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# The Effect of Type II DM on the Incidence of Sensorineural Deafness at Bali Royal General Hospital

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**Abstract**

Type II diabetes mellitus (DMT II) is a major health threat, and DM is known to be associated with sensorineural deafness. Age, duration of DM, hypertension and hypertriglycerides are believed to influence this process. This study aims to determine the relationship between type II DM and the incidence of sensorineural hearing loss at Bali Royal General Hospital. The study used a case control design which was carried out on patients admitted between July-September 2021 at Bali Royal General Hospital. The sampling technique employed in the DMT II group with sensorineural deafness was total random sampling, while for comparison, simple random sampling was used. The analyses were carried out by descriptive analysis, chi square test for bivariate data, and logistic regression test for multivariate analysis. The p value is said to be meaningful if <0.05. The whole process of data analysis in this study used SPSS.sav 25. The number of samples was 8 patients with an average age of 49.62 ± 8.45. The mean of RBS (Random Blood Sugar) sugar was 152.25±60.92 mg/dL, and FBS (Fasting Blood Sugar) was 87.87±14.09 mg/dL. Patients with low FBS values and diabetes duration of <5 years had more normal hearing conditions in the right ear (60%), while patients with high FBS and diabetes duration of ≥5 years had more SNHL (66.7%). However, the two conditions did not show a statistically significant relationship (p>0.05). The results of multivariate analysis found that there was no significant relationship between FBS levels and age with hearing conditions in the left ear (p> 0.05). In this study, there was no significant relationship between FBS, duration of DM, pattern of drug consumption, age, and hypertension status of DM patients with the incidence of SNHL in the right and left ears.

**Keywords:** Type II diabetes mellitus, sensorineural deafness, hearing loss

## INTRODUCTION

Diabetes mellitus (DM) has become one of the main threats to human health in the 21st century. According to the WHO report, the number of people with type II DM in 2000 reached 171 million people and is predicted to reach 366 million in 2030, an increase of 114%. During the same period in Asia, the increase reached 141%. (Suyono, 2009). This disease is a chronic disease that will last a lifetime.(1) People have a 2-fold greater risk of hearing loss if they have a history of DM.(2) There are quite a number of studies that assessed the relationship between DM and hearing loss, but this relationship between DM and hearing loss is still unclear and much debated.(3)

Several factors that are believed to be associated with hearing loss in DM patients are age, duration, presence of hypertension and hypertriglyceridemia. Age plays a role in sensorineural hearing loss. The older you get; the risk of hearing loss also increases. There is a relationship between age and hearing threshold in the elderly. The average hearing threshold increases by 1 dB annually for those aged 60 years and over.(4)

The duration of having type II DM also increases the risk of sensorineural hearing loss. Hyperglycemia also causes complications. The risk of complications in DM increases with chronic disease.[5] In this study, hypertension in DM was also measured to determine the presence of higher

risk factors than without hypertension. Circulatory disorders can also affect hearing in several ways. Among them is through an increase in blood viscosity which will reduce blood capillary flow resulting in a decrease in oxygen transport, leading to tissue hypoxia and hearing loss.

Hypertriglyceridemia was also measured to determine the presence of sensorineural hearing loss in patients with type II DM. The combination of triglycerides with low high density lipoprotein, high triglycerides with blood glucose levels and between triglycerides and blood pressure is most often associated with hearing loss.[6]

Naini and Fatholomi (2003), found hearing impairment in the form of hearing loss in 31% of DM patients at a frequency of 4000 Hz and 34% at a frequency of 8000 Hz. Meanwhile, the results of the National Health and Nutrition Examination Survey (NHANES) between 1999-2004 reported that sensorineural hearing loss due to DM occurred at a frequency of 500 to 8000 Hz. [7] According to Pemmaiah dan Srinivas (2011), hearing loss caused by DM is sensorineural deafness with bilateral progressive characteristics at high frequencies, that is 2000 Hz and 4000 Hz frequencies.[8] Although several studies have proven that there is a relationship between DMT II and sensorineural hearing loss, there is only limited research on this matter, especially research related to different socio-demographic backgrounds, which also affects the results of the relationship between them. As the high number of people with type II diabetes mellitus and its estimation of increase over time, thus, it has the potential to increase the incidence of sensorineural deafness. In addition, research related to DMT II and its relationship with sensorineural deafness has not been widely carried out, especially in Bali. For this reason, research related to the relationship between DMT II and the incidence of sensorineural deafness needs to be carried out in the hope that it can be used as a reference for clinicians to apply non-pharmacological methods by reducing exposure to these risk factors. And can be the basis for developing research on related topics.

