INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Hearing Thresholds among Type 2 Diabetics in Sokoto, Nigeria: A Comparative Study

Dr. Yikawe Semen Stephen
Resident Doctor, Department of ENT, Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria
Iseh Kufre Roberts
Professor and Consultant, Department of ENT, Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria
Dr. Sabir Anas Ahmad
Consultant Endocrinologist, Department of Internal Medicine, Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria
Dr. Solomon Joseph Hassan
Resident Doctor, Department of ENT, Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria
Dr. Osisi Kingsley
Resident Doctor, Department of ENT, Usmanu Danfodiyo University Teaching Hospital, Sokoto, Nigeria

Abstract:
BACKGROUND: It has been observed that diabetics have higher hearing threshold when compared with non – diabetics. This is likely due to microvascular changes in the ear.
AIMS/OBJECTIVES: The aim of this study is to determine the pure tone audiometric profile of Type 2 diabetes mellitus patients and to compare it with non – diabetic controls.
METHOD: This was a cross sectional study. The pure tone thresholds of consenting Type 2 diabetic patients and non – diabetic controls attending Endocrinology and General outpatient clinics of Usmanu Danfodiyo University Teaching Hospital was measured for both ears after administering a pretested questionnaire and examining the patients.
DATA ANALYSIS: The pure tone average was calculated. Data analysis was done using Statistical Package for Social Sciences version 21 (IBM - SPSS Inc., Chicago, IL).
RESULTS: This study involved 170 consenting type 2 diabetic individuals and 170 consenting non-diabetic age and sex matched controls. Mean age of type 2 diabetics was 46.49±10.02 years, and 45.39±9.60 years for controls. Among the type 2 diabetic group, 57.6% were females, while 42.4% were males. Hearing loss was observed among 71.8% of type 2 diabetics and 7.1% of controls. Mean hearing thresholds (AC) among the study group was 32.06±12.31dB, and 16.72±7.71dB among the controls ($p<0.0001$). Mean hearing thresholds were found to be elevated across all tested frequencies in type 2 diabetics, and the difference with the control group was found to be significant for all frequencies ($p<0.0001$). Among the type 2 diabetics with hearing loss, 95% had sensorineural hearing loss, 71% being mild hearing loss.
CONCLUSION: Type 2 diabetes mellitus was found to be related to hearing loss in this study. This study showed a crude prevalence of hearing loss among Type 2 diabetics of 71.8% and 7.1% among Non - diabetic controls.

Keywords: *Diabetes mellitus, pure tone Audiometry, hearing loss, Usmanu Danfodiyo university teaching hospital.*

1. Introduction

Diabetes mellitus (DM) is a syndrome of chronic hyperglycaemia due to relative insulin deficiency, resistance or both[1]. DM is a systemic disease with accompanying pathology affecting multiple organ systems[1, 2, 3]. The number of people living with Diabetes Mellitus is increasing due to population growth, and increasing risk factors (aging, urbanization, obesity and physical inactivity). With this, DM will be a leading cause of morbidity and mortality for the foreseeable future[1,4]. There is also a rising prevalence of diabetes mellitus among middle and low-income countries and over 80% of the morbidity and mortality of diabetes mellitus occurs in low and middle-income countries[4]. It has been observed that patients with DM have a higher likelihood of developing hearing loss than the general population[6 - 13]. This is likely due to the microvascular complications of DM [9, 12, 13]. Microvascular involvement has been demonstrated in the endolymphatic sac and basilar membrane in diabetics[12,14,15]. Atrophy of the spiral ganglion and demyelination of the eight-cranial nerve among autopsied diabetic patients suggest a neurological aetiology[15, 16].

Type 2 diabetes mellitus is the predominant form of diabetes worldwide, accounting for 90% of cases globally[17]. It usually occurs in adults, but can be seen in children, particularly obese Adolescents[2,17,18]. With the alarming increase in prevalence of Type 2 Diabetes Mellitus, it has become one of the World's most important public health problems[17].

