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(EVALUATION OF HEARING IMPAIRMENT IN IRAQI PATIENTS WITH TYPE 2 DIABETES MELLITUS)

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Abstract:

Background: High prevalence of hearing impairment (HI) in recent decades among diabetes has aroused the concern of researchers. Diabetes Mellitus (DM) is a serious chronic disease that has a large impact on the lives around the world. People with diabetes have twice the rate of hearing loss compared to people without diabetes.

Objectives: the aim of this study was to determine the level of hearing in diabetic and non-diabetic people in Al Najaf city

Materials and Method: A cross sectional study was carried out to estimate the hearing impairment in a sample of diabetics and non-diabetics in diabetic Centers of two major hospitals (Al-Sadder Medical City and Middle Euphrates teaching hospitals) at Al-Najef city, Iraq from the 1st of July 2022 to the end of August 2022. Data of 80 diabetic patients with a median age of 52 (range=50-55) years and 80 nondiabetics with median age of 41 (range=41-45) years was collected using a questionnaire paper. Data frequencies and percentages were represented by tables and figures. P value < 0.05 was considered as statistically significant. The approval of the Scientific Ethical Committee of the Tehran University of Medical Science was obtained.

Results: Thirty-seven (46.3%) diabetics and thirty-six (45.0%) non-diabetics were males, while 43 (53.8%) diabetics and 44 (55.0%) non-diabetics were females, there were bilateral HI (both ears) 36 (45.0%) among diabetics and 18 (22.5%) among non-diabetics with significant differences (P=0.005). HI of right ear that diagnosed at high and mid frequencies was higher significantly among diabetics (P=0.009 and P=0.02), respectively. HI of the left ear that was diagnosed at mid and low frequencies was higher significantly among diabetics (P=0.028 and P=0.02), respectively.

The age group (40-59 years) with a longer duration of disease (>10 years) were found to be potential risks for HI among diabetics with significant differences (OR=2.11, 95% CI=1.65-2.7, P=0.006) and (OR=3.63, 95% CI=1.29-10.24, P=0.015), respectively. Female gender with normal blood pressure found to be protective factors against HI among diabetics with significant differences (OR=0.26, 95% CI=0.1-0.66, P=0.007) and (OR=0.18, 95% CI=0.05-0.61, P=0.006) respectively. Median levels of FBS, HbA1c, and serum creatinine were significantly higher among diabetics with HI in comparison to those without HI (P=0.006, P<0.001, and P<0.001), respectively. (40-59) age group with higher levels of both FBS and serum creatinine were considered as risk factors for HI among diabetics with significant differences (OR=1.106, 95% CI=1.013±1.209; P=0.025), (OR=1.010, 95% CI=1.003±1.018; P=0.005), and (OR=13.947, 95%CI=1.578±123.262; P=0.018), respectively. HbA1c level was correlated positively and significantly with both serum creatinine and duration of

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disease (P=0.002 and P=0.025), respectively.
Conclusions: The age group (40-59) and longer duration of disease (>10 years) were found to be potential risks for HI among diabetics, while female gender with normal blood pressure were found to be protective factors. The Median levels of FBS, HbA1c, and serum creatinine were significantly higher among diabetics with HI in comparison to those without HI.

Keywords: hearing impairment, diabetes mellitus, pure tone audiometry, fasting blood glucose, serum creatinine, HbA1c, hypertension.

1.1 INTRODUCTION:

High prevalence of hearing impairment (HI) in recent decades among diabetes has aroused the concern of researchers. Whilst; the epidemiological association among diabetes and HI was inconsistent. Most researchers be thought with that mild and subclinical sensorineural hearing loss (SNHL) is regularly present in diabetes mellitus [1]

A meta-analysis study reported a consistent high prevalence of HI among diabetics in comparison to healthy group; whatever the age was. [2]

HI is a common complication among patients with type 2 diabetes mellitus, often with high frequencies. Diabetic neuropathic factors may interpret the mechanism of the relation between diabetes and hearing loss (HL). [3]

Diabetes Mellitus (DM) is a serious chronic disease that has a large impact on the lives and wellbeing of individuals, families, and communities around the world. It is one of the top ten causes of adults' mortality, and was estimated to have caused 4 million deaths globally in 2017. In 2017, the global health expenditure on Diabetes Mellitus was estimated to be around 727 billion USD [4]

The global prevalence of DM in 2019 was estimated to be 9.3% (463 million persons), rising to 10.2% (578 million) by the year 2030 and 10.9% (700 million) by 2045. It is a debilitating long-term epidemic with potentially numerous different complications. [5]

In Iraq, DM was increased from 5 percent during (1978) up to 19.7 percent during (2012); therefore, Iraq, as in Middle East, face an epidemic regarding DM disease. [6]

DM is associated with multiple complications. Within time, high glucose levels could cause harm to the small blood vessels and the nervous tissue within the inner ear. In addition to chronic low levels of blood sugar can disrupt the travelling signals from the inner ears reaching the auditory cortex in the brain. Collectively, both mechanisms of nerve damage could lead to SNHL. [7]

Hearing loss is two times more prevalent in diabetic patients as it is in age matched normo-glycemic individuals. In patients with pre-diabetes condition; serum glucose is exceeding normal values but does not reach higher than the threshold for type 2 Diabetes Mellitus, they have a 30% higher rate of SNHL than people without blood sugar level disturbances. [7]

High frequency hearing loss may be a results of poor control DM which appeared to be affect the sense of hearing and cause hearing impairment. Long duration and poor controlled DM with diabetic complications or associated with other risk factors, leads to audiological and endocrine follow-up to prevent further sensorineural hearing loss. [8]

People with diabetes have twice the rate of hearing loss compared to people without diabetes, while people with prediabetes have a 30% hearing loss. It remains to be determined whether hearing loss is related to diabetes independently of glycemic control. Hearing loss has its own set of risk factors and it shares others with diabetes. [9]

One study reported hearing loss of low, medium and high frequencies [3] which could be due to polyneuropathy [10] or microvascular complications. [11]

Hearing loss complications in DM can be bilateral (B/L) and sensory (SN) and may be progressive. Sensorineural hearing loss (SNHL) is a disorder of the inner ear, vestibulocochlear nerve, or central brain processing unit impairment that can be congenital or acquired. Cochlear changes, such as increased thickness of the basement membrane and vascular walls, sclerosis of the internal auditory artery, and degeneration of the inner ear nervous system [12] are responsible for hearing impairment among DM patients.

Therefore; this study was done at Al Najaf City to assess the auditory function of patients with type 2 DM and the influence of proposed factors that could be associated with hearing loss in diabetics.

1.2: Justification

High incidence of hearing loss may be prevented using suitable interventions like health education within the community. Since the year 2007, World Health Organization (WHO) has promoted increased community awareness about hearing impairment through the initiation of World Hearing Day, held on the third of March. Actions required to control the increasing people's number with hearing loss and to improve style of life for them have also been meticulously reported. [13-15]

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Volume-16, December 2022
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However, this progress is still underdeveloped, specifically in low and moderate income nations, due to small local capacity to scale up proven interventions at all of health care delivery levels. (13-15)
Since SNHL cannot be brought back to normal, knowing preventable etiologies of hearing loss is a main clinical and public health aim to achieve. (16)
Many of the impacts of HL can be decreased through early diagnosis and management. (16, 17)
Hearing loss has an impact on many aspects of life like speech, communication, and cognition. In the aspect of education and employment, as seen in developing countries, children with hearing loss do not get the proper education or any schooling at all. (17)
Hearing loss also leads to social isolation, loneliness and increases stigma. The WHO has estimated that the yearly global cost of hearing loss is about 980 billion USD, which include the costs of the health sector, education, the loss of productivity, and costs on the level of the society, where 57% of all those costs occur in the low and middle income countries. (16, 17)

1.3: Research Objectives and Goals:

1.3.1. Main Objective:

Determining of hearing Impairment in Iraqi Patients with Type 2 Diabetes Mellitus

1.3.2. Specific Objectives:

1.3.2.1-Descriptive Objectives:

1. Determining the hearing level in diabetic and compare it with non-diabetic people in Al Najaf city**.**
2. Determining Fasting blood glucose (FBG), Hemoglobin A_{1c} (HbA_{1c}) and serum creatinine (S. creatinine) levels in diabetic people Al Najaf city

1.3.2.2-analytic objectives:

1. Finding the correlation between HI and DM regarding the duration of disease
2. Finding the correlation between HI and DM regarding the age/ gender of the patients.
3. Determine the correlation between HbA1c blood values and HI in diabetic patients.
4. Determine the correlation between serum creatinine levels and HI in diabetic patients.
5. Finding the correlation between HI and DM regarding the type of management.
6. Finding the correlation between HI and DM regarding presence or absence of hypertension (HT)

1.3.3. Goals:

1. To contrast the prevalence of HI among the diabetics with that among the healthy controls.
2. To acquaint the association between HI and serum creatinine, HbA_{1c}, and duration of diabetes

1.4: Research Questions and hypothesis:

1.4.1. Research Question:

1. Is there effect of DM on hearing in diabetic people Al Najaf city?
2. What is the hearing level in diabetic and non-diabetic people Al Najaf city?
3. Is there relation between HI and DM concerning the duration of disease?
4. Is there relation between HI and DM concerning the age/ gender of subjects?
5. Is there relation between HI and DM concerning the HbA_{1c} levels?
6. Is there relation between HI and DM concerning the serum creatinine levels?
7. Is there relation between HI and DM concerning the type of management?
8. Is there relation between HI and DM concerning presence or absence of HT?

