



# Audiometric Thresholds and Tinnitus Functional Index of Adult Patients with Tinnitus

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## Abstract

**Introduction:** Tinnitus is a common irritating symptom. Tinnitus functional index (TFI) and measurements of tinnitus match are useful tools for evaluating tinnitus impact. This study aimed at comparing the hearing thresholds to the Quality of life (QoL) of tinnitus patients.

**Methodology:** Clinical assessment, Pure tone audiometry (PTA), and QoL assessment were carried out. The data gathered from the study were evaluated and results were interpreted.

**Results:** The mean age of tinnitus subjects was 51.7 years. Male to female ratio was 1:1.4. Higher number of subjects experienced chronic tinnitus. High frequency and the tinnitus loudness above 15dB were the highest among them. The association between the QoL assessment and tinnitus loudness match (TLM) was statistically significant. Similarly, there was positive correlation between the TFI scores and pure tone average (PTAv), tinnitus pitch match and TLM.

**Conclusion:** Most patients described their experience of tinnitus as a big problem. There was a positive correlation between the pure tone average, TLM and the QoL measure. Routine measurement of tinnitus distress with TFI and psychoacoustic assessments were advocated.

**Keywords:** Tinnitus functional index; quality of life; pure tone average; psychoacoustic assessments

**Abbreviations:** TFI: Tinnitus Functional Index; QoL: Quality of Life; PTA: Pure Tone Audiometry; TLM: Tinnitus Loudness Match

## Introduction

Tinnitus, one of the common symptom in ear disorders [1] is defined as an undesirable sound perceived inside the ears or in the head but not related to any external stimuli [2,3]. The term tinnitus was derived from a Latin name "tinnere" meaning ringing. Therefore, it is being used to describe sounds like buzzing, hissing, ticking, clicking, whining, screaming, whistling, humming, tingling, roaring, roaring, cricket or tree frog, clicking in nature etc. [4,5]. It is mostly a subjective complaint with no proper means of detecting or measuring it objectively [6]. Tinnitus commonly manifests as unilateral, short term, intermittent and non-pulsatile in nature [3]. Global prevalence of tinnitus was 10% to 33% among adult population [7-9] with prevalence of significant tinnitus of about 8%.<sup>2</sup> According to the study done in the USA, 17% of the population experienced tinnitus [10]. Similarly, The National Institute of Health

found tinnitus to be a common symptom that affects approximately 15% of Americans [2,11]. Prevalence was also reported to range between 5 to 33% in studies carried out in various regions of Nigeria [1,3,7,9,12-14]. Studies have also shown that about one third of the world population will experience tinnitus one time or the other in their lifetime with approximately 1- 5% developing serious psychosocial features [15,16]. Tinnitus can be classified based on its characteristics which includes duration of a single episode (seconds or minutes; intermittent or continuous); longitudinal duration of tinnitus (days, months, years) or according to severity (degree of tinnitus distress, affectation of daily activities) [10,17]. At the second technical meeting of the World Health Organization (WHO) on quantifying disease, longitudinal duration of tinnitus was classified into acute (less than 3 months), sub-acute (3 to 12

months), and chronic (greater than 12 months) [18]. More recently, tinnitus classification was modified according to the Tinnitus Clinical Practice Guideline [19] and The European guideline for tinnitus management [20]. Another classification was proposed by Stephens and Héту which was based on patient's abilities and quality of life (QoL) [21]. Patients who started to notice tinnitus, whether spontaneous or induced by noise, trauma or other causes are likely to experience spontaneous resolution, but some will still end up with a persistent type of tinnitus [18]. Those with persistent symptoms suffer adverse effects on feeling, thinking and other activities which include sleep affectation [18].