## METHODS

This research is an analytic observational study with a case-control design. The design of this study was chosen because it aims at understanding the risk factors and the relationship between DMTII and sensorineural deafness. The study was carried out on patients between July-September 2021 at Bali Royal General Hospital. This hospital was chosen as research location because its strategically location, which is in the middle of Denpasar city and it this hospital is an alternative for the community to obtain adequate health services. Moreover, this general hospital has a Diabetes Center, a gathering place for DM patients in the city of Denpasar to share information related to their DM disease.

The subjects of this research were type II DM patients who had sensorineural hearing loss with the comparison type II DM patients who did not experience sensorineural hearing loss. The cases were selected by total random sampling, while the controls were selected by simple random sampling in accordance with the predetermined inclusion and exclusion criteria.

The inclusion criteria in this study included: 1) DM patients at Bali Royal Hospital, 2) male and female gender, 3) willing to participate in the study and filling out and signing an informed consent form, 4) having good condition based on general physical examination. While the exclusion criteria in this study included: 1) a history of having a head injury, 2) a history of having an ear infection resulting in permanent hearing loss, 3) a history of using ototoxic drugs for more than 3 months continuously, 4 ) history of hearing loss since childhood which is inherited from parents, 5) a history of exposure to noise, 6) history of exposed to trauma from bomb explosions, explosions or gun explosions, 7) history of smoking and drinking alcohol, 8) currently suffering from acute ear infections, nose and throat, 9) presence of con-

genital abnormalities in the ear, nose and throat area, 10) presence of tumors in the ear, nose and throat area.

The independent variable in this study was type 2 diabetes mellitus which is defined as DM. The dependent variable in this study was sensorineural hearing loss. Intermediary variables in this study included: age, duration of DM, hypertension and hypertriglycerides.

The instruments used in this study were questionnaires and data extraction sheets. Patients who have been diagnosed with DMT II and meet the inclusion exclusion criteria will be sampled for this study. In the data collection process, the research sample was asked to fill out a questionnaire that had been provided related to sample biodata, risk factors for sensorineural hearing loss, and attached audiometric examination results. Next, the questionnaires were collected, and the results were collected on the data extraction sheet. Then transferred to SPSS, coding and data cleaning were carried out. Subsequently, data were analyzed and presented in tabular form.

Statistical analysis used in the form of descriptive analysis presented in tabular form, while bivariate analysis was carried out by Chi Square (X2) test, and multivariate analysis conducted by logistic regression test. The 95% confidence interval (95% CI) and p value were employed as the assessment of statistical test; result was considered statistically significant if the p value <0.05. Data analysis using SPSS.25.sav

## RESULTS

### Basic Characteristics of Type II Diabetes Mellitus Patients With SNHL

In this study, there were 8 samples that met the inclusion and exclusion criteria. The average age in this study was 49.62±8.45, with male sex. The majority of the sample graduated from high school with 50% of work as private employees, and the rest were civil servants. Based on their vital signs, the sample has an average value within normal limits, both respiratory temperature and pulse. However, the systolic blood pressure was above the normal limit, which was 132.5 ± 23.75 mmHg. However, 75% of the samples had a history of high blood pressure. The sample had an average history of diabetes for 50±10.32 months, with a mean blood sugar of 152.25±60.92 mg/dL, and a fasting blood sugar of 87.87±14.09 mg/dL. But unfortunately, the majority of blood sugar levels are not controlled (75%) (Table 1).