1.4.2. Hypothesis:

1. There is an effect of DM on hearing level.
2. There is a correlation between HI and duration of diabetes.
3. There is a correlation between HI and gender-age differences among diabetic patients
4. There is a correlation between HI and DM regarding the HbA1c level
5. There is a correlation between HI and DM regarding serum creatinine level .
6. There is a correlation between HI and DM regarding the type of management.
7. There is a correlation between HI and DM regarding presence or absence of HT.

1.5. Definitions of terms:

1.5.1. Hearing impairment (HI) is a pure tone threshold of more than 25 dB hearing loss in the better ear; above which the HI makes it difficult to hear lower than normal. (17)

1.5.2. Sensorineural hearing loss is a Hearing loss caused by an impairment in the function of the cochlea and/ or the auditory nerve.

1.5.3. Diabetes mellitus is a metabolic disease which involve incorrect high level of blood sugar.
DM has several types including:

1. Type 1 DM
2. Type 2 DM
3. Gestational DM.

The most common types of DM are Type 1 DM and Type 2 DM, which mainly result from defects in insulin secretion (Type 1) and/or action (Type 2). Type 1 DM appears in children or adolescents, however T2DM is appears in middle-aged and older adults with prolonged hyperglycemia due to bad dietary behavior and poor lifestyle. (18)

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Volume-16, December 2022
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LITERATURE REVIEW

2.1: Theoretical Background

2.1.1. Epidemiology

In the year 2019, the Global Burden of Disease Study (GBD) estimated that more than 1.57 billion persons have some form of hearing loss (more than 20 dB of hearing loss), (GBD 2019 Diseases and Injuries Collaborators 2020). There were negative impacts associated with all levels of hearing loss. [7]

2..1.2 Auditory System anatomy and physiology of hearing

The outer ear is formed by the pinna and the external auditory canal. It is separated from the middle ear by the tympanic membrane as shown in Fig.1.

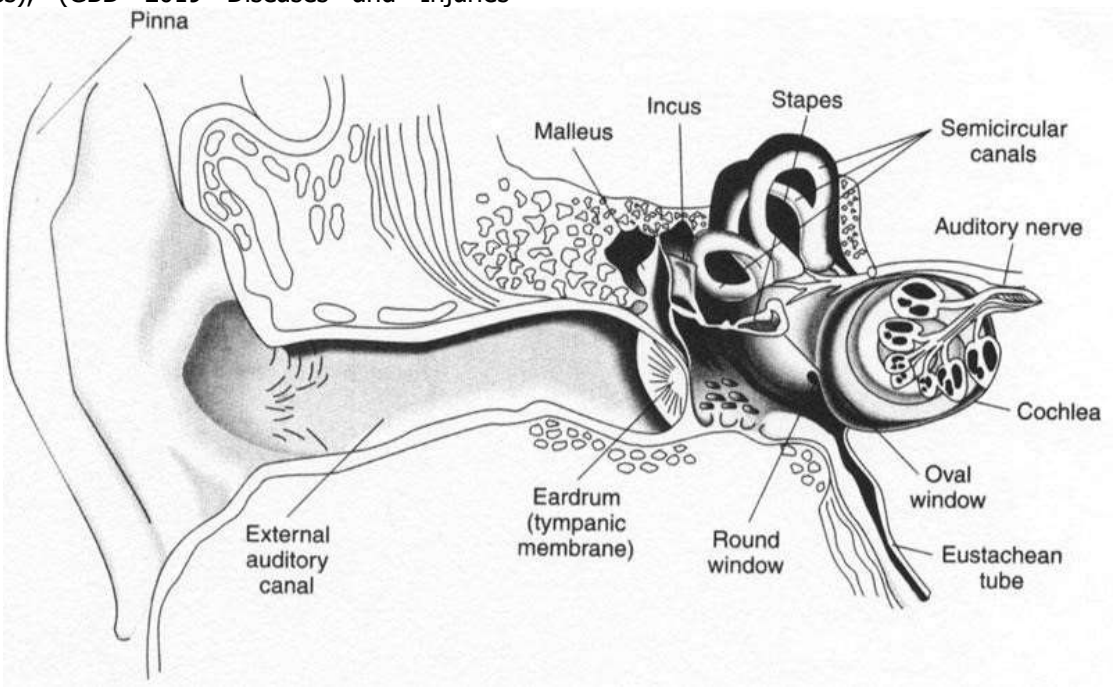

Figure 1: Auditory system

The outer ear is responsible for collecting sound. The middle ear is an impedance matching device, and houses the three ossicles. These are namely the malleus, incus and stapes. This ossicular chain is a system of levers that serve to amplify sound. The outer and middle ear form the sound conducting mechanism and also amplifies sound signals. The inner ear consists of the cochlea and the vestibular labyrinth (semicircular canals) (Alberti, 2010).

Physiology of hearing: Sound waves are collected by the pinna through the external auditory canal. These sound waves set the tympanic membrane into vibration. The vibrations are conveyed through the three ossicles to the oval window. The vibrations stimulate the fluids of the cochlea, which in turn stimulate the hair cells (sensory receptors) of the organ of corti. The response of the hair cells activates the neurons in the auditory nerve, which converts the signal into a neural code. This is now transported through the auditory nerve to the brain to be processed by central nervous system.

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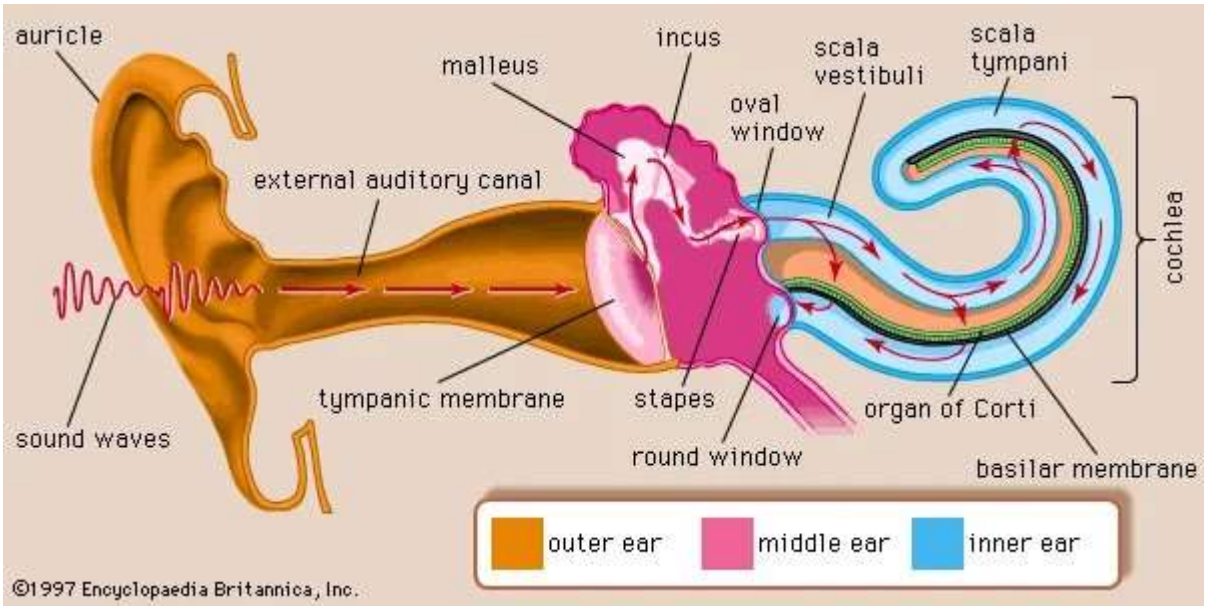

Fig 2 Mechanism Of Hearing

2.1.2. Types of Hearing Loss

There are four types of hearing loss:

1. Conductive Hearing Loss: This type of hearing loss is caused by a factor that prevents the sound waves from getting through the outer or middle ear. It can often be managed medically or surgically.
2. Sensorineural Hearing loss: it occurs when there is a disturbance in the function of the inner ear or the vestibulocochlear nerve.
3. Mixed Hearing Loss: that includes both a conductive and a sensorineural component.
4. Auditory Neuropathy Spectrum Disorder hearing loss: that takes place when sound waves reach the ear normally, but because of the damaged inner ear or the auditory nerve, sound isn't organized in an understandable fashion to the auditory cortex. [19]