Individuals with Type 2 DM have been shown to have higher hearing thresholds than their non-diabetic counterparts[9 – 11, 19]. The typical hearing impairment described in diabetics is a bilateral sensorineural hearing loss; however, some studies describe diabetes as a possible cause of unilateral sudden hearing loss[19]. Type 2 Diabetes Mellitus and deafness are major public issues that affect the quality of life of many Nigerians[10]. Ologe et al reported a more likelihood of hearing loss among middle aged Nigerians with Type 2 Diabetes Mellitus than their non-diabetic counterparts[10]. A similar study by Isa et al in Maiduguri, North-Eastern Nigeria, showed a female preponderance, with the age group 40 to 49 years mostly affected[9]. Isa et al described mild to moderate sensorineural hearing loss with progressively high frequency losses[9].

Hearing thresholds are higher in diabetics at every frequency when compared with non-diabetics and symmetric sensorineural hearing loss has been observed among them, particularly with higher frequency[20 - 22]. Diabetes Mellitus patients 60 years and younger tend to have more hearing loss than non-diabetic controls, and this difference is greatest at 10 and 12.5KHz which are not tested on routine clinical audiometry[7, 23]. The finding of hearing loss at higher frequency is also observed in age related hearing loss which may be due to loss of cells at the basal turn of the cochlea and loss of cochlea neurons[24]. Changes similar to this have been found in diabetic animal models[25]. Clinically higher frequency loss is important because it often indicates a future progression from higher to lower frequencies where speech understanding is affected. Some authors however found that the greatest deficit of hearing in diabetics was at low frequencies[26]. This study intends to assess the hearing threshold among type 2 diabetics and compare it with non-diabetic controls.

2. Methodology

2.1. Study Population

This was a cross sectional study conducted among 170 type 2 diabetics attending the endocrinology clinic of Usmanu Danfodiyo University Teaching Hospital Sokoto, and 170 age and sex matched controls attending the General Outpatient Clinic of Usmanu Danfodiyo University Teaching Hospital, Sokoto from October 2015 to May, 2016. Ethical approval was obtained from the ethics and research committee of Usmanu Danfodiyo University Teaching Hospital, Sokoto. Informed consent was obtained from the participants before they were recruited for the study. Participants were randomly selected. For the study group, the inclusion criterion was; Physician diagnosed type 2 DM patients attending the Endocrinology clinic of the Usmanu Danfodiyo University Teaching Hospital, Sokoto. Patients with; history of ear surgery performed in the past, history of exposure to loud sounds, history of ear disease and history of head injury were excluded from the study group. For the control group, the inclusion criterion was; non-diabetic adults matched for age and sex evidenced by normal fasting or random blood sugar values attending the General Outpatient Clinic of Usmanu Danfodiyo University Teaching Hospital Sokoto. Patients with; history of ear surgery performed in the past, history of exposure to loud sounds, history of ear disease, history of head injury and patients having DM evidenced by abnormal fasting or random blood sugar values as stated above were excluded from the control group.

2.2. Diabetes and Demographic Variables

Interviewer administered semi-structured questionnaire was used and information on details of bio data, medical history and lifestyle were obtained. General physical examination was done including blood pressure, weight and height measurements. Patients had examination of the ear, nose and throat done. Fasting or Random blood sugar was done for participants. Venous blood was taken from the forearm after cleaning with methylated spirit.

2.3. Pure Tone Audiometry

Pure tone thresholds were measured using the Modified Hughson – Westlake method at 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz, 6000Hz and 8000Hz for air conduction and 500Hz, 1000Hz, 2000Hz and 4000Hz for bone conduction using a Diagnostic Audiometer (Oscilla SM 960 – D, Diagnostic memory audiometer, Denmark) in a sound isolated room, which satisfied the criteria of ISO 8253-1. Average of audiometric hearing threshold at 500, 1000, 2000 and 4000 Hz for both air and bone conduction was determined, this was taken to be the Pure tone average for both air and bone conduction. This was categorized in accordance to the WHO grades of hearing impairment as follows: normal hearing (< 25dB), mild hearing loss (26 – 40dB), moderate hearing loss (41 – 60dB), severe hearing loss (61 – 80dB), profound hearing loss (81dB or greater).