Tinnitus constitutes a big trouble to the patients and managing specialist as well [3,15]. Its impact on QoL is highly individualized; therefore, personality features may predispose some people to experience it as a distressing symptom when compared with others who have better coping strategy [22,23]. Previous studies have found a reduction in the QoL of patients with severe tinnitus distress. Depression and anxiety were found to be the commonest psychological comorbidities suffered by these patients [24]. It can also result into suicidal attempts if care is not taken [18]. Tinnitus Functional Index (TFI) is a standard instrument for quantifying the QoL in both clinical and research settings.<sup>25</sup> It covers a wide area in the broad spectrum of negative impact of tinnitus with very good properties for scaling the tinnitus severity and high responsiveness to tinnitus treatment monitoring; an important feature missing in previous instruments for measurement of tinnitus outcome [25]. Pure tone audiometry (PTA) is a subjective procedure used to measure the tinnitus pitch and intensity by matching the frequency and loudness with an external tone [22]. Researchers that have studied the loudness-pitch tinnitus match have reported estimates that usually fall between 0- and 10-dB SL in most subjects [4,18]. However, these measurements do not necessarily predict a high level of psychological distress in tinnitus patients [18]. Therefore, the aim of this study is to look into the association between the audiometric thresholds and the QoL of adult tinnitus patients.

## Methodology

A hospital based cross-sectional analytical study that was performed at University of Ilorin Teaching Hospital (UITH), Nigeria. Convenience sampling technique was employed. A total of 100 adult patients with complaints of tinnitus were recruited for the study based on the sample size calculation and inclusion criteria. This study included all consenting adults of age 18 years and above who presented to Ear, Nose and Throat (ENT) clinic with tinnitus symptom (as primary complaint) with or without associated hearing loss. Tinnitus was clinically diagnosed to be significant when it occurred for at least once a week and lasted for at least 5 minutes [26]. The duration of tinnitus was also classified into acute (< 3 months), subacute (3 months to less than 6months) and chronic ( $\geq$  6 months) tinnitus according to the Tinnitus Clinical Practice Guideline [19] and the Multidisciplinary European Guideline for management of tinnitus [20]. Clinical assessment and PTA were carried out. TFI questionnaire containing 25 items;

further divided into 8 subscales [25] was administered. All the subjects had pure tone audiometric test done with an audiometer in a sound booth. Air and bone conduction thresholds were assessed at different frequencies between 125 - 8000Hz and 250 - 4000Hz respectively with maximum levels presented at 120dB. The Pure Tone Average (PTAv) was computed from the average of the four speech frequencies of 500Hz, 1000Hz, 2000Hz, and 4000Hz [27]. Audiometric results of the air and bone conduction threshold were plotted on an audiogram and also documented on the audiometric thresholds report sheet.

The degree of hearing loss was measured according to the World Health Organization Grading of Hearing Impairment: Normal hearing ( $\leq$ 25 dB HL), Mild hearing loss (26 to 40 dB HL), Moderate hearing loss (41 to 60 dB HL), Severe hearing loss (61 to 80 dB HL), and profound hearing loss ( $\geq$  81 dB HL) [28]. The type of hearing loss was classified as sensorineural hearing loss (the air and bone conduction thresholds are above 25 dB HL with air-bone gap <10dB HL), conductive hearing loss (air and bone conduction thresholds are >25dB HL and <25dB HL respectively and air-bone gaps of  $\geq$ 10dB HL) and mixed hearing loss (air and bone conduction thresholds are above 25 dB HL with air-bone gaps of  $\geq$ 10dB HL) [11,29]. Tinnitus loudness match (TLM) was categorized as < 10dB above the threshold, 10-15 dB above the threshold, and >15 dB above the audiometric threshold.<sup>15,29</sup> The tinnitus pitch match (TPM) was categorized as low frequency tinnitus (125 Hz, 250 Hz and 500 Hz), mid frequency tinnitus (1 kHz, 2 kHz and 3 kHz) and high frequency tinnitus (4 kHz, 6kHz and 8 kHz) [11,15,29]. The approval to carry out this study was obtained from the Ethical Review Committee (ERC) of UITH before commencement (ERC PAN/2017/12/1758). Statistical analysis was performed with version 20 of the Statistical Product and Service Solutions (SPSS). Results were presented in tables and figures. Correlation was obtained with the Spearman's ranking for the relationships between symptoms score from the QoL questionnaire, PTA findings and tinnitus matching. The relationship between continuous variables and specific outcome variables were evaluated using student t-test or chi square, where the assumptions are met. For all statistical studies, p-value  $\leq$  0.05 was regarded as being statistically significant.