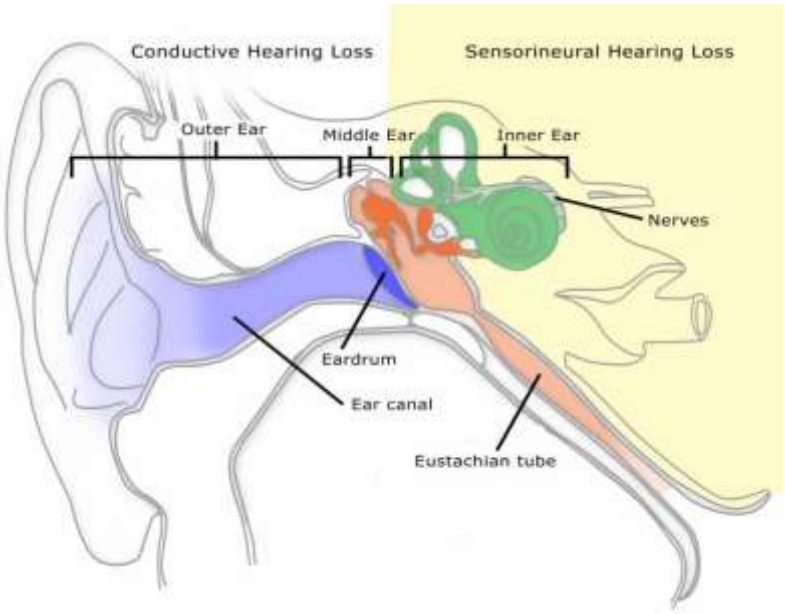

Fig.3: Types of hearing loss

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2.1.3. Etiology of Sensorineural Hearing Loss

Hearing loss can be caused by damage to any part of the peripheral and central auditory systems. The main etiological factors of sensorineural hearing loss are the following:

- Age-Related Degenerative Processes: The main reason of adult-onset hearing loss is the effects of aging on the auditory system. Hearing loss in older individuals is caused not only by the degenerative changes of aging regarding the cochlea but by the accumulated effects of noise and ototoxic agents as well. [20]
- Noise-induced hearing loss that occur temporarily or permanently, which depends on the intensity and time of exposure. [19]
- Exposure to therapeutic agents: Aminoglycoside antibiotics and Cisplatin, which are toxic to sensory hair cells. [21]
- Sudden hearing loss: the cause of sudden hearing loss is idiopathic but is presumed to be due to viral, vascular, or autoimmune factors. [22]

2.1.4. Degrees of Hearing Loss

• The degree of hearing loss can range from mild to profound as shown in (table 1)

Table 1: ASHA's Classification of degree of Hearing Loss.[23]

Degree of hearing loss	Hearing loss range (dB HL)
Normal	-10 to 15
Slight	16 to 25
Mild	26 to 40
Moderate	41 to 55
Moderately sever	56 to 70
Sever	71 to 90
Profound	91+

In the mild type of HL, a person may hear some speech sounds but finds it difficult with soft sounds. While in moderate HL, they may hear almost no sound when another person is talking at a normal level. A person with severe type of HL will don't hear sound at all when a person is talking at a normal level but solely some loud sounds might be caught. A person with a profound type of HL will not hear any speech with very few loud sounds.

Hearing loss can also be described as unilateral or bilateral, pre-lingual or post-lingual (happened before or after a person learned to talk), symmetrical or asymmetrical, progressive or sudden, congenital or acquired, fluctuating or stable. [24]

2.1.5. The impact of hearing loss:

Emotional and social problems may result from hearing loss even in cases of mild degree. [25]

Hearing loss impacts many aspects of life at the individual level like communication and employment problems. Adults with hearing impairment have a notable higher unemployment rate. Among those who are employed, a higher percentage of them are in the lower grades of employment chances compared with the general workforce. [26]

2.1.6. Pathophysiological mechanisms of Sensorineural Hearing Loss due to DM

Neural hearing loss is the result of the dysfunction of the spiral ganglion neurons or of the more proximal auditory structures. Auditory neuropathy is known for normal (or near-normal) sensory hair cells in addition to abnormal neural responses and typically lesser word recognition than is seen in sensory hearing loss. [27,28]

Hyperglycemia is initiated by various pathophysiological pathways in the nervous system due to apoptosis, hyponeurysm, and excitation of intracellular calcium, formation of glycosylated products, hypo oxidation and ischemia, resulting in damage to different components of nerves. [29]

Increased outflow of the polyol pathway (sorbitol-aldose reductase pathway), described in peripheral nerves in 1966, [30] was found to be damaged by myelin sheaths and other nerve components of the peripheral nervous system because of hyperglycemia. [31]

It is known that for the inner ear to function properly there must be a good balance between insulin and glucose levels. Diabetics have glucose in their blood, but it cannot enter the inner ear cells due to lack of insulin resulting in functional disorders. This may be an

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important causative factor in labyrinthine disorders. [32, 33]

One of the most theoretical mechanism is interference with nutrient transport through thick capillary walls, decreased flow due to narrow vessels, and secondary degeneration of the vestibulocochlear nerve causing neuropathy. [34-36]

Vasculopathy occurs mainly in the stria vascularis and spiral ligament. Clinical trials on diabetic animals indicate that hearing impairment is primarily due to a reduced number of spiral ganglion cells and secondarily by edema of blood vessels (stria vascularis) [37].

The cochlear and auditory pathways are also compromised in diabetes. [38] Several histopathological changes can occur during the disease such as decreased number of ciliated cells, spiral ganglionic atrophy, and demyelination of the eighth nerve. [39] Because of these changes; a close relationship has been postulated between DM and hearing loss. [40-42]

Pathological support for this relation may be related to the increase in capillary lesions in the cochlea, and more specifically in the blood vessels and basilar membrane. Other studies also reported a decrease in the number of spiral ganglion neurons. These differences may be related to the duration of DM and to the presence of comorbidities that can affect the inner ear [43].

Over time, high blood sugar levels can damage the small blood vessels and nerves in the inner ear. In addition, hypoglycemia over time can damage how the nerve signals travel from the inner ear to your brain. Both types of nerve damage may lead to HL. [7]

The main clinical manifestation of diabetes is a disturbance of glucose, lipid, and protein metabolism as a result of impaired production and/or metabolism of insulin.

High levels of glucose in the blood lead to increased deposits of glycated hemoglobin on the blood vessels walls, abnormal growth of endothelial cells, and high levels of lipids in the blood, all of which contribute to joint stiffness characterized by thickening of the vessels basement membranes. The restrictive effect of DM on the vessels appears to be more clear on body systems that depend on the microvascular supply. [44]

One such system may be the cochlea, which depends on complex microcirculation to supply energy, eliminate metabolic waste, and maintain internal homeostasis. The underlying mechanisms of pathophysiology are thought to be increase blood glucose induced by oxidative and nitrogenous stress. [45]

These histological variations are thought to be the underlying cause of important diabetes- related complications such as vascular ischemia in neural tissue leading to atrophy and demyelination. The generation of cochlear endogenous potentials, which drive cochlear transport, depends on the continuous metabolism of oxygen and glucose from the stria vascularis. [46]

Therefore, any abnormality or insufficiency of the vascular networks may underlie some of complications related to peripheral auditory (e.g., sensorineural hearing loss) as a result of diabetes. [45]

Another pathophysiological mechanism associated with diabetic microangiopathy is the infiltrating macrophage activity responsible for waste migration from areas like the endolymphatic sac. Inadequate removal may lead to accumulation of high molecular waste product and debris which will have highly toxic effects on inner ear hair cells resulting in hair cell malfunction. Thus, the adverse effects of toxic waste accumulation may be related to the statistically significant relationship among hearing impairment and microvascular alteration in the endolymphatic sac of diabetic patients. [47]

Recent investigations have indicated that oxidative stress (imbalance of free radicals and antioxidants in the body) may play an important role in hearing impairment in diabetic patients, since many reports revealed association of diabetic complications with oxidative stress that related to diabetes itself. [48]

Vascular abnormalities and persistently elevated glucose levels as a result of diabetes also affect cranial nerves from malnutrition and progression to dysplasia, nerve cell membrane necrosis, and demyelination. These changes are thought to result in reduced conduction efficiency, a hallmark of diabetic peripheral neuropathy. [49]

2.1.7. Prevention of hearing loss in DM:

Hearing loss can be frustrating for diabetic patients and their families, affecting their social life. [7] It cannot reverse hearing loss, but it can follow these tips to help protect the ears among diabetic patients:

• Keeping blood sugar as close as possible to target levels.

• Having hearing examination every year:

A hearing test should be done by an audiologist (a health care professional who evaluates hearing for medical problems) at diagnosis of diabetes annually and making it as a part of the diabetes care schedule.

• Avoiding other causes of hearing loss, including loud noises.

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Volume-16, December 2022
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• Asking doctors if anti-DM medications can harm hearing and what other options are available.

2.2 Articles Review:

In this section, some studies that have been done on hearing loss and diabetes are mentioned:

• A prospective cohort study was performed by Min-Beam Kim et al for assessing the association between Diabetes Mellitus and incidental hearing loss in 253,301 adults with normal hearing by a regular health-screening exam in the period between 2002 and 2014. During the follow up, 2817 participants had developed incidental loss of hearing. The rate of hearing loss in non-diabetics, pre-diabetics and diabetics were 1.8, 3.1 and 9.2 per 1000 person-years, respectively ($P < 0.001$). The risk has increased progressively with HbA1c levels above 5%. It was concluded that Diabetes Mellitus was associated with the development of bilateral hearing loss & diabetics have an increased risk of future hearing loss. (50)

• In a study by Huihui Ren et al, with a goal of evaluation auditory alterations and their possible associations with vascular/neurological dysfunctions in 160 persons with type 2 Diabetes Mellitus against a 100 with similar age and sex healthy controls, where pure tone audiometry was applied. When compared with controls, diabetics had higher mean hearing thresholds at each frequency. "Prevalence of hearing loss in diabetics was 67.5% (108/160), including high-frequency (72.22%, 78/108), and low/mid- and high-frequency (27.78%, 30/108). Mild hearing loss was predominant in diabetics with high-frequency impairment (52.56%), while the moderate/severe hearing loss was high in individuals with both low and high frequency hearing loss (80%)". It was concluded that hearing loss is common in diabetic subjects, with mainly high frequency. Diabetic neuropathic cause may explain the underlying mechanism of the relationship between diabetes and hearing loss. (3)

• A cross-sectional study by Abdulbari Bener et al, to measure the prevalence of hearing loss and its association with type 2 Diabetes Mellitus, done in the ENT and endocrinology outpatient clinics of the Hamad Medical Corporation during the period from Jan 2013 to Jul 2014. Grason Stadler GSI 61 and Madsen Orbiter 922 audiometers were used for evaluation.
The study results confirm previous reports that adults with Diabetes Mellitus and associating hypertension showed greater hearing impairment. And diabetic patients with hearing loss were likely to have high blood glucose and other risk factors like hypertension. (51)

• In another cross-sectional study by Caroline Luiz Meneses-Barriviera et al, done to assess the prevalence of hearing loss and its possible link to hypertension and Diabetes Mellitus in the elderly, utilizing 519 persons > 60 years that were examined by Pure Tone Audiometry, and answered a comorbidity questionnaire. The dependent variable was the presence of hearing loss. The independent variables were age, gender, Diabetes Mellitus and hypertension.
The final sample was composed of 498 subjects. Sensorineural hearing loss was more prevalent (66.26%) occurring most frequently with bilateral hearing loss of 91.56% and 26.50% with a mild degree. The statistical analysis showed that the variable Diabetes Mellitus was associated with a high frequency of hearing loss in the elderly. (52)

• A Cohort Study done by Lerman-Garber et al to evaluate the prevalence and association of hearing impairment in patients with diabetes aged 30 to 50 years old. Which were diagnosed before the age of 40 years (early onset). 46 diabetic patients with an early onset were matched against 47 controls with rheumatoid arthritis (with a similar age period). Clinical, serologic, and auditory assessments were done for both groups. The patients with type 2 Diabetes Mellitus had a mean age of 42 ± 6 years and mean disease duration of 11 ± 6 years. The prevalence of unilateral or bilateral hearing loss was significantly higher in the patients with type 2 Diabetes Mellitus than in the group of controls (21.7% vs 6.4%, respectively; $P = .01$), there was a significant association between hearing loss and HbA1c value.
So it was concluded that Patients with early-onset type two Diabetes Mellitus and accompanying poor glycemic control have an increased prevalence of subclinical hearing loss and impaired auditory brainstem responses. These results explain how hearing impairment may be an under-recognized complication of diabetes. (53)

• In another cross-sectional study that included 104 type 2 diabetic individuals attending the diabetic clinics of The University of Guilan for Medical Sciences, done through an one year period (from 2014 to 2015). The first study group contained 52 patients with a poor glycemic control, matched against the second group of patients with a moderate - good glycemic control (measured using HbA1c level). Pure Tone Audiometry and Distortion Product Otoacoustic Emission,

World Bulletin of Public Health (WBPH)
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Volume-16, December 2022
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assessments were done to all subjects. It was concluded that poorly controlled Diabetes Mellitus can affect hearing and causes HL, particularly at the high frequencies, it looks that diabetic patients with a duration of disease more than ten years, diabetic complications, poor control status or co-morbidities should suffer both endocrine and audiological follow-up to decline progressive sensory neural hearing loss. (8)

● Raveendra P Gadag, et al, 2020 study of 140 patients with diabetes assessed for hearing loss, 60 of whom had SNHL and most of them had bilateral hearing loss. SNHL was significantly associated with family history, age, duration of DM. FBG and PPBG levels were significantly correlated with duration of DM, FBS and PPBG level. Significant SNHL was recorded at 500 Hz and at 8000 Hz. Conclusive evidence has been found that family history of diabetes serves as a valuable variable in the assessment of SNHL among patients with DM. (54)

● A retrospective, hospital-based, observational study using data collected from 7,382 hearing-impaired patients (2016–2020). Diabetes with SNHL was observed in 37.7% of patients. Of the total diabetic patients, 11.3% had type 1 DM and 88.7% had type 2 DM. According to the PTA readout, SNHL was found among 37.74% DM patients and 62.25% among non-diabetic patients (P < .001). A lower age at onset of DM and longer duration of diabetes were associated with more severity of SNHL. Age at onset and duration of diabetes were associated with SNHL. The study revealed a higher prevalence of SNHL in type 2 DM. DM is a more important initiation and progression factor for hearing loss than other factors. With a PTA, early detection of hearing loss in type 2 DM may help avoid or worsen deafness. (55)

Considering that there has been no study on hearing loss and diabetes in Iraq, this study was conducted with the aim of determining of hearing Impairment in Iraqi Patients with Type 2 Diabetes Mellitus.

3. MATERIALS AND METHODS:

3.1. Study design, setting and period:

The current cross sectional study protocol has been approved by the Research Ethics Committee of Tehran University of Medical Sciences (Code: IR. TUMS.FNM.REC.1410.102), it was conducted to estimate the hearing impairment in a sample of diabetics and compare it with a sample of non-diabetics, as well as to determine the association between hearing impairment and gender/age/ HbA1c level / serum creatinine levels/ duration of diabetes and history of hypertension among diabetic group .diabetics participants were register in Centers of two major hospitals (Al-Sadder Medical City and Middle Euphrates teaching hospitals at Al-Najef city, Iraq from the 1st of July 2022 to the end of August 2022.

3.2. Study population:

The study population was represented by the patients who attended to the diabetic centers of two major hospitals and non-diabetic patients, at Al-Najef city, based on the inclusion and exclusion criteria of the study.

Inclusion criteria:

1- Diabetics that is medically diagnosed with type 2 diabetes and under anti-diabetic treatment in the age group (20-59).
2- Duration of the disease (1- 19) years
3- No congenital hearing loss.
4-There is no clear causing for acquir
ed hearing loss other than diabetes because patients who receive a heavy course of ototoxic drugs as an aminoglycoside group or chemotherapy regimen.
5- Lack of conductive hearing loss
6- No history of ear surgery or obvious deformity.
7- No history of mumps, measles, rubella and meningitis.
7. Lack of chronic kidney failure.
8. Not a pregnant woman.
9- Lack of SNHL family history

Exclusion criteria:

1- Loss of admission requirements.
2- Fatigue and unwillingness of the patient to continue the tests.

3.3. 1_Sampling method:

This study was carried out through multistage systematic random for two major teaching hospitals in al Najaf city, IRAQ.
80 of medically diagnosed diabetic patients (20-59-year-old) were selected from the diabetics registered in two diabetes centers of Al Sadder medical city and Middle Euphrates Hospital. They interviewed by endocrinologist for usual checking and sent to laboratory unit to do blood investigation (blood sugar test, hemoglobin A1c and serum creatinine). After that, they referred to the audiology center for an ear examination and detection the hearing level by conventional pure tone audiometer.

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
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Other 80 participants (non- diabetics) were randomly selected from group of normal volunteers to measure their hearing level and compare it with diabetic participants.
all the collected information was documented and scaled by specific computer programs

3.3.2-Sample size:

The sample size would be expected to be 80 of diabetics and another (80) of non- diabetics in the study. and the sample size would be calculated according to the following equation regarding the small sample size of a cross-sectional study.

$$n = \frac{\left(\sigma_1^2 + \sigma_2^2\right)\left(Z_{1-\alpha/2} + Z_{1-\beta}\right)^2}{\delta^2}$$

$$\alpha = 0.05 \Rightarrow Z_{1-\alpha/1} = 1.96 \qquad 1-\beta = 0.90 \Rightarrow Z_{1-\beta} = 1.28$$

$$n = \frac{(6.54^2+5.81^2)\,(1.96 + 1.28)^2}{10\%}$$

$$\approx \quad 80$$

Where:
n was the minimum sample size required in each group in power 90% and marginal error 10%.
Standard deviations for diabetics and compared group were 6.54 , 5.81 respectively [56].
Z represent statistical correspondence of confidence.

A consideration of non- responsive peoples was taken; so the final sample size was extended to (175) subjects.

3.4. Data collection:

After taking official permissions and selecting two main diabetic centers in the city, the centers were invited to participate in the study.

Method of assignment to study groups
All the subjects of two groups that were agreed to participate was asked to sign the consent form (Appendix 1). Then they completed medical questionnaires (Appendix 2) and underwent audiological examinations (otoscopy, tympanometry and audiometry),

Regarding diabetic patients referred to laboratory tests and did (blood glucose test, Hemoglobin A1c and serum creatinine)

3.5. Measures/instruments:

3.5.1. *Questionnaire*

3.5.2. Otoscopy (Germany)
3.5.3. Conventional diagnostic audiometer (AD226 by interacoustics, Denmark)

3.5.5. Laboratory blood tests.

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
ISSN: 2749-3644

3.6. Procedures:

Firstly, the researcher introduced yourself to participant and explained a short description about the aim of research and after obtaining the approval of the ethics committee and conducting sampling, each selected patient was filled the accepting forma and signature on it (Appendix 1), then, the researcher was take short history from participant according to the questionnaires already designed for purpose of this study (Appendix 2).

Diabetics were referred by an endocrinologist and sent to a laboratory unit for blood investigations (blood glucose test, hemoglobin A1c, and serum creatinine).

All participants (diabetics and non-diabetics) referred to audiological center where audiometry and tympanometry were done by researcher.

Audiometric procedure for threshold measurement:

In sound proof room, the examiner explained the test to each participant

briefly and teach him who to respond when he\she heard the given tone (by hand rising , head nodding or press special button),started with air conduction threshold measurements through supra-aural head phone and check frequencies (250 , 500, 1000,2000,4000 and 8000 Hz) then bone conduction threshold measurements by bone vibrator to check frequencies (500, 1000, 2000 and 4000 Hz) , thresholds typically were obtained using a Hughson-Westlake down- up procedure (down-10/up-5 rule), and all the collected information was documented and scaled by specific computer programs. Before hearing testing, if there is wax impaction, or foreign body in otoscopic examination, the patient was referred to the ENT unit for otolaryngologist consultation and ear cleaning.

Tympanometry: an objective test used to evaluate middle ear status and tympanic membrane mobility. test results of 3 types: normally type A, conducive element as wax, otitis media with effusion or perforated tympanic membrane result type B, and type c in case of negative middle ear pressure as ETD, it is important to exclude any participant didn't show type A.

3.7. Statistical consideration:

Data entry and analysis were done using Microsoft excel 2010 and SPSS 26 (Statistical Package for Social Sciences). Parametric data was presented as mean and standard deviation. Categorical data was presented as numbers and percentages. Chi- square test and Fisher exact test was used to test homogeneity. To test the hypotheses, the data was examined for normality using the Kolmogorov-Smirnov test, and then, Mann Whiney test was used for non-normally distribution to measure the differences between groups. Odd ratio at 95% confidence interval and multivariate regression analysis were estimated to predict risk factors. To investigate the relationship between HbA1c /duration of disease and the audiometric findings, spearman's correlation test was used. P value less than 0.05 considered as statistically significant.

3.8. Ethics:

The study protocol would be approved by the Scientific Ethical Committee of the Tehran University of Medical Science. All subjects were briefed about the study objectives before the start of the study. They will sign a written informed consent before enrolment (appendix1). All participants will have complete rights to withdraw from the study at any time without any threat., any participants with hearing impairment would referred to appropriate facilities for further investigation and treatment. All hearing tests are non-invasive.

3.9. Variables:

1- Age: it is the number of complete years from birth [57].
2- Gender: a person's gender based on their phenotype: either male or female [61].
3- Duration of DM: the time during which DM exists or lasts was there for the duration of the concert [58].
4- Type of management: Methods that used to keep blood sugar within normal level as oral anti glycemic drugs, insulin injection or both [58].
5- Fasting blood sugar (FBS). Blood sugar level after an overnight fast (no eating for 8- 10 hours) [58].
6- Hemoglobin A1c (HbA1c): a simple blood test that measures the blood sugar levels over the past 3 months, a normal A1C level is below 5.7%, a level of 5.7% to 6.4% indicates prediabetes, and a level of 6.5% or more indicates diabetes [58].
7- Serum creatinine: is an important indicator of kidney health because it is an easily measured byproduct of muscle metabolism that is excreted unchanged by the kidneys, normally

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
ISSN: 2749-3644

for adult males. 0.6 to 1.1 mg/dL for adult females. 0.5 to 1.0 mg/dL [58].

8- Pure-tone average: is the main hearing test used to identify hearing threshold levels of an individual, enabling determination of the degree, type and configuration of a hearing loss. [59,60].

9- History of chronic disease (HT): mean HT that lasts 1 year or more and requires ongoing medical attention.

10-Tympanometry an instrument to get information regarding the middle ear status using a 226 Hz probe tone at 85-dB sound pressure level. [61].

3.10. Limitations:

The main limitation of this study is coordination with cases, a cross-sectional study is of value. since, this study had been run during the COVID-19 pandemic, it is expected some limitation for subjects to participate in this study

4. Results:

1. Determining the features and the hearing level in diabetic and non-diabetic

A total of 160 participants were included in the study. Eighty (50%) participants were diabetics with a median age of 52 (range=50-55) years; and another eighty (50%) participants were non-diabetics with median age of 41 (range=41-45) years with a significant difference, P<0.001(Table 2).

Table 2. The median age of diabetic and healthy groups

Groups	No.	%	Median age/ years	Lower	Upper	P* value
Diabetics	80	50%	52	50	55	<0.001
Non diabetics	80	50%	41	41	45	

Mann Whitney test

Out of the total participants, 72 (90.0%) diabetics and 51 (63.8%) nondiabetics were within the age group 40-59 years. The diabetic group was significantly older than the healthy group, P<0.001. Thirty-seven (46.3%) diabetics and thirty- sex (45.0%) nondiabetics were males, while 43 (53.8%) diabetics and 44 (55.0%) non-diabetics were females. Eighteen (22.5%) diabetics and sixteen (20.0%) non-diabetics were hypertensive (Table 3).

Out of the total diabetics, the duration of the disease was ≤10 years among 57 (71.3%) patients and >10 years among 23 (28.8%) patients. The type of treatment was oral antidiabetic drugs among 37 (46.3%) patients, insulin injection among 25 (31.3%) patients, and mixed treatment (oral & insulin) among 18 (22.5%) patients (Table 3).

Table 3. Distribution of demographic features and clinical data among studied groups, n=160

Demographic Features		Groups				P value
		Diabetics		Nondiabetics		
		No.	%	No.	%	
Age Group	20-39 years	8	10.0%	29	36.3%	<0.001**
	40-59 years	72	90.0%	51	63.8%	
Gender	Male	37	46.3%	36	45.0%	1**
	Female	43	53.8%	44	55.0%	
History of hypertension	Yes	18	22.5%	16	20.0%	0.84**
	No	62	77.5%	64	80.0%	
DM duration/ years	≤10	57	71.3%			
	>10	23	28.8%			
Type of treatment	Drugs	37	46.3%			
	Insulin	25	31.3%			
	Both	18	22.5%			

Fisher's Exact Test

World Bulletin of Public Health (WBPH)
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Volume-17, December 2022
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There were 38 (47.5%) patients with HI among diabetics and 27 (33.8%) among non-diabetics; with no significant difference (P=0.077) as shown in table 4, figure 4.

According to the side of HI; HI of the right ear was found among 2 (2.5%) diabetics and 4 (5%) non-diabetics; HI of the left ear was found among 5 (6.3%) non-diabetics; while HI of both ears was found among 36 (45%) diabetics and 18 (22.5%) non-diabetics with significant differences; (table 4, figure 5).

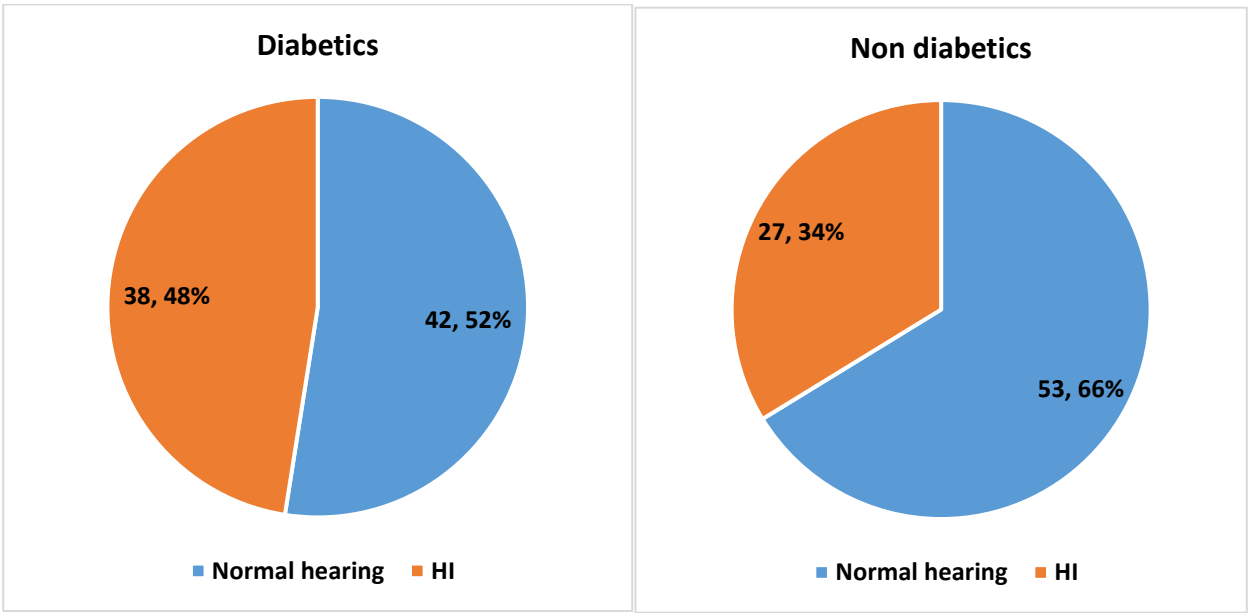

Figure 5: HI among studied groups, n=160

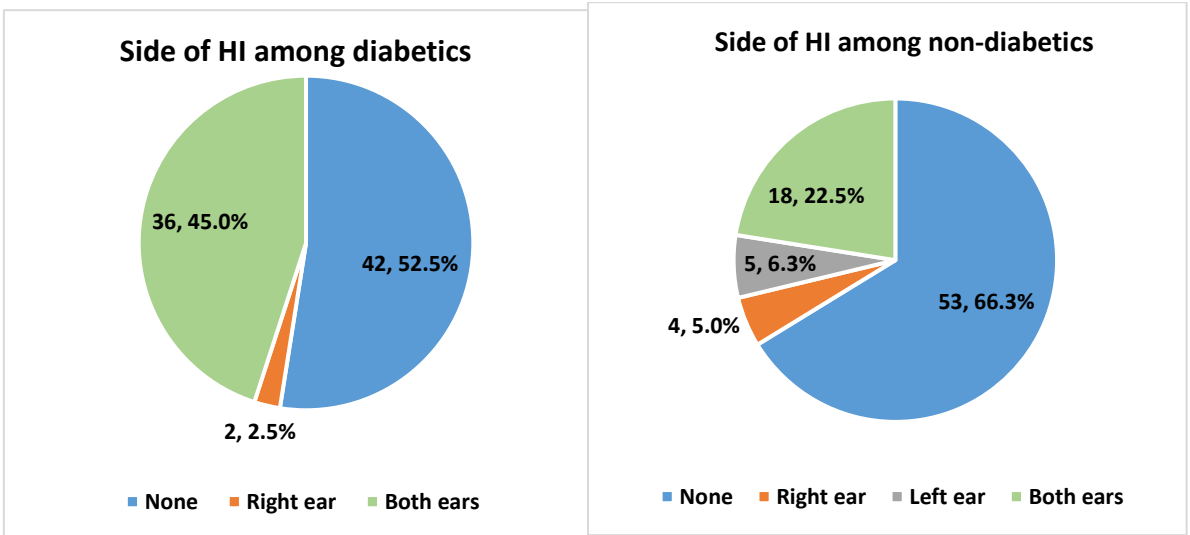

Figure 6: Hearing impairment according to the sides of the ear with HI among studied groups, n=160

Table 4. Distribution of hearing impairment and the side of ears among studied groups, n=160

		Groups				P value
		Diabetics		Non-diabetics		
		No.	%	No.	%	
Side of HI	None	42	52.5%	53	66.3%	0.005*

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
ISSN: 2749-3644

	Right ear	2	2.5%	4	5.0%	
	Left ear	0	0.0%	5	6.3%	
	Both ears	36	45.0%	18	22.5%	
Total HI	Normal hearing	42	52.5%	53	66.3%	0.077**
	HI	38	47.5%	27	33.8%	

Chi² test** ****Fisher's Exact Test

HI of right ear that diagnosed at high frequency was found among 38 (47.5%) diabetics and 22 (27.5%) non-diabetics with significant difference (P=0.009), HI of right ear that diagnosed at mid-frequency was found among 28 (35.0%) diabetic and 15 (18.8%) non-diabetics with significant difference (P=0.02), while that diagnosed at low frequency was found among 17 (21.3%) diabetics and 11 (13.8%) non-diabetics with no significant difference (P=0.054) as shown in (table 5, figure 7).

HI of the left ear that was diagnosed at high frequency was found among 36 (45%) diabetics and 24 (30%) non-diabetics with no significant difference (P=0.051), HI of the left ear that was diagnosed at mid-frequency was found among 26 (32.5%) diabetic and 14 (17.5%) non-diabetics with significant difference (P=0.028), while that diagnosed at low frequency was found among 19 (23.8%) diabetics and 8 (10%) non-diabetics with significant difference (P=0.02) as shown in (table 5, figure 8).

Patients have HI of both ears were 54 (33.75%) of the total; and all of them have HI at high frequency level [36 (100%) diabetics and 18 (100%) non-diabetics] with constant P. HI of both ears that diagnosed at mid-frequency was found among 26 (72.2%) diabetic and 13 (72.2%) non-diabetics with no significant difference (P=1), while that diagnosed at low frequency was found among 19 (52.8%) diabetics and 4 (22.2%) non-diabetics with significant difference (P=0.043) (Table 5).

Table 5. Distribution of hearing impairment according to different frequencies among studied groups

HI		Groups				P* value
		Diabetics		Nondiabetics		
		No.	%	No.	%	
Right ear						
High Frequency	Normal	42	52.5%	58	72.5%	0.009
	HL	38	47.5%	22	27.5%	
Mid Frequency	Normal	52	65.0%	65	81.3%	0.02
	HL	28	35.0%	15	18.8%	
Low Frequency	Normal	63	78.8%	69	86.3%	0.2
	HL	17	21.3%	11	13.8%	
Left ear						
High Frequency	Normal	44	55.0%	56	70.0%	0.051
	HL	36	45.0%	24	30.0%	
Mid Frequency	Normal	54	67.5%	66	82.5%	0.028
	HL	26	32.5%	14	17.5%	
Low Frequency	Normal	61	76.3%	72	90.0%	0.02
	HL	19	23.8%	8	10.0%	
Both ears						
High Frequency	Normal	0	0.0%	0	0.0%	Constant
	HL	36	100.0%	18	100.0%	
Mid Frequency	Normal	10	27.8%	5	27.8%	1
	HL	26	72.2%	13	72.2%	
Low Frequency	Normal	17	47.2%	14	77.8%	0.043
	HL	19	52.8%	4	22.2%	

Fisher's Exact Test

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
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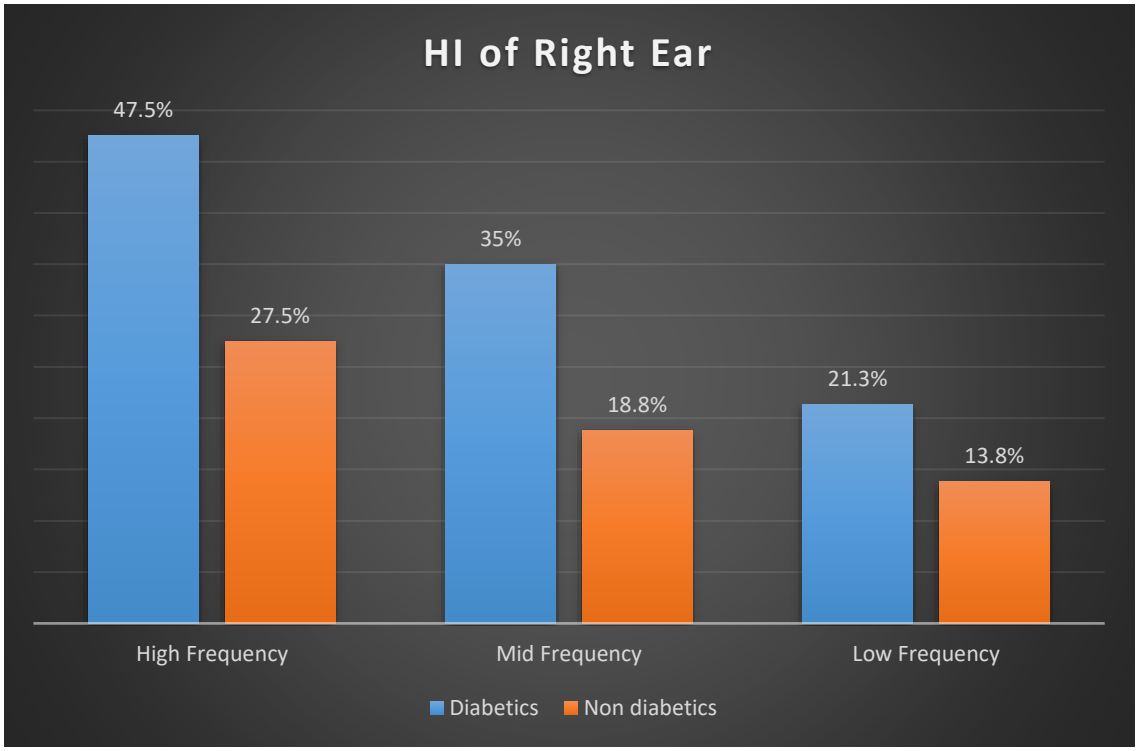

Figure 7: Hearing impairment of right ear diagnosed according to different frequencies among studied groups