2.4. Statistical Analysis

Data analysis was done using Statistical Product and Service Solutions version 21 (IBM - SPSS Inc., Chicago, IL). Chi – square test was used to determine the relationship between categorical variables and T – test was used to determine the relationship between quantitative variables. Frequency distribution and cross tabulations were also done to examine the relationship between variables. Regression analysis was done to test for association between variables. Data was presented using tables, charts and graphs. Level of significance was set at $p < 0.05$.

3. Results

3.1. Demographics

A total of 340 participants completed the study, out of which, 170 were Type 2 diabetics and 170 were non – diabetic controls.

The mean age of Type 2 diabetes mellitus participants was 46.49±10.02 years, with ages ranging from 33 to 87 years. Among non – diabetics, mean age was 45.39±9.60 years, with ages ranging from 31 to 84 years (see table 1). The most frequently observed age group among study and control groups was 40 – 49 years.
Females accounted for 57.6% of the Type 2 diabetes mellitus patients, while 42.4% of them were males. Among the non – diabetic control group, 58.2% were females, while 41.8% were males. The Male: Female ratio in both groups was 1:1.4. The differences in age and sex between the two groups were not statistically significant (see table 1).

		Non Diabetics	Type 2 diabetics
Age (Years)	Mean (± SD)	45.39±9.60	46.49±10.02
	Median	44.00	45.50
	Independent t test	p= 0.305, t= 1.028, df= 338	
Sex	Females	99 (58.2%)	98 (57.6%)
	Males	71 (41.8%)	72 (42.4%)
	Chi-square	$\mathcal{X}^2$= 0.012, p=0.913	

Table 1: Demographic profile of participants
** Significant*

3.2. Hearing Threshold among Participants
The mean pure tone average of air conduction (average of hearing thresholds at 500, 1000, 2000 and 4000Hz) among non – diabetic controls was 16.72±7.71 dB HL, while the mean pure tone average among Type 2 diabetes mellitus participants was 32.06±12.31dB HL. This was found to be statistically significant (see table 2).

Status	Number of Participants	Mean pure tone average (dB HL) ± SD	Test statistic (Independent t test)
Non diabetic controls	170	16.72 ± 7.71	t= 13.765
Type 2 diabetics	170	32.06 ± 12.31	p<0.001*
			df = 338

Table 2: Mean pure tone average (air conduction) among participants
**** Significant***

Prevalence of Hearing loss among Type 2 diabetics was 71.8%, and 7.1% among non – diabetic controls, this was found to be statistically significant (p < 0.0001). Among the Type 2 diabetics 21 (12.4%) had self-reported hearing loss, while none of the non – diabetics had self reported hearing loss.
Eighty-seven (51.2%) of Type 2 diabetics had mild hearing loss, 18.8% had moderate hearing loss (see table 3). Among type 2 diabetics with hearing loss, 71.3% of them had mild hearing loss, while 26.23% had moderate hearing loss.

Degree of hearing loss	Non-diabetic controls Number (percentage)	Type 2 diabetics Number (Percentage)	Test statistic (Chi-square)
Normal	158 (92.9%)	48 (28.2%)	$\mathcal{X}^2$= 149.332
Mild	10 (5.9%)	87 (51.2%)	P< 0.0001*
Moderate	2 (1.2%)	32 (18.8%)	df= 3
Severe	Nil	3 (1.8%)	
Profound	Nil	Nil	

Table 3: Degree of Hearing Loss of participants (Based on WHO criteria)
**Significant*

Elevated mean air conduction thresholds (above 25dB HL) in the better ear in Type 2 diabetics across all frequencies tested was observed with mean air conduction thresholds below 25dB HL in the better ear across all frequencies tested in the non – diabetic control group (see figure 1).