## Results

Out of the 100 adult subjects, unilateral tinnitus was found among 74 subjects while 26 presented with tinnitus in both ears. In all, two hundred ears were analysed with 126 ears experiencing tinnitus as at the time of the study. Age and gender distributions were shown on Table 1. The age range of subjects was between 18 and 84 years with mean age of 51.7 years  $\pm$  17.8. The highest number of subjects was in age group 65-74{18 (18.0%)}. This is closely followed by age groups 55- 64 and 45-54 with 17 (17.0%) and 16 (16.0%) subjects respectively. The subjects were comprised of 58 (58.0 %) females and 42 (42.0%) males with a male to female ratio of 1:1.4. The frequency of the duration of tinnitus, as at patient's first presentation to the hospital with complaints of tinnitus was shown in Table 2. Chronic tinnitus was found as the commonest

with 39 (39.0%) subjects. Acute and subacute tinnitus were seen among 36.0% and 25.0% of subjects respectively. Tinnitus duration was in the range of one week to 15 years with mean duration of  $17.9 \pm 28.7$  months. All the subjects had subjective tinnitus. Tinnitus was only left sided in 43 (43.0%) subjects, 31(31.0%) subjects experienced it only on the right ears while 26 (26.0%) had bilateral tinnitus. Continuous tinnitus was the complaint of 46

(46.0%) subjects while intermittent tinnitus was found among 54 (54.0%) of them. Tinnitus was worse at night in 52% of subjects while 4 (4.0%) subjects had it worse during the day and 44 (44%) found no difference in their tinnitus in both day and night period. High frequency tinnitus pitch match was noticed to be commonest in 36 (36.0%) subjects.

**Table 1:** Age and sex distribution of participants.

Variable	Frequency	Percentage (%)
<b>Age (in Years)</b>		
18 - 24	8	8
25 - 34	13	13
35 - 44	15	15
45 - 54	16	16
55 - 64	17	17
65 - 74	18	18
75 - 84	13	13
Total	100	100
Mean $\pm$ SD	$51.72 \pm 17.84$	
Range	18 - 84	
<b>Sex</b>		
Male	42	42
Female	58	58
Total	100	100

**Table 2:** Characteristics of tinnitus among subjects.

Variable	Frequency	Percentage
<b>Tinnitus Duration (n = 100)</b>		
Acute tinnitus	36	36
Subacute tinnitus	25	25
Chronic tinnitus	39	39
Total	100	100
Mean $\pm$ SD (in months)	$17.91 \pm 28.72$	
Range(months)	0.25 - 180.00	
<b>Tinnitus Localization (n = 100)</b>		
Right sided tinnitus	31	31
Left sided tinnitus	43	43
Bilateral tinnitus	26	26
Total	100	100
<b>Tinnitus Recurrence (n = 100)</b>		
Intermittent	54	54
Continuous	46	46
Total	100	100
<b>The time of Worse Tinnitus (n = 100)</b>		
Day time	4	4
Night	52	52
Same both day and night	44	44
Total	100	100

Mid frequency and low frequency were observed among 33 (33.0%) and 31 (31.0%) subjects, respectively. Similarly, a high number of subjects (48.0%) had tinnitus loudness greater than 15dB above hearing levels while those with 10 - 15dB and those with less than 10dB were 28 (28.0%) and 24 (24.0%) subjects, respectively. The TLM above hearing threshold ranged from 4dB to 60dB with average TLM of 18.38dB. The audiogram on Figure 1A revealed the pattern of the mean pure tone average of the right and left sided tinnitus when compared with the contralateral non-tinnitus ears in subjects with unilateral tinnitus. The audiogram on Figure 1B also revealed a similar pattern in air conduction mean PTA<sub>v</sub> of right and left sided tinnitus in subjects with bilateral tinnitus. The histogram in Figure 2 showed the participants' perception of their tinnitus on TFI. The scores range from small to very big problem. A higher number of the subjects (37.0%) described their tinnitus as big