**Tabel 1.** Characteristics of samples

| Variable | N (8) |
|---|---|
| **Age (mean±SD)** | 49.62±8.45 |
| **Gender, n(%)** | |
| Male | 8(100) |
| Female | 0(0) |
| **Education, n(%)** | |
| Junior High School | 2(25) |
| Senior High School | 5(62.5) |
| Undergraduate Degree | 1(12.5) |
| **Body Height (mean±SD)** | 168.75±2.54 |
| **Body Weight (mean±SD)** | 70.62±6.96 |


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| | |
|---|---|
| **Occupation, n(%)** | |
| State | 4(50) |
| Private | 4(50) |
| **Vital signs, n(%)** | |
| Temperature | 36.37±0.51 |
| Respiration | 22±2.13 |
| Pulse | 81.5±2.07 |
| **Blood Pressure, n(%)** | |
| Sistole | 132.5±23.75 |
| Diastole | 81.75±3.61 |
| **Hypertension, n(%)** | |
| Yes | 6(75) |
| No | 2(25) |
| **Blood Sugar Level, n(%)** | |
| RBS | 152.25±60.92 |
| FBS | 87.87±14.09 |
| **Diabetic Medication Intake, n(%)** | |
| Regular | 2(25) |
| Non-regular | 6(75) |
| **Duration with Diabetes (mean±SD)*** | 50±10.32 |

*in month

## Characteristics of Ear, Nasal, and Pharyngeal Conditions

On the examination of ears, the average condition of the ear samples, both right and left, was within normal limits, except for the right tympanic membrane, which was 62.5% perforated. Likewise, on examination of the nasal cavity, only the left nasal cavity was congested (87.5%). While the throat examinations found 12.5% hypertrophic granulomas and dendrites on the tonsils.

**Table 2.** Examination of the condition of the ears, nose and throat

| VARIABLE | N(8) |
|---|---|
| **Ears** | |
| **Right Earlobe, n(%)** | |
| Normal | 8(100) |
| Abnormal | 0(0) |
| **Left Earlobe, n(%)** | |
| Normal | 8(100) |
| Abnormal | 0(0) |
| **Right Ear Canal, n(%)** | |
| Normal | 8(100) |


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| | |
|---|---|
| Abnormal | 0(0) |
| **Left Ear Canal, n(%)** | |
| Normal | 8(100) |
| Abnormal | 0(0) |
| **Right Tympanic Membrane, n(%)** | |
| Intact | 3(37.5) |
| Perforated | 5(62.5) |
| **Left Tympanic Membrane, n(%)** | |
| Intact | 8(100) |
| Perforated | 0(0) |
| **Nose** | |
| **Right Nasal Cavity, n(%)** | |
| Wide | 8(100) |
| Narrow | 0(0) |
| **Left Nasal Cavity, n(%)** | |
| Wide | 8(100) |
| Narrow | 0(0) |
| **Right Nasal Cavity Obstruction, n(%)** | |
| Congested | 0(0) |
| Decongested | 8(100) |
| **Left Nasal Cavity Obstruction, n(%)** | |
| Congested | 7(87.5) |
| Decongested | 1(12.5) |
| **Secrete** | |
| **Right Nasal Cavity, n(%)** | |
| Present | 0(0) |
| Absent | 8(100) |
| **Left Nasal Cavity, n(%)** | |
| Present | 0(0) |
| Absent | 8(100) |
| **Faring** | |
| **Pharyngeal Mucosa, n(%)** | |
| Pink | 8(100) |
| Hyperemia | 0(0) |
| Livid | 0(0) |


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| | |
|---|---|
| **Hypertrophic granules on the back wall of the pharynx, n(%)** | |
| Present | 1(12.5) |
| Absent | 7(87.5) |
| **Tonsils** | |
| **Right Tonsil Size, n(%)** | |
| T1 | 8(100) |
| T2 | 0(0) |
| T3 | 0(0) |
| **Left Tonsil Size, n(%)** | |
| T1 | 8(100) |
| T2 | 0(0) |
| T3 | 0(0) |
| **Detritus, n(%)** | |
| Present | 1(12.5) |
| Absent | 7(87.5) |
| **Crypts, n(%)** | |
| Widen | 0(0) |
| Not Widen | 8(100) |

### Overview of Hearing Examination Results in DM Patients

Based on the results of the hearing examination using audiometry, the average hearing threshold for the sample in the right ear was 48.15 ± 36.92 dB, while in the left ear it was 44.93 ± 28.34 dB. The majority of the right ear was in normal condition (50%), while the rest experienced mild sensorineural hearing loss (12.5%), moderate (25%), very severe (12.5%). Meanwhile, the hearing condition in the left ear has the same proportion, both samples with normal conditions and very severe sensory-neural deafness (25%).