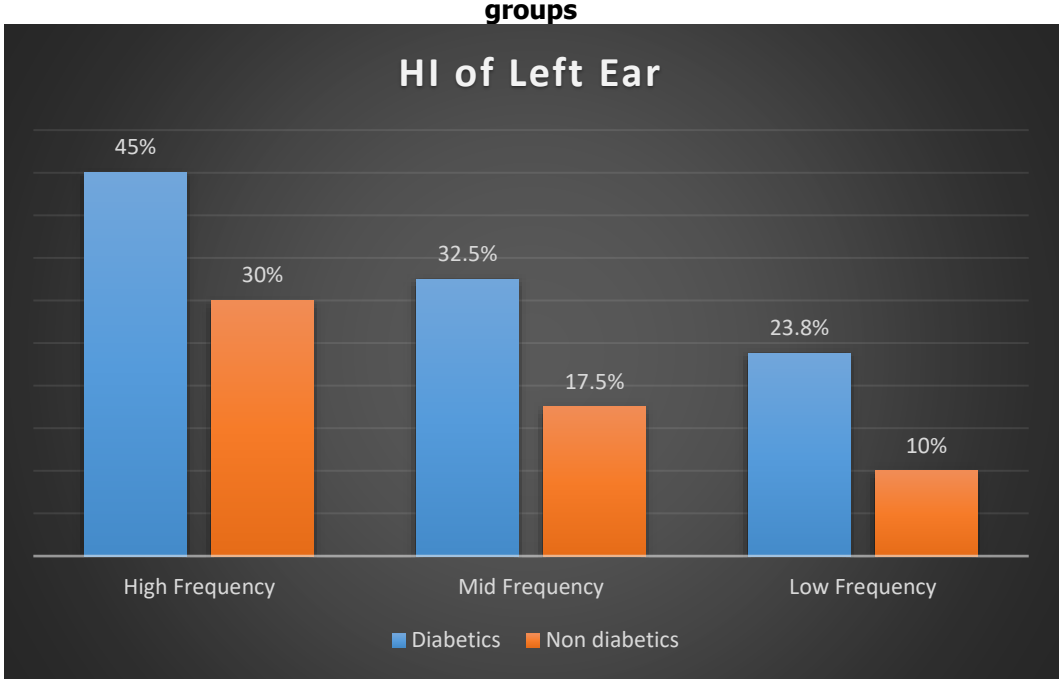

Figure 8: Hearing impairment of left ear diagnosed according to different frequencies among studied groups

2. Determining FBS, HbA_{1c}, and serum creatinine levels in diabetic people

Mean level of FBS was 235.76±100.66 mg/dl among diabetics, the mean level of HbA1c was 8.32±2.56 mg/dl. In contrast, the mean level of S. Creatinine was 0.81±0.3 mg/dl (Table 6).

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
ISSN: 2749-3644

Table 6: Mean levels of FBS, HbA1c, and serum creatinine of diabetic patients, n=80

Variables	Mean	SD
FBS mg/dl	235.76	100.66
HbA1c mg/dl	8.32	2.56
S. Creatinine mg/dl	0.81	0.33

3. Finding the correlation between HI and DM regarding the duration of disease, age, gender, and type of management among diabetic patients.

The older age group (40-59 years) with a longer duration of disease (>10 years) were found to be potential risks for HI among diabetics with significant differences (OR=2.11, 95% CI=1.65-2.7, P=0.006) and (OR=3.63, 95% CI=1.29-10.24, P=0.015) respectively (Table 6).

Female gender with normal blood pressure found to be protective factors against HI among diabetics with significant differences (OR=0.26, 95% CI=0.1-0.66, P=0.007) and (OR=0.18, 95% CI=0.05-0.61, P=0.006) respectively, regarding the type of treatment was not significant (P=0.36).

Table 7: Distribution of demographic features and clinical data among diabetic patients, n=80

Variables		Diabetics (n=80)				P value	OR (95% CI)
		Normal hearing		HI			
		No.	%	No.	%		
Age Group/ years	20-39	8	100.0%	0	0.0%	0.006**	Reference
	40-59	34	47.2%	38	52.8%		2.11 (1.65-2.7)
Gender	Male	13	35.1%	24	64.9%	0.007**	Reference
	Female	29	67.4%	14	32.6%		0.26 (0.1-0.66)
History of hypertension	Yes	4	22.2%	14	77.8%	0.006**	Reference
	No	38	61.3%	24	38.7%		0.18 (0.05-0.61)
DM duration/ years	≤10	35	61.4%	22	38.6%	0.015**	Reference
	>10	7	30.4%	16	69.6%		3.63 (1.29-10.24)
Type of treatment	Drugs	18	48.6%	19	51.4%	0.36*	Reference
	Insulin	16	64.0%	9	36.0%		0.53 (0.18-1.5)
	Both	8	44.4%	10	55.6%		1.18 (0.38-3.67)

Chi² test** ****Fisher's Exact Test

4. Determine the correlation between FBS, HbA1c, and serum creatinine levels and HI in diabetic patients.

Median levels of FBS, HbA1c, and serum creatinine were significantly higher among diabetics with HI in comparison to those without HI (P=0.006, P<0.001, and P<0.001), respectively.

Table 8: Distribution of FBS, HbA1c, and serum creatinine levels among diabetic patients, n=80

Variables	Diabetics (n=80)						P* value
	Normal hearing			HI			
	Median	Lower	Upper	Median	Lower	Upper	

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
ISSN: 2749-3644

FBS mg/dl	191.0	191.0	250.0	255.0	230.0	300.0	0.006
HbA1c mg/dl	7.2	7.2	9.5	9.05	8.1	9.5	<0.001
S. Creatinine mg/dl	0.6	0.6	0.8	0.9	0.8	1.2	<0.001

Mann Whitney test

Multivariate regression analysis of age, gender, FBS, and S. Creatinine of diabetic patients was done and revealed that age group (40-59) with higher levels of both FBS and S. Creatinine were considered as risk factors for HI among diabetics with significant differences (OR=1.106, 95% CI=1.013±1.209; P=0.025), (OR=1.010, 95% CI=1.003±1.018; P=0.005), and (OR=13.947, 95% CI=1.578±123.262; P=0.018), respectively.

Table 9: Multivariate regression analysis of age, gender, FBS, and S. Creatinine among diabetic patients, n=80

Variables	**B**	**S.E.**	**Wald**	**P value**	**OR**	**95% CI**	
						Lower	**Upper**
S. Creatinine mg/dl	2.635	1.112	5.618	0.018	13.947	1.578	123.262
Age/years	0.101	0.045	5.000	0.025	1.106	1.013	1.209
Gender	1.012	0.637	2.521	0.112	2.750	0.789	9.583
FBS mg/dl	0.010	0.004	7.793	0.005	1.010	1.003	1.018

To investigate the relationship between HbA1c, S. Creatinine, and duration of disease with the audiometric finding among diabetics, spearman's correlation test was used and revealed that HbA1c level was correlated positively and significantly with both S. Creatinine and duration of disease (P=0.002 and P=0.025) respectively.

S. Creatinine was correlated positively and significantly with HbA1c level only, P=0.002; as well as, the Duration of disease was correlated positively and significantly with HbA1c level only, P=0.025(Table 10).

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-17, December 2022
ISSN: 2749-3644

Table 10: Correlation between HbA1c, S. Creatinine, and duration of disease with the audiometric finding among diabetics, n=80

Variables		HbA1c mg/dl	S. Creatinine mg/dl	Duration of disease/ years
HbA1c mg/dl	r	1.000	0.349**	0.250*
	P value		0.002	0.025
S. Creatinine mg/dl	r		1.000	-0.025-
	P value			0.825
Duration of disease/ years	r			1.000
	P value			

. Correlation is highly significant at the 0.01 level (2-tailed).
. Correlation is significant at the 0.05 level (2-tailed).
r=Correlation Coefficient using Spearman's test

5. DISCUSSION:

The aim of this study was to determine hearing impairment in Iraqi patients with type 2 Diabetes Mellitus.

And the findings would be interpreted and discussed depending on the relationship between diabetes mellitus and the initiation of hearing loss, in addition to the correlation of different personal variables with the development of hearing loss in diabetic patients.

In here, every factor would be presented independently (age, gender, the side of ear affected, hearing frequencies, duration of Diabetes Mellitus, HT, and biomarkers).

In this way, it would be practical in determining hearing impairment in Iraqi patients with type 2 Diabetes Mellitus.

According to this study there was significant difference of bilateral HI among diabetics and non-diabetics especially at high frequencies. The age group (40-59), longer duration of diabetes (>10 years), male gender and high blood pressure were found to be risk factors of developing Hl in diabetics. The Median levels of FBS, HbA1c, and serum creatinine were significantly higher among diabetics with HI in comparison to those without HI.

5.1. Determining the features and hearing level in diabetic and non-diabetic patients

Half of selected sample were diabetic, this finding was consistent with a cross sectional study done by Idugboe1 et al (2013-2014) in which 140 subjects were included, half of them were diabetics [62].

The mean age of diabetics was older than non-diabetics. This was in accordance with a retrospective study done by Seo et al (2015-2018) assessing the effect of DM on idiopathic sudden sensorineural hearing loss, among 403 patients, 94 of them had DM. The subjects with DM were older than those without [63].

Another cross-sectional study had a similar finding within the selected sample, which was conducted by Samelli et al (2017) in Brazil that involved 901 participants. It was revealed that Diabetic subjects were older than non-diabetics with significant difference [64].

5.2. Distribution of demographic features and clinical data among studied groups

Out of the total diabetics, the duration of the disease was ≤10 years among two third of them. This was consistent with a study done by Ren et al (2013-2014), which assessed hearing loss in patients with DM, in a sample of 100 subjects, the estimated

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
ISSN: 2749-3644

duration of DM in about 70 % of them was < 10 years [3].

Most of recruited sample were females. In a cross-sectional study with an aim of assessing the prevalence of hearing impairment among patients with DM, that was done in Nepal by Bhat et al (2021), a similar finding of female predominance was noted among the selected sample of 55 patients [65].

This was also in line with another study done by Hosseini et al (2016-2017) in Tehran, Iran. Out of 200 selected patients, 108 (54%) were females [66].

About half of the recruited sample were on oral drug treatments only, which was consistent with a cross-sectional study done by Ashkezari et al (2016-2017), that was conducted with a sample size of 81 type 2 DM patients, 35 (43.2%) of them were on oral antihyperglycemic agents only [67].

5.3. Distribution of hearing impairment and the side of ears among the studied groups

Among the recruited diabetic subjects, almost half of them had hearing impairment, while only a third of non-diabetics had their hearing impaired, but this had no significant difference.

The mentioned results were not in agreement with a prospective cohort study done by Kim et al (2002-2014) in Seol, Korea, where (253301) subjects with normal hearing tests were chosen as a part of a regular screening exam. The results revealed that the rate of hearing impairment in participants with normal glucose levels, pre-diabetes and Diabetes were 1.8, 3.1 and 9.2 per 1000 person-years, respectively [50].

The noted difference might be explained by the variance between the sizes of the samples (a smaller sample size of 160 subjects in our study in comparison with 253301 subjects in the study mentioned above). This is alternative to our hypothesis, thus rejected.

Hearing impairment of both ears was found among approximately half of the diabetic subjects, and among a quarter of non-diabetics with significant differences.

A study by Lerman-Garber et al (2012) had showed similar observations, it had an aim of evaluating the prevalence of hearing impairment in patients with type 2 DM, the sample consisted of 46 diabetic patients and 47 controls that had rheumatoid arthritis, the results revealed that the prevalence of hearing impairment in both ears was significantly higher in the patients with type 2 DM than in the patients with Rheumatoid Arthritis [68].this is goes with our hypothesis (DM effect on hearing), thus accepted.

5.4. Distribution of hearing impairment according to different frequencies among studied groups

HI of the right ear that was diagnosed at high frequency was found in about half of the diabetics and a quarter of the non-diabetics with significant difference, while HI of the left ear that was diagnosed at high frequency was found among almost half of the diabetics and about a third of non-diabetics with no significant difference. HI of both ears that was diagnosed at low frequency was higher significantly among diabetics.

This goes with study done by Kumar Sunkum et al (2013) aimed to compare hearing thresholds of diabetics and normal control group, which revealed a significant high frequency HI in diabetic group as compare to controls. [69]while another study noted by Mirsa V. et al (2013) observed low frequncies SNHL with significant diffrances.[92]

5.5. Finding the correlation between HI and DM regarding the duration of disease

The longer duration of DM (> 10) years was found as potential risk factor for HI among diabetics with significant differences and this agree with a cross sectional study that was conducted by Al-Rubeaan et al (2015-2017), in which 157 type 2 diabetic subjects were recruited in, Riyadh, Saudi Arabia, that were chosen from the general DM clinic using a systematic random technique (every 3rd patient with type 2 DM). The study results revealed that the duration of DM longer than ten years was found to be a significant risk factor for hearing loss among diabetic patients [70].

Another study that was done by Thimmasettaiah et al (2012) in in Bangaluru, India had similar observations that DM patients with a duration longer than 5 years were found to have an increased rate of hearing impairment (79%) when compared to newly diagnosed diabetic

patients (42%) [71]. This goes with our hypothesis, thus accepted.

5.6. The correlation between Hl and age -gender difference among diabetic's patients

According to current study, the age group (40-59) and male gender were potential risk factor for Hl among diabetic patients.

This finding consist with a cross-sectional study had a similar finding within the selected sample, which was conducted by Alessandra G. Samelli et al in Brazil, that evaluated 901 participants from São Paulo, Brazil using audiometry testing. it was revealed that Diabetic subjects were older than non-diabetics with significant difference [64].

The reason of difference in HI between two gender may be related to biologic factors such as periodic ovarian hormonal changes in woman. [92]

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-16, December 2022
ISSN: 2749-3644

5.7. The relationship between HI and HT among diabetic patients

Diabetic patients with HT showed HI more than those with normotensive with significant differences, so according to this finding, HT considered as potential risk factor among diabetic patients.

This results agreement with a study conducted by Sigasbee et al (1997), that aimed to support the hypothesis that diabetic end- organ damage of the cochlea is augmented in the sitting of HT, the results of audiological findings were analyzed to support the hypothesis that sensorineural hearing loss in patients result from the effects of hypertension in conjunction with insulin-dependent diabetes mellitus [91], thus accepted with our hypothesis.

5.8. Determining the correlation between FBS, HbA1c, and serum creatinine levels and HI in diabetic patients

The median levels of FBS, HbA1c, and serum creatinine were significantly higher among diabetics with HI in comparison to those without HI.

Those findings were in agreement with a cross-sectional study by Tiwari and Mudhol (2016- 2016), where 125 subjects with type 2 Diabetes mellitus were recruited. There was a positive correlation between sensorineural hearing loss and the Hemoglobin A1c levels [72].

It was also consistent with a study conducted by Sachdeva and Azim (2018) [73], where 92 type-2 DM subjects were selected and underwent audiometric evaluation. When they were compared with the same number of sex and age matched non-diabetic controls, it was revealed that glycemic status had a significant correlation with hearing impairment, which might be due to the effect of diabetic microangiopathy of the inner ear. The strongest co-relation was found with increased levels of HbA1c, another consistent finding was that DM related hearing impairment is directly proportional to serum creatinine levels where 75.8% of the studied diabetic subjects with hearing impairment had serum creatinine levels above 2 mg/dl. This goes with our hypothesis, thus accepted.

Lastly, the study had also revealed a significant association with high fasting blood glucose [73].

The increased glucose level would target the marginal cells of the stria vascularis along with the mitochondria inside their basal cell membrane [74-76].

A microvascular network supplies the inner ear and its lateral wall [77, 78], this network along with the stria vascularis maintains an active role in the transport of electrolytes and fluids [79].

Elevated blood sugar starts a series of pathological processes including mitochondrial DNA disruption. The harmed mitochondria would stop oxidative phosphorylation and thereby the production of Adenosine Triphosphate (ATP), this in turn would affect the function of certain organ systems that have high energy consumption, in this case, the inner ear's stria vascularis [80-83].

In diabetes mellitus, the vascular walls of the Stria Vascularis and the basilar membrane were found to be much thicker when compared to non-diabetic population. This was accompanied by a deficit of outer hair cells within the basal turn. The starting point of microvascular pathology is thought to be endothelial dysfunction, which is manifested by: hyperplasia of endothelial cells, degeneration of pericytes, and thickening of the basement membrane [84].

Many studies were not able to show a direct relation between diabetes and hearing loss, however, there is a number of risk factors that accompany both of them. Since there are receptors of insulin, and transporters of glucose, along with insulin signaling components within the spiral ligament, cochlea, and the Stria Vascularis, any defect of utilization of glucose would make the inner ear vulnerable to hearing loss [85-90].

CONCLUSION

there was significant difference of bilateral HI among diabetics and non-diabetics especially at high frequencies. The age group (40-59) and longer duration of disease (>10 years) were found to be potential risks for HI among diabetics with significant differences. Female gender with normal blood pressure were found to be protective factors against HI among diabetics with significant differences. The Median levels of FBS, HbA1c, and serum creatinine were significantly higher among diabetics with HI in comparison to those without HI.

LIMITATIONS OF THE STUDY:

It is more valuable to use extended high frequency audiometer or OAE to detect early hearing impairment but unfortunately these devices were not available at the time of the study, and for the researcher, it is of high, non-affordable cost. So, it is not intended and not performed in this study, and only available instruments were conventional pure tone audiometer and Tempanometer as hearing assessment tests, in addition to limitation due to loss of some inclusion criteria.

RECOMMENDATIONS

- ✓ Another study should be conducted on a larger sample size and a prospective study design to achieve a more precise result.

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- ✓ In order to detect the onset of hearing loss and limit its negative effects on the quality of life, a screening and monitoring approach must be established for patients with diabetes mellitus.

Establishing campaigns, whether by media or in the community setting to spread the awareness regarding the effect of Diabetes Mellitus on hearing, which would encourage patients to seek medical help for controlling their disease as well as getting their hearing assessed regularly.

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Appendix 1

The consent form for participation in the project

Evaluation of Hearing Impairment in Iraqi Patients with Type 2 Diabetes Mellitus

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
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ISSN: 2749-3644

Dear Sir/Madam

Herby, you are invited to participate in the above-mentioned research. Information about the research is provided in this sheet and you are free to participate in this research or not. You do not have to make an immediate decision, and you can ask your questions from the research team or consult with anyone you like. Before signing this form, please make sure that, you have understood all the information in this form and all of your questions havebeen answerd.

1-I confirmed that I had listened and understood the information for above study and have the opportunity to ask question: ____
2- I understand that my participation is voluntary and I free to withdraw at any time without giving reason: ____
3- I understand that my personal information will be treated confidentially:
_____
4- I agree to take part in the above study: _____
Name of participant __ , Date __ , signature ____
Name of researcher _ , Date__ , signature ___

Appendix 2
Questionnaires
**Patient's information:*
1-Name_____ __, age_____ , sex___ __, address_____.
2- what are the duration of disease? (1- 19 years)
3- what is the type of treatment?
oral antiglysemic medications_____, insulin injection_____, both_____.
4- Is there history of HT? yes__, No__.

**Laboratory measures:*
Blood sugar test ____mg/dL
HbA1c ___ %
S. creatinine ____mg/dL

**Tympanometry:(type A___, type B __, type C___)*

**hearing thresholds finding*

Freq.in Hz	*250*	*500*	*1000*	*2000*	*4000*	*8000*
RT ear						
LT ear						