problem. This was followed by those who described the experience of tinnitus as moderate problem (34.0%), very big problem (15.0%) and small problem (14.0%). As shown on Table 3, the relationship between the grades of TFI scores and duration of tinnitus and that of tinnitus localization were not statistically significant ( $p$  value > 0.05). Table 3 also showed that the association between the TFI scores and TLM revealed a statistically significant difference ( $p$  value = 0.002). However, it was not statistically significant with TPM. Table 4 reported the correlation between TFI scores and the duration of tinnitus, PTA<sub>v</sub> and psychoacoustic measures. There was a statistically significant positive correlation between the TFI scores and the PTA<sub>v</sub> as well as the TLM ( $p$  < 0.05). There was a very weak positive correlation between the TFI scores and duration of tinnitus and TPM.

**Table 3:** The association between TFI scores and tinnitus localization, tinnitus duration and tinnitus matching grades.

Variable	Grades of TFI Scores				$\chi^2$	p value
	Small problem n(%)	Moderate problem n(%)	Big problem n(%)	Very big problem n(%)		
<b>Tinnitus Localization</b>						
Unilateral	14 (18.9)	24 (32.4)	25 (33.8)	11 (14.9)	4.279 <sup>Y</sup>	0.233
Bilateral	0 (0.0)	10 (38.5)	12 (46.2)	4 (15.3)		
<b>Tinnitus Duration</b>						
Acute tinnitus	5(13.9)	11(30.6)	16(44.4)	4(11.1)	3.551	0.737
Subacute tinnitus	5(20.0)	7(28.0)	9(36.0)	4(16.0)		
Chronic tinnitus	4(10.3)	16(41.0)	12(30.8)	7(17.9)		
<b>Tinnitus Pitch Match</b>						
Low frequency	6 (19.4)	14 (45.2)	9 (29.0)	2 (6.4)	5.606 <sup>Y</sup>	0.469
Mid frequency	5 (15.2)	11 (33.3)	10 (30.3)	7 (21.2)		
High frequency	3 (8.3)	9 (25.0)	18 (50.0)	6 (16.7)		
<b>Tinnitus Loudness Match</b>						
<10dB	8 (33.3)	12 (50.0)	4 (16.7)	0 (0.0)	20.271	0.002*
10 - 15dB	1 (3.6)	13 (46.4)	11 (39.3)	3 (10.7)		
>15dB	5 (10.4)	19 (18.8)	22 (45.8)	12 (25.0)		

$\chi^2$ : Chi square test; Y: Yates corrected chi square; \*:  $p$  value <0.05 (i.e., statistically significant).

**Table 4:** Correlation of tinnitus duration, PTA<sub>v</sub>, TPM and TLM with TFI scores.

Variable	TFI Scores	
	r	p value
Tinnitus duration	0.028	0.779
Pure tone average (PTA <sub>v</sub> )	0.262	0.009*
Tinnitus Loudness Match (TLM)	0.434	<0.001*
Tinnitus Pitch Match (TPM)	0.167	0.097

r: Spearman correlation coefficient; \*:  $p$  value <0.05 (i.e., statistically significant).

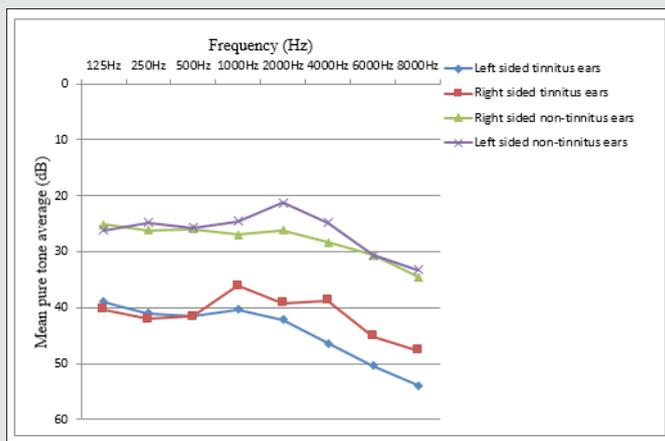


Figure 1(A): Mean air conduction thresholds for the right sided tinnitus ears, left sided tinnitus ears and non-tinnitus ears.