**Table 3.** Examination of hearing loss in patients with type 2 diabetes mellitus who have sensorineural hearing loss

| VARIABLE | N (8) |
|---|---|
| **Hearing Examination, (mean±SD)** | |
| Right Ear Audiogram | 48.15±36.92 |
| Left Ear Audiogram | 44.93±28.34 |
| **Interpretation of Right Audiogram, n(%)** | |
| Normal | 4(50) |
| Mild | 1(12.5) |
| Moderate | 2(25) |
| Severe | 1(12.5) |


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| | |
|---|---|
| **Interpretation of Left Audiogram n(%)** | |
| Normal | 2(25) |
| Mild | 2(25) |
| Moderate | 2(25) |
| Severe | 2(25) |

**Relationship between Diabetes Mellitus and Sensorineural Deafness**

The relationship between diabetes and the incidence of sensorineural deafness is presented using cross tabulation in Table 4.2 and Table 4.3. The FBS value of DM patients was grouped into less than 87.9 and more than or equal to 87.9 based on the average value in the sample. Patients with low FBS values and diabetes duration of less than five years had more normal hearing conditions in the right ear (60%), while patients with high FBS and diabetes duration 5 years had more SNHL (66.7%). However, the two conditions did not show a statistically significant relationship ($p>0.05$). Based on the aspect of the regularity of taking medication, there is no difference in the proportion of DM patients who take medication regularly and irregularly with normal hearing conditions and SNHL. Patients with age less than 50 years showed more experienced SNHL in the right ear (60%), while patients with age 50 years had more normal hearing conditions in the right ear. The proportion of patients with hypertension was higher in normal hearing conditions (66.7%), on the other hand, a high proportion (100%) was found in non-hypertensive patients who had SNHL in the right ear.

**Table 4.** Relationship between Diabetes Mellitus and Sensorineural Deafness in the Right Ear

| Variable | Right Ear Hearing Conditions | | P-value |
|---|---|---|---|
| | Normal n(%) | SNHL n(%) | |
| **FBS** | | | |
| FBS <87,9 | 3 (60) | 2 (40) | 0,500 |
| FBS ≥87,9 | 1 (33,3) | 2 (66,7) | |
| **Duration with Diabetes** | | | |
| <5 year | 3 (60) | 2 (40) | 1,000 |
| ≥5 year | 1 (33,3) | 2 (66,7) | |
| **Medication** | | | |
| Regular | 1 (50) | 1 (50) | 1,000 |
| Not Regular | 3 (50) | 3 (50) | |
| **Age** | | | |
| <50 year | 2 (40) | 3 (60) | 1,000 |
| ≥50 year | 2 (66,7) | 1 (22,2) | |
| **Hypertension** | | | |
| No | 0 (0) | 2 (100) | 0,429 |
| Yes | 4 (66,7) | 2 (33,3) | |

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**Table 5.** Relationship between Diabetes Mellitus and Sensorineural Deafness in the Left Ear

| Variable | Left Ear Hearing Conditions | | P-value |
|---|---|---|---|
| | Normal | SNHL | |
| **FBS** | | | |
| FBS <87,9 | 0 (0) | 5 (100) | 0,107 |
| FBS ≥87,9 | 2 (66,7) | 1 (33,3) | |
| **Duration with Diabetes** | | | |
| <5 year | 2 (40) | 3 (60) | 0,464 |
| ≥5 year | 0 (0) | 3 (100) | |
| **Medication** | | | |
| Regular | 1 (50) | 1 (50) | 0,464 |
| Not Regular | 1(16,7) | 5 (83,3) | |
| **Age** | | | |
| <50 year | 0 (0) | 5 (100) | 0,107 |
| ≥50 year | 2 (66,7) | 1 (33,3) | |
| **Hypertension** | | | |
| No | 1 (50) | 1 (50) | 0,464 |
| Yes | 1 (16,7) | 5 (83,3) | |

The results of the bivariate analysis found that 2 variables had a p value of <0.25, namely the FBS and age variables which were associated with hearing conditions in the left ear. Therefore, to ascertain the relationship between these two variables and the dependent variable (left ear hearing condition), it is necessary to carry out a multivariate analysis to rule out the influence of other variables to produce an independent picture of the effect. Multivariate analysis was performed using logistic regression test. From the results of multivariate analysis, it was found that there was no significant relationship between FBS levels and age with hearing conditions in the left ear (p> 0.05) (Table 6)


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**Table 6.** Multivariate Analysis of FBS Levels and Age with Hearing Conditions in the Left Ear

| | B | S.E | *P* value | *Adjusted* OR |
|---|---|---|---|---|
| FBS Level | 21,896 | 17974,843 | 0,999 | 323094972,298 |
| Constant | -0,693 | 1,225 | 0,571 | 0,500 |
| Age | 21,896 | 17974,843 | 0,999 | 3230949728,756 |
| Constant | -0,693 | 1,225 | 0,571 | 0,500 |

## DISCUSSION

### Patient Characteristics

Several studies have shown a relationship between diabetes or duration of diabetes with sensorineural events. Diabetes patients on average are in the range of older adults, but it is possible to attack young adults considering their sedentary lifestyle. In a study of diabetic patients aged 46.16 ± 9.7 years, pre-diabetics aged 39.4 6 ± 8.5, whereas normal patients were aged 36.9 6 ± 7.3. 9 Likewise with this study, where diabetic patients had an average age of 49.62±8.45. The comparison of the two studies above shows the average age of DMT II patients in the range of 40 years. Based on the basic characteristics, the majority of patients with DM were female (58.3%), compared to men (41.7%). diabetes 6 years. 11 Duris suffering from DMT II in our study also varied but not more than 6 years, i.e., ±4 years (50±10.32 months).

### Factors Causing SNHL in DM Patients

Several previous studies have shown that DM is one of the factors that can initiate hearing loss, and several DM conditions affect the incidence of SNHL. The study of Mozaffari et al found that the FBS of DM and SNHL patients (175.3 mg/dL) was higher than that of DM patients without SNHL (157.7 mg/dL). In the same study, it was also found that the incidence of SNHL in uncontrolled DM patients (55.9%) was higher than in controlled DM patients (44.1%). However, these two findings are not significantly significant.[12] These results are in line with this study where FBS was not significantly related to the incidence of SNHL in both the right and left ears. This indicates that glucose metabolism is not the most important factor in the development of SNHL in DM patients, but only becomes one of the aggravating factors. [8]

Furthermore, the duration of patients suffering from DM was also associated as a risk factor for SNHL. This is related to the duration of DM patients experiencing periods of hyperglycemia. Research by Rianto et al. found that the long duration of suffering from DM was associated with an increase in the hearing threshold to 2000 Hz in the DM patient population.[10] However, the results of this study did not find a significant relationship between the duration of DM with the incidence of SNHL or an increase in the hearing threshold. Similar findings were also found in Krismanita et al's study which did not find a significant relationship between the duration of DM and the incidence of increased hearing threshold. [13] Duration is one of the factors associated with SNHL because the longer the duration of DM, the longer the hyperglycemia condition. Hyperglycemia can cause mitochondrial DNA damage that interferes with the process of oxidative phosphorylation and ATOP production which causes impaired function of organs that have high energy consumption such as the stria vascularis in the inner ear. [14]

Age at onset of DM and duration of DM can also be one of the factors that influence the onset of SNHL. However, the study of Mozaffari et al found that the age of DM patients was not very convincing as


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a triggering factor for SNHL.[12] This is in line with this study which did not find a relationship between the age of DM patients and the incidence of SNHL in the right and left ears. Age is not too important a factor in the incidence of SNHL in DM patients, especially patients with the elderly because in that age range, hearing loss can be caused by aging or presbycusis. However, DM patients who experience SNHL generally experience it at an older age. This is related to environmental exposure and aging processes that are influenced by DM factors and comorbid diseases that may accompany DM patients. This comorbid disease in DM patients increases the risk of long-term use of drugs that have ototoxic effects.[14,15]