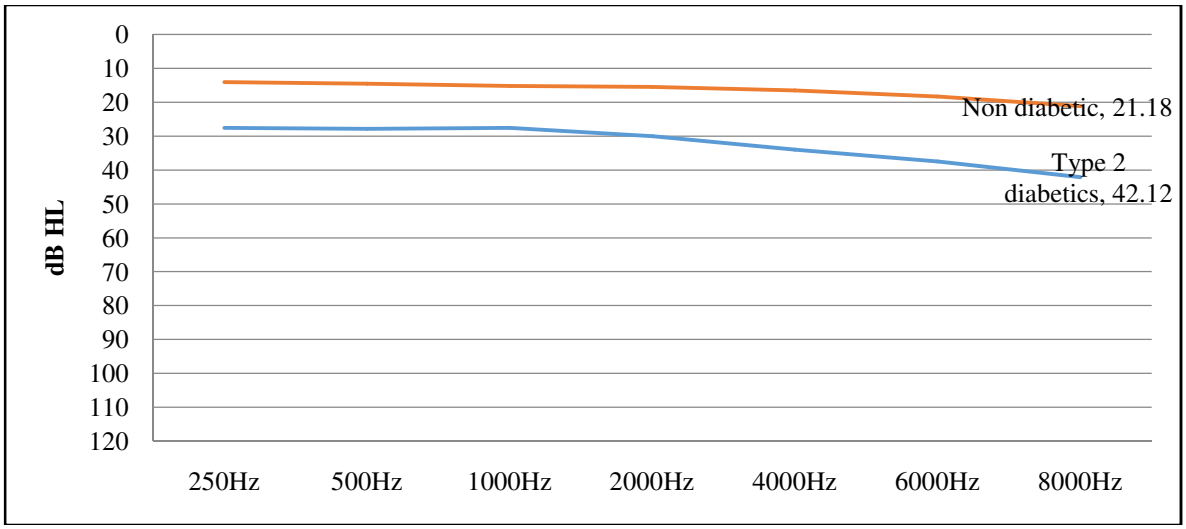

Figure 1: Mean air conduction thresholds across all tested frequencies in the better ear among participants.

Elevated mean bone conduction thresholds (above 25dB HL) in the better ear in Type 2 diabetics across all frequencies tested with mean bone conduction thresholds below 25dB HL in the better ear across all frequencies tested in the non – diabetic control group was observed (see figure 2).

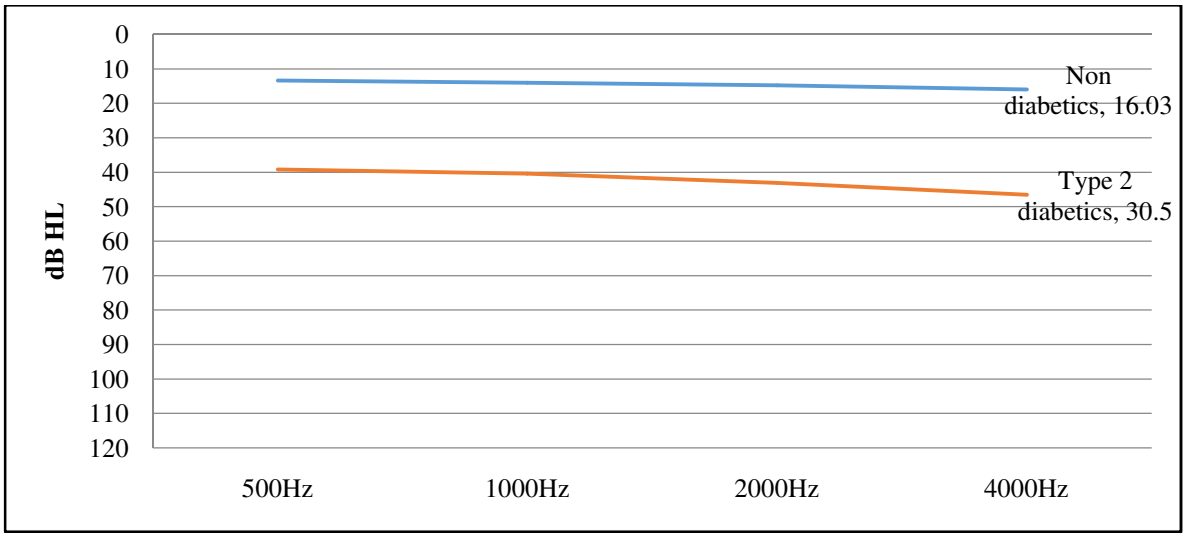

Figure 2: Mean bone conduction thresholds across frequencies tested by bone conduction in the better ear among participants.

3.3. Type of Hearing loss among Participants

Among the Type 2 diabetics, 68.2% had sensorineural hearing loss, 2.4% had conductive hearing loss, 1.2% had mixed hearing loss, while 28.2% had normal hearing threshold (see table 4).

Among the subset of type two diabetics with hearing loss, 95% had sensorineural hearing loss.

Type of hearing loss	Non diabetic controls Number (Percentage)	Type 2 diabetics Number (Percentage)	Test statistic (Chi-square)
Sensorineural	12 (7.1%)	116 (68.2%)	χ^2=147.231
Conductive	Nil	4 (2.4%)	P< 0.0001*
Mixed	Nil	2 (1.2%)	df = 2
Normal	158 (92.9%)	48 (28.2%)	

Table 4: Type of hearing loss among participants
**Significant*

The fasting blood sugar of Type 2 diabetic patients in this study was positively associated with increase in hearing thresholds (p = 0.009). For every 1mmol/l increase in the value of fasting blood sugar, the pure tone average is expected to increase by 0.82dB (see table 5).

Variable	Coefficient of regression	T	Significance
Constant	25.67	10.452	< 0.001
Fasting blood sugar	0.82	2.641	0.009

Table 5: Association between fasting blood sugar and pure tone average (AC) among Type 2 diabetics
R square = 0.40, n = 170

The mean fasting blood sugar among Type 2 diabetes mellitus patients in this study was 7.42±3.0mmol/l. The fasting blood sugar values ranged from 3.0 – 20.0mmol/l.

4. Discussion

The findings on age distribution in this study agrees with studies conducted by Bamanie et al and Isa et al. Isa et al, in North-eastern Nigeria among 127 diabetics and age and sex matched controls found a mean age of 47.8±11.6 years among diabetics, ages ranging from 20 – 73 years, with the age group 40 – 49 years as the age group most frequently seen among diabetics[9]. Bamanie et al working on hearing among Type 2 diabetics in Saudi Arabia also had similar results (mean age of 47.9 years) among Type 2 diabetics, Ren et al had lower mean age among diabetics (40±6 years)[31,32]. The findings on sex distribution among participants agrees with studies conducted by Lasisi et al and Isa et al. Lasisi et al had a Male: Female ratio of 1:1.4, while in the study conducted by Isa et al, 60.6% of the study participants were females, while 39.4% were males[6,9]. This may be due to the poor health seeking behaviour observed in men, as some men don't see the need to keep hospital appointments let alone participate in a study[33].

4.1. Prevalence of Hearing Loss

The findings on prevalence of hearing loss among participants agree with studies conducted by Rajendran et al, and Isa et al. Rajendran et al, observed a prevalence of hearing loss among Type 2 diabetics of 73.3% against 6.7% prevalence in the control group[19]. Isa et al also observed that 21.2% of the diabetic population in their study had normal hearing, while 78.8% had hearing loss. Their study, however, included both Type 1 and Type 2 diabetes mellitus participants, though 82.9% of the diabetic population in that study were Type 2 diabetics. A review of patients with diabetes by Kakarlapudi et al observed a prevalence of sensorineural hearing loss among diabetics of 13.1% against 10.3% in non-diabetic controls[8]. This study does not agree with the findings by Kakarlapudi et al. The study by Kakarlapudi was a retrospective review of electronic records of patients who had a diagnosis of both sensorineural hearing loss and diabetes, and as such only patients with self-reported hearing impairment were likely to have had their hearing thresholds measured. Diabetic patients with mild degree of hearing loss that do not notice their hearing deficit and hence do not self report will have been missed out in their study giving rise to the relatively low prevalence as compared to other studies.

Mitchell et al, working with data obtained from a population based longitudinal study (the Blue mountains hearing study) of age related hearing loss among 210 Type 2 diabetics, found a prevalence of hearing loss among Type 2 diabetics of 50% compared with a prevalence of 38.2% among non-diabetic controls. They reported an independent association between Type 2 diabetes mellitus and hearing loss after adjusting for multiple risk factors including, age, male gender and cigarette smoking[34]. This study however found a higher prevalence (71.8%) of hearing loss among Type 2 diabetics and a lower prevalence (7.1%) among the control group when compared with the study conducted by Mitchell et al. The relatively lower prevalence of hearing loss in the control group of this study when compared to that of Mitchell et al might be because of the relatively younger participants in this study. The study by Mitchell et al was conducted among elderly diabetics and age matched controls, so it is not surprising that the prevalence of hearing loss among the controls was 38.2%. This could be due to age related hearing loss in the control group.

4.2. Degree of Hearing Loss

The mean pure tone average (AC) among Type 2 diabetics in this study was 32.06±12.31dB, and 16.72±7.71dB among the control group. This agrees with the study conducted by Ologe et al, who assessed the hearing thresholds of 56 Type 2 diabetics, and 52 controls in a tertiary health centre in North – central Nigeria. They observed higher mean hearing threshold values across all frequencies in Type 2 diabetics and the difference between the study and control groups was statistically significant ($p<0.001$). The study by Ologe et al was conducted among Africans and they observed that hearing loss was seen at least a decade earlier among their study participants than that observed in other studies involving non Africans[10,34].

While some studies have demonstrated high frequency hearing loss among diabetics, others have demonstrated low frequency hearing loss among them[26,32]. High frequency hearing loss among diabetics is comparable to age related hearing loss, which also affects higher frequencies, both conditions are due to loss of cells in the basal turn of the cochlea[23]. This study however demonstrated elevated hearing thresholds across all frequencies tested, with higher hearing thresholds at higher frequencies.

Ren et al, in Shandong, China compared the hearing thresholds of 50 Type 2 diabetics and 50 controls. They observed deficits at higher frequencies with elevated thresholds at 4000Hz and 8000Hz, when compared to controls ($p<0.01$)[32].Rajendran et al in India also compared 60 Type 2 diabetics and controls and observed abnormal hearing thresholds from 2000Hz which increased with increase in frequency. Mean thresholds in their study was maximum at 8000Hz[19]. This is in contrast to the findings in this study that showed elevated hearing thresholds across all frequencies tested, but like the study conducted by Rajendran et al, this study also demonstrated maximum mean hearing threshold at 8000Hz.

4.3. Type of Hearing Loss

In this study, out of the 122 Type 2 diabetics with hearing loss, 116 (95%) of them had sensorineural hearing loss, 4 (3%) had conductive hearing loss, and 2 (2%) had mixed hearing loss.

This is in contrast to findings by Adebola et al and Lasisi et al. Adebola et al observed that sensorineural hearing loss accounted for 61.9% of cases, Conductive hearing loss 14.3%, and mixed hearing loss 23.9% of cases[35]. Out of the 240 diabetics assessed by Lasisi et al, 132 (55%) had sensorineural hearing loss, 44 (14%) had mixed hearing loss, 30 (12.5%) had conductive hearing loss while 34(14%) had normal hearing[6]. Other authors however excluded patients with conductive hearing loss from their study[10,19,31, 32,34]. This may be because the most frequent finding in diabetics with hearing loss is bilateral sensorineural hearing loss[26].

5. Conclusion

Type 2 diabetes mellitus was found to be related to hearing loss in this study. This study showed a crude prevalence of hearing loss among Type 2 diabetics of 71.8% and 7.1% among Non - diabetic controls. Mean hearing thresholds were elevated across all frequencies tested among Type 2 diabetics who mostly had mild sensorineural hearing loss. Routine audiologic evaluation of type 2 diabetics is important to detect hearing impairment at an early stage.

6. Acknowledgements

The authors wish to appreciate the management of Usmanu Danfodiyo University Teaching Hospital for providing an enabling environment for this research to be carried out.

→ *Conflict of interest*. None

7. References

i. Gale EAM, Anderson JV. Diabetes mellitus and other disorders of metabolism. In: Kumar P, Clark Meditors. Kumar & Clark's Clinical Medicine 8th ed. Spain: Saunders Elsevier; 2012; p 669 - 790.
ii. Powers AC. Diabetes Mellitus. In: Fauci AS, Braunwald E, Longo DL, kasper DL, Hauser SL, Jameson JL, et al editors. Harrison's Principles of Internal Medicine 18thed. New York: McGraw – Hill 2012; p 2968 - 3003.
iii. Bainbridge KE, Hoffman HJ, Cowie CC. Diabetes and Hearing Impairment in the United States: Audiometric evidence from the National Health and Nutrition Examination Survey; 1999 – 2004. Ann Intern Med 2008; 149: 1 – 10.
iv. Wild S, Roglic G, Green A, King H. Global Prevalence of Diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care 2004; 27: 1047 – 1053.
v. World Health Organization. Global Burden of Disease: 2004 update. Geneva: World Health Organization; 2008. http://www.who.int/healthinfo/global_burden_disease/2004_report_update/en/. Last Accessed 24thJanuary, 2017.
vi. Lasisi OA, Nwaorgu OG, Bella AF. Cochleovestibular complications of diabetes mellitus in Ibadan, Nigeria. IntCongr Series. 2003; 1240: 1325 – 1328. International Federation of Otorhinolaryngological Societies (IFOS).
vii. Vaughan N, James K, McDermott D, Griest S, Fausti S. A 5 year Prospective Study of Diabetes and Hearing Loss in Veteran Population. OtolNeurotol 2005; 27: 37 – 43.
viii. Kakarlapudi V, Sawyer R, Staecker H. The Effect of Diabetes on Sensorineural Hearing Loss. OtolNeurotol 2003; 24: 382 – 386.
ix. Isa A, Mubi BM, Garandawa HI, Sandabe MB, Ngamdu YB, Kodiya AM. Diabetes mellitus, Glycosylated Haemoglobin levels and Hearing impairment in adults. Sahel Med J 2012; 15: 44 – 49.
x. Ologe FE, Okoro EO. Type 2 Diabetes and Hearing Loss in Black Africans. Diabetic Medicine 2005; 22: 664 – 665.
xi. Krishnappa S, Naseeruddin K. A Clinical study of age related hearing loss among diabetes patients. Indian J Otol 2014; 20: 160 – 165.
xii. Akinpelu OV, Ibrahim F, Waissbluth S, Daniel SJ. Histopathologic changes in the cochlea associated with diabetes mellitus – A review. Oto& Neurology 2014; 35: 764 – 774.
xiii. Makishima K, Tanaka K. Pathological changes of the inner ear and central auditory pathway in diabetics. Ann Otolrhinollaryngol 1971; 80:218 – 228.
xiv. Kurien M, Thomas K, Bhanu TS. Hearing threshold in patients with diabetes mellitus. J LaryngolOtol 1989; 103: 164 –168.
xv. Bainbridge KE, Cheng YJ, Cowie CC. Potential mediators of diabetes related hearing impairment in the U S Population. Diabetes care 2010; 33: 811 – 816.
xvi. Onyemelukwe GC. Trends in Non-Communicable diseases in Nigeria. www.profgconyemelukwe.com/public-lectures. Last Accessed on 20th January, 2017.
xvii. Buse JB, Polonsky KS, Burant CF. Type 2 Diabetes Mellitus. In: Larsen PR, Kronenberg HM, Polonsky KS, Melmed S editors. Williams Textbook of Endocrinology 12th ed. Philadelphia: Elsevier Saunders; 2011; p 1371 - 1435.
xviii. International Diabetes Federation. IDF Diabetes Atlas, 6th edition. Brussels, Belgium: International Diabetes Federation, 2013. http://www.idf.org/diabetesatlas.Last Accessed 18th January, 2017.
xix. Rajendran S, Anandhaalakshmi, Mythili B, Viswanatha R. Evaluation of the incidence of sensorineural hearing loss in patients with type 2 diabetes mellitus. Int J Bio Med Res. 2011; 2: 982 – 987.
xx. Anandhalakshmi S, Rajendran S, Mythili M. Evaluation of the auditory effects of hyperlipidaemia and diabetes mellitus by using audiometry. J ClinDiagn Res 2011; 5:1528 – 1532.

xxi. Acuna GM, Herrero L, Duran DC, Menendez – Arguelles ME, Vallejo VLA, Diaz SI. Diabetic Complications and hypoacusis. An otorhinolaringolIbero Am 1997; 24: 465 – 476.

xxii. Cullen JR, Cinnamond MJ. Hearing loss in Diabetics. J LaryngolOtol 1993; 107:179 -182.

xxiii. Akinpelu OV, Mujica – Mota M, Daniel SJ. Is Type 2 Diabetes Mellitus associated with alterations in hearing? – A systemic review and Meta – analysis. The Laryngoscope 2014: 124: 767 – 776.

xxiv. Gratton MA, Schmiedt RA, Schuite BA. Age related decreases in endocochlear potential are associated with vascular abnormalities in the stria vascularis. Hear Res 1996; 102: 181 – 190.

xxv. Tachibana M, Nakae S. The Cochlea of spontaneously diabetic mouse. Electron Microscope observation of K K mice. Arch Otorhinolaryngol 1986; 243:238 – 241.

xxvi. Frisina ST, Mapes F, Kim S, Frisina DR, Frisina RD. Characterization of hearing loss in aged type II diabetics. Hear Res 2006; 211: 103 – 113.

xxvii. Jankar DS, Bodhe CD, Bhutada TB. A study on hearing loss in type II diabetics. Int J Med Res Health Sci. 2013; 2: 893 – 898.

xxviii. Sturzbecher E, Werbs M. Influence of age, sex and hearing loss on auditory brainstem response (ABR) latencies. ScandAudiol 1988; 17:248 – 250.

xxix. Taylor IG, Irwin J. Some audiological aspects of diabetes mellitus. J LaryngolOtol 1978; 92: 99 – 113.

xxx. Chamyal PC. Vestibulo – Cochlea functions in diabetes mellitus. I J O & HNS 1997; 49: 162 – 164.

xxxi. Bamanie AH, Al-Noury KI. Prevalence of hearing loss among Saudi type 2 diabetic patients. Saudi Med J. 2011; 32: 271 – 274.

xxxii. Ren J, Zhao P, Chen L, Xu A, Brown S, Xiao X. Hearing Loss in Middle-aged Subjects with Type 2 Diabetes Mellitus. Archives of Medical Research. 2009; 40:18-23.

xxxiii. Galdas P, Cheater F, Marshall P. Men and health help-seeking behaviour: literature review. J AdvNurs. 2005; 49:616-623.

xxxiv. Mitchell P, Gopinath B, McMahon CM, Rochtchina E, Wang JJ, Boyages SC, et al. Relationship of Type 2 Diabetes to the prevalence, incidence and progression of age – related hearing loss. Diabet Med 2009; 26: 483 – 488.

xxxv. Adebola SO, Olamoyegun MA, Sogebi OA, Iwuala SO, Babarinde JA, Oyelakin AO. Otologic and audiologic characteristics of type 2 diabetics in a tertiary health institution in Nigeria. Braz J Otorhinolaryngol. 2016. Available at: http://dx.doi.org/10.1016/j.bjorl.2015.10.016, last accessed 4th February, 2017.