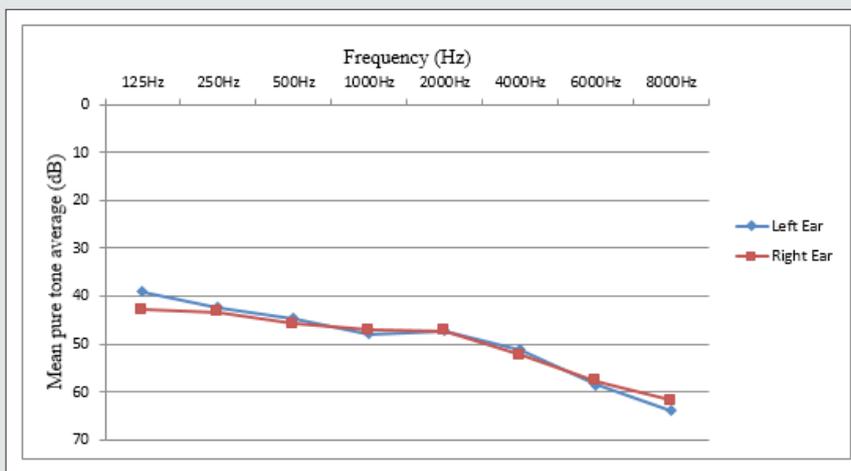


Figure 1(B): Mean air conduction thresholds for the bilateral tinnitus ears.

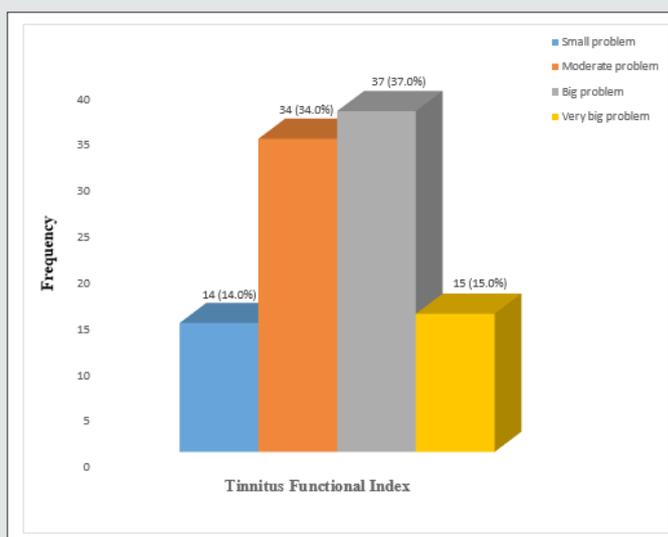


Figure 2: Tinnitus Functional Index scores of subjects' perception of their tinnitus.

## Discussion

The mean age of 51.7 years with highest frequency found in the age group of 65 - 74 years were similar to the findings of Fackrell et al. average age of 53.6 years with a range of 18-84 years [30]. Okhakhu et al. [31] also reported an age range of 18 to 80 years and mean age of 46.8 years while Bhatt et al [32] revealed a mean age of 53.1 years. In consonance with this study, Martines et al. [23] reported that patients with tinnitus were more frequently between the age of 51 and 70 years with an average age of 58.1 years. In the work done by Sogebi et al. [12] among elderly tinnitus patients, they revealed that a higher number of the subjects were between 60 and 69 years of age. Majority of patients with tinnitus in our study were females. This is in consonance with findings in previous studies [11,24,31-35]; however, some other studies [3,30,36] revealed a higher number of male subjects with tinnitus. Despite the inconsistent data on the effect of gender on characteristics of tinnitus and its distress, females are more likely to perceive annoyance of tinnitus earlier than their male counterparts irrespective of age at presentation. It has also been found that the psychosomatic complaints that are related to tinnitus symptoms are likely to be more persistent among females than the male gender [35]. A high number of subjects in this study presented with chronic tinnitus at the time of first presentation to the clinic. This report has similarity with the study done by Sogebi [14] on the characteristics of tinnitus and other previous studies where a greater number of subjects has been having tinnitus for more than 2 years [30,32,34]. Most of our tinnitus patients might have taