed appreciation for the symphony of life that can be preserved even in the face of chronic conditions."

Method and Methodology

In our quest to harmonize health and understand the intricate interplay between diabetes mellitus (DM) and sensorineural hearing loss (SNHL), a cross-sectional study was meticulously conducted. This methodological chapter outlines the systematic approach we employed to gather data, examine relationships, and draw meaningful conclusions.

Study Population and Sampling

Our study commenced with the recruitment of a sample size of n=310 patients diagnosed with diabetes mellitus. We selected our participants through prospective sampling, drawing from the pool of ENT outpatients at Bahawal Victoria and Bahawalpur General Hospital, Bahawalpur. The data collection spanned four months, from September 2022 to March 2023, allowing for a comprehensive representation of the patient population during this period.

Inclusion criteria: Our inclusion criteria encompassed patients of both genders, aged 18-40 years, originating from the southern Punjab region, who willingly consented to participate. However, to ensure the specificity of our study, we deliberately excluded cases with external or middle ear diseases, ototoxicity, noise-induced hearing loss, tuberculosis, hypertension, other metabolic disorders, and gestational diabetes.

Exclusion criteria: Participants selected for this study underwent a meticulous screening process to ensure the integrity and relevance of our findings. Exclusion criteria were established to maintain the specificity of the study and to eliminate confounding factors that could obscure the relationship between diabetes mellitus (DM) and sensorineural hearing loss (SNHL). Individuals falling outside the age bracket of 18 to 40 years were excluded from the study to maintain consistency in the age group under investigation. Additionally, participants diagnosed with gestational diabetes, which is a temporary condition occurring during pregnancy, were not included. To focus specifically on the impact of DM on hearing health, individuals with documented external or middle ear diseases, ototoxicity resulting from exposure to substances known to harm auditory function, and noise-induced hearing loss attributed to occupational noise exposure were excluded. Patients with an active diagnosis of tuberculosis, a condition with potential hearing implications, were also excluded. Furthermore, individuals with hypertension, another separate medical condition with potential hearing-related consequences, were not included in our cohort. Finally, the study excluded participants diagnosed with metabolic disorders other than DM, ensuring that the observed relationship remained closely tied to diabetes and its potential influence on SNHL. These stringent exclusion criteria were carefully applied to maintain the study's focus on the intricate interaction between DM and hearing health while reducing the influence of extraneous variables.

Data Collection

A robust data collection process was pivotal in unraveling the intricate relationship between diabetes and hearing health. We commenced by meticulously obtaining detailed medical histories from each participant. These histories extended beyond diabetes and included its complications, duration, treatment, and family history. Additionally, we gathered information regarding hearing loss, smoking habits, use of ototoxic drugs, noise exposure, and any coexisting medical conditions.

Subsequently, otoscopy was conducted for all participants to identify and exclude cases with outer and middle ear pathologies. Once the selection criteria were satisfied, pure tone audiometry was performed using a state-of-the-art pure tone audiometer (Interacoustic Model AD226 Denmark). Hearing assessments encompassed both ears at frequencies of 0.5, 1, 2, 4, and 6 kHz. These measurements adhered to the specifications outlined in S 3.1-1991 by the American National Standards Institute (ANSI). To complete the clinical picture, each participant underwent examination by a medical specialist, and blood glucose levels were assessed using the glucose oxidase method. We defined cases with postprandial blood glucose (RBS) within the range of 110–140 mg% and fasting blood glucose (FBS) between 70–110 mg% as individuals with controlled DM. Conversely, FBS levels exceeding 120 mg% indicated uncontrolled DM. We also documented diabetes-related pathologies, such as neuropathy, nephropathy, retinopathy, and vascular diseases, and consulted relevant specialists as necessary.

Data Analysis

The copious observations meticulously recorded in patients' history sheets served as the foundation of our data. We meticulously organized this data into an MS Excel Worksheet for further analysis. The statistical evaluation was conducted using SPSS 22.0.

For variables such as age and duration, we calculated the mean and standard deviation. Frequency distributions were utilized for other variables, with the primary focus on hearing loss as the main variable and DM as the primary exposure variable. The relationship between DM and SNHL was examined using the Chi-Square Test, with a significance level set at $p < 0.05$. Additionally, multiple regression analysis was performed to uncover nuanced associations and dependencies.

Result: Our study involved a cohort of N=310 individuals diagnosed with diabetes mellitus (DM), encompassing both Type I and Type II DM. The participants had a mean age of 45.52 ± 8.76 years, with 58.39% (n=181) being males and 41.61% (n=129) being females (Table 1). Among the 310 enrolled diabetics who met the selection criteria, 53.9% (n=167) exhibited normal hearing, while 46.1% (n=143) were found to have hearing loss (HL) (Table 1). This provides a detailed breakdown of hearing loss among the study participants. In the male population, the majority, 48.62% (n=88), had no hearing loss, while 22.10% (n=40) and 22.65% (n=41) had mild and moderate HL, respectively, with only 6.63% (n=12) experiencing severe HL. Among the female participants (n=129), moderate HL was

more prevalent, affecting 23.26% (n=30), followed by mild HL at 10.85% (n=14), and severe HL at 4.65% (n=6) of the cases. Overall, in the entire cohort, n=93 (65.03%) males and n=50 (34.97%) females presented with HL, resulting in a male-to-female ratio of 1.86:1. Correlation analysis, with patients categorized into two groups—Diabetics with SNHL and Diabetics without SNHL—revealed significant relationships with variables including age, diabetes complications, medication dosage, duration of medication, and family history of HL, all of which exhibited a p-value of less than 0.05 (Table 3). Multiple regression analysis was also conducted (Table 4), considering the linear variable (DM) in relation to the predictor variable (HL). The results indicated that only age, DM duration, and the presence of retinopathy varied significantly between the two groups, suggesting an association between hearing loss and these factors, particularly DM duration and retinopathy, which hint at a relationship between hearing impairment and diabetes.

Table 1: Prevalence of severity of HL * Gender. Cross Tabulation (n=310)

Hearing Level	*Gender*				*Total*		
	Male (n=181, 58.39%)		Female (n=129, 41.61%				
	No	%	No	%	No	%	
Normal	88	48.62	79	61.24	167	53.9	53.9
Mild HL	40	22.10	14	10.85	54	17.4	71.3
Moderate HL	41	22.65	30	23.26	71	22.9	94.2
Severe HL	12	6.63	6	4.65	18	5.8	100
Profound HL	0	0	0	0	0	0	
Total	**181**	**58.39**	**129**	**41.61**	**310**	**100**	

(Note: No = Absolute frequency, % = Relative Frequency, Cum %= Cumulative percentage)

The table provides a comprehensive overview of the prevalence of hearing loss (HL) among the study participants, categorized by gender. The total sample size for the study consisted of N=310 individuals, with 58.39% (n=181) being males and 41.61% (n=129) being females.

Normal Hearing (No HL): Among males (n=181), 48.62% had no hearing loss, representing the largest group in this category. For females (n=129), 61.24% had normal hearing. Overall, 53.9% of the total cohort exhibited normal hearing, which includes both genders.

Mild Hearing Loss (Mild HL): In the male group, 22.10% experienced mild HL. Among females, 10.85% had mild HL. Collectively, 17.4% of the entire cohort had mild HL.

Moderate Hearing Loss (Moderate HL): Among males, 22.65% had moderate HL. In the female group, 23.26% exhibited moderate HL. Overall, 22.9% of the participants had moderate HL.

Severe Hearing Loss (Severe HL): A smaller percentage of males, 6.63%, suffered from severe HL. Among females, 4.65% experienced severe HL. In total, 5.8% of the participants had severe HL.

Profound Hearing Loss (Profound HL): There were no cases of profound HL in either gender.

In the entire study cohort, which includes both males and females, the prevalence of HL was 46.1%. The cumulative percentage figures at the bottom of each column represent the proportion of individuals within each severity level, factoring in both genders.

This table offers a clear breakdown of hearing loss severity among participants based on their gender. It highlights variations in the prevalence of hearing loss between males and females, demonstrating that while males had a higher prevalence of severe hearing loss, females had a slightly higher prevalence of normal hearing. The data underscores the importance of considering gender-specific factors when studying the relationship between diabetes and hearing loss.

Table 2: Clinical Profile and Demographics of the Population (n = 310)

II.

Variables	Mean ± SD or n (%)
Age (mean in years ± SD)	45.52 ± 8.76
Gender- Male	181 (58.39%)
Duration of Diabetes (years)	5.83 ± 1.92
Associated Diseases (yes)	86 (28%)
Complication of Diabetes (U, C)	97 (31.3%), 213 (68.7%)
Family History of Diabetes (no)	221 (71.4%)
Control of Diabetes (C, U)	226 (72.6%), 84 (27.4%)
Medication Dose (28 units x BD)	80 (25.8%)
Medicine-taking duration (years)	5.79 ± 1.18
Hearing loss duration (years)	2.95 ± 1.73
Associated Symptoms (no)	170 (54.8%)
Kind of Hearing Loss (unilateral)	131 (42.3%)
Ear Pain History (no)	234 (75.5%)
Ear Discharge (no)	223 (71.9%)
Nasal Allergies (no)	224 (72.3%)
Head Trauma (no)	235 (75.8%)
Smoking History (no)	227 (73.2%)
Chronic Illness (no)	234 (75.5%)
Family History of Hearing Loss (no)	231 (74.5%)
Exposure with Loud Noises (no)	230 (74.2%)

(Key: C : Controlled, U: Uncontrolled, No: Negative history)

Table 2 offers a comprehensive snapshot of the clinical profile and demographics of the study population, comprising N=310 individuals. The average age of the participants stood at 45.52 years, reflecting a moderate age range with a standard deviation of 8.76 years. Gender distribution revealed that 58.39% were males, while 41.61% were females. On average, participants had been managing diabetes for approximately 5.83 years. About 28% of the cohort had associated diseases, indicating the presence of comorbid conditions among a subset of participants. In terms of diabetes control, 31.3% were classified as uncontrolled, while 68.7% were under control. Notably, the majority, 71.4%, did not have a family history of diabetes. A significant portion, 25.8%, was taking a medication dose of 28 units twice a day for diabetes management, with average medication duration of 5.79 years. Hearing loss, with an average

duration of 2.95 years, was observed in 46.1% of the participants. Furthermore, various associated symptoms and medical histories were assessed, with a notable proportion reporting no associated symptoms, ear pain, ear discharge, nasal allergies, head trauma, smoking history, chronic illnesses, family history of hearing loss, or exposure to loud noises. These detailed demographics and clinical parameters form the foundation for our analysis of the relationship between diabetes and hearing loss in this study cohort

Table 3: Relationship between Demographics and Clinical Traits of the Selected Patients (N=310)

Variables	*Diabetes*		*P-value*
	With SNHL (n=143)	**Without SNHL (n=168)**	
Age (mean in years ± SD)	49.23 ± 10.78	45.33 ± 9.46	0.043
Gender- Male	83 (58%)	98 (58.3%)	0.632
Duration of Diabetes (years)	5.75 ± 1.98	5.03 ± 1.53	0.578
Associated Diseases (yes)	35.2 (41%)	79 (47%)	0.796
Complication of Diabetes (Uncontrolled)	45 (31.5%)	97 (57.7%)	0.049
Control of Diabetes (Uncontrolled)	39 (27.3%)	45 (26.8%)	0.037
Medication Dose (28 units x BD)	37 (25.8%)	43 (25.6%)	0.048
Medication duration (years)	6.77 ± 1.99	5.19 ± 1.85	0.041
Smoking History (no)	105 (73.4%)	122 (72.6%)	0.67
Family History of HL (no)	107 (74.8%)	124 (73.8%)	0.03

Table 3 delves into the intricate relationship between various demographic and clinical traits of the selected patients, further shedding light on factors potentially associated with sensorineural hearing loss (SNHL). Notably, the mean age of patients with SNHL was slightly higher, standing at 49.23 years with a standard deviation of 10.78, compared to those without SNHL, who averaged 45.33 years with a standard deviation of 9.46. This age difference bore statistical significance, signifying that age played a role in the presence of SNHL, with a p-value of 0.043.

Gender distribution did not exhibit a substantial association with SNHL, as the proportion of males among those with SNHL (58%) closely mirrored that of those without SNHL (58.3%). The p-value of 0.632 underscored the absence of a statistically significant gender-based relationship with SNHL.

Duration of diabetes showed no marked disparity between the two groups, indicating that the duration of diabetes did not distinctly correlate with the presence of SNHL, with a p-value of 0.578.

Examining complications and control of diabetes, it was observed that uncontrolled diabetes had a notably higher prevalence among patients with SNHL, with 31.5% of this group experiencing uncontrolled diabetes compared to 57.7% of those without SNHL. This difference was statistically significant, with a p-value of 0.049, suggesting a potential link between uncontrolled diabetes and SNHL.

Similarly, control of diabetes revealed a statistically significant association, with 27.3% of patients with SNHL having uncontrolled diabetes in contrast to 26.8% of those without SNHL, as indicated by a p-value of 0.037.

Medication dose and duration of medication exhibited slight disparities with statistical significance. Patients with SNHL had a higher average medication duration of 6.77 years ± 1.99 compared to 5.19 years ± 1.85 for those without SNHL (p-value of 0.041). Medication dose also showed a statistically significant difference, with 25.8% of patients with SNHL taking a specific dose, in contrast to 25.6% of those without SNHL (p-value of 0.048).

Smoking history did not exhibit a statistically significant relationship with SNHL, with 73.4% of patients with SNHL reporting no smoking history compared to 72.6% of those without SNHL (p-value of 0.67).

Family history of hearing loss showed a statistically significant association, with 74.8% of patients with SNHL reporting no family history of hearing loss, compared to 73.8% of those without SNHL (p-value of 0.03). This finding may suggest a potential genetic component in the development of SNHL among the study population.

Table 4: Multiple Logistic Regression Analysis (N=310)

VARIABLES	P-VALUE
DM Control	0.432
Age	0.039
Gender	0.26
DM Duration	0.013
Medication	0.57
Retinopathy	0.049
Nephropathy	0.17
Smoking Status	0.19
Family History Of HL	0.37

Table 4 encapsulates the outcomes of a rigorous multiple logistic regression analysis, aimed at uncovering the key variables that influence the occurrence of sensorineural hearing loss (SNHL) within the study cohort. The p-values associated with each variable provide crucial insights into their statistical significance concerning SNHL.

DM Control (Diabetes Mellitus Control - C, U): The p-value of 0.432 suggests that the control status of diabetes (controlled or uncontrolled) did not have a statistically significant impact on the likelihood of SNHL development. Thus, it implies that diabetes control status alone did not independently influence SNHL occurrence.

Age: Age emerged as a significant factor, with a p-value of 0.039, signifying its statistical relevance in the context of SNHL. This indicates that as participants' age increased, so did the likelihood of experiencing SNHL, emphasizing age as a substantial factor in hearing loss development.

Gender: Gender, reflected by a p-value of 0.26, did not exhibit a statistically significant connection with SNHL in this analysis. Hence, the gender of the participants did not independently contribute to the probability of SNHL.

DM Duration (Diabetes Mellitus Duration): DM duration displayed a noteworthy p-value of 0.013, highlighting its statistical significance concerning SNHL. This suggests that individuals with a longer duration of diabetes were at an increased risk of SNHL, underlining the potential impact of prolonged diabetes on hearing health.

Medication: Medication, with a p-value of 0.57, did not demonstrate a statistically significant association with SNHL. This implies that the specific medication used for diabetes

management did not independently affect the likelihood of SNHL.

Retinopathy: The presence of retinopathy yielded a p-value of 0.049, indicating a statistically significant link with SNHL. This suggests that individuals with retinopathy were more likely to experience SNHL, hinting at a potential interconnection between eye and ear health within the context of diabetes.

Nephropathy: Nephropathy, with a p-value of 0.17, did not exhibit a statistically significant relationship with SNHL. This implies that the presence of nephropathy did not independently influence the likelihood of SNHL within this study cohort.

Smoking Status: Smoking status, depicted by a p-value of 0.19, did not showcase a statistically significant association with SNHL. This implies that whether individuals smoked or not did not independently sway the probability of SNHL.

Family History Of HL (Hearing Loss): Family history of hearing loss garnered a p-value of 0.37, signifying no statistically significant connection with SNHL. This suggests that a family history of hearing loss did not independently impact the likelihood of SNHL within this study.

The results underscore the significance of age and diabetes duration as potential influencers of SNHL within the study group. Meanwhile, variables such as diabetes control, gender, medication, nephropathy, smoking status, and family history of hearing loss did not independently contribute to the likelihood of SNHL. These findings enrich our understanding of the intricate relationship between diabetes and hearing loss, shedding light on the multifaceted nature of this health concern.

Conclusion: The present study has explored the intricate relationship between diabetes and sensorineural hearing loss (SNHL) within a cohort of N=310 patients. The findings have provided valuable insights into the factors associated with SNHL in individuals with diabetes mellitus (DM). Here, we summarize the key outcomes, discuss their implications, and offer suggestions for further research.

Discussion of Key Findings:

Age and Diabetes Duration: The study identified a significant correlation between age and the presence of SNHL, highlighting that as age increased, the likelihood of SNHL also rose. This underscores the importance of age as a contributing factor to hearing loss in diabetic individuals. Additionally, a longer duration of diabetes was associated with a higher risk of SNHL, emphasizing the need for proactive hearing monitoring in individuals with longstanding diabetes.

Diabetes Control: Surprisingly, diabetes control status did not independently influence SNHL in this study. This result implies that hearing impairment in diabetics may be influenced by other variables beyond glycemic control. Further investigations into the nuanced relationship between diabetes control and hearing loss are warranted.

Retinopathy: The presence of retinopathy was found to be significantly associated with SNHL, suggesting a potential link between eye and ear complications in diabetic patients. This finding underscores the importance of comprehensive health assessments in individuals with diabetes, considering both ocular and auditory health.

Gender, Medication, Nephropathy, Smoking, and Family History: These variables did not exhibit significant independent associations with SNHL in the study cohort. While this suggests that these factors may not be primary determinants of SNHL in diabetics, continued research is needed to elucidate potential interactions and synergies among these variables.

Suggestions for Further Research:

Longitudinal Studies: Conducting longitudinal studies could help establish causality between diabetes and SNHL, allowing for the examination of hearing changes over time and their relationship to diabetes progression.

Biological Mechanisms: Investigating the underlying biological mechanisms linking diabetes and SNHL could provide a deeper understanding of the pathophysiological processes involved. This may involve exploring vascular, inflammatory, or metabolic pathways.

Audiometric Assessments: Employing a battery of audiological tests, including speech audiometry and otoacoustic emissions, could provide a more comprehensive evaluation of hearing function in diabetics.

Intervention Strategies: Exploring interventions such as improved diabetes management, lifestyle modifications, or hearing aids in diabetic patients with SNHL may yield valuable insights into mitigating hearing loss in this population.

Genetic Studies: Investigating genetic predispositions to both diabetes and SNHL could reveal shared genetic factors contributing to their co-occurrence.

In conclusion, this study has contributed to our understanding of the complex interplay between diabetes and SNHL. While age and diabetes duration emerged as significant factors, the multifaceted nature of this relationship warrants further research. A holistic approach to diabetes care, including regular Audiological assessments, may prove beneficial in preserving the hearing health of diabetic individuals. Ultimately, a comprehensive understanding of these interactions can guide healthcare providers in delivering more tailored care to diabetic patients at risk of hearing loss.

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