**Type II DM mechanism causes Sensorineural Deafness Hearing Loss**

Hearing loss in diabetic patients is explained through pathophysiological theories, namely the theory of neuropathy, angiopathy and a combination of theories of angiopathic neuropathy. Vascular abnormalities in the inner ear are caused by microangiopathy, namely the formation of blood vessel wall precipitates that are visible on periodic acid Schiff staining. These vascular abnormalities generally occur in the capillaries of the stria vascularis and internal auditory arteries, then in the vasa nervosum spiral ganglion and auditory nerve demyelination.[16] Microangiopathy manifested by thickening of the capillary walls will cause the blood supply to the cochlea as well as nutrient transport to decrease. Microangiopathy also occurs in the organ of Corti due to the accumulation of toxic substances resulting from metabolism in the endolymph which originates from abnormal absorption of blood vessels around the endolymphatic sac. Indirectly, there is also a decrease in blood flow due to narrowed blood vessels, resulting in secondary degeneration of the VIII nerve. Furthermore, microangiopathy of the vasa nervosum nerve VIII and vasa spiral ligament will cause atrophy of the spiral ganglion and demyelination of the VIII nerve fibers.[17] The condition of the lack of glycogen in the tissue causes the transduction process in the organ of Corti not to take place optimally due to a lack of ATP derived from glycogen, resulting in manifestations of hearing loss, especially at high frequencies.[18]

A study comparing pure tone audiometry in patients with Type 2 DM and non-DM, the results obtained that the hearing threshold of patients with Type 2 DM was higher than that of non-DM patients $p<0.05$.[19] According to several previous studies, hearing loss conditions such as SNHL in DM patients are also associated with age, duration of DM, medication adherence and other comorbidities. However, the findings of this study indicate that all these factors do not have a significant relationship with sensorineural hearing loss. Several other studies also showed similar results, that FBS levels, age and duration of suffering from DM did not significantly affect hearing loss based on statistical tests ($p>0.05$).[19,20] Meanwhile, another study that evaluated the relationship between age with Type 2 DM and audiometric examination results showed that there was an increased risk of hearing loss in DM patients aged 55 years by 2.8 times in the right ear (OR 2.8; $p=0.072$) and increased risk of 2.1 times in the left ear (OR=2.1; $p=0.200$).[21] DM duration ≥ 8 years also increased the risk of hearing loss by 2.6 times higher (OR= 2.6; $p=0.077$).

Patients with diabetes mellitus with long-lasting hyperglycemia are known to trigger non-enzymatic protein glycosylation reactions, which occur in various body tissues.[22] The glycosylation process begins with the attachment of glucose to the amino acid group until a biochemical reaction occurs that forms an amadori product with the final result in the form of an irreversible advanced glycosylation end product (AGEP). One form of AGEP in DM patients is 2furoyl-4(5)-(2-furanyl)-1-H-imidazole or FFI which can form free radicals that are highly reactive oxidants. These free radicals will later be able to cause


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hearing loss if there is accumulation for a long time due to ototoxic properties that cause denaturation and aggregation effects. Several previous clinical studies have shown a correlation between the duration of hyperglycemia (the duration of diagnosis of diabetes mellitus) and the progression of microangiopathy in DM patients.[23] It was found that conditions approaching normoglycemia can inhibit the formation of microangiopathy which at the same time prevent hearing loss in DM patients.[22,23]

### Research Limitations and Suggestions

This study still has several limitations, such as the number of samples that are still limited and do not include research with a larger number of samples. In addition, this research is still limited to one research center so that it cannot describe the overall characteristics of DM patients in Bali Province. This study also has not been able to carry out regular audiometric checks in DM patients so that they cannot see the progression of hearing loss experienced by DM patients. The researchers suggest conducting a study with a larger sample, with a longer duration of diabetes (more than or less than 10 years), and the HbA1C result is less or more than 7%.

## CONCLUSIONS

In this study, it was found that the majority of the samples had hearing conditions within normal limits in the right ear, but in the left ear the proportion of patients with hearing loss and normal conditions was the same. From several risk factors analyzed such as fasting blood sugar levels, duration of diabetes, drug consumption patterns, age and history of hypertension statistically did not show a relationship between DMT II patients and sensorineural deafness, although in some patients DMT II patients were found to have sensorineural hearing loss.

## CONFLICT OF INTEREST

The author has no conflict of interest in writing this article

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## ETHICAL CLEARANCE

This research has been approved ethically and has received research recommendations from the Dinas Penanaman Modal dan Pelayanan Terpadu Satu Pintu of Bali Province.

## AUTHOR CONTRIBUTIONS

All authors contributed equally in writing this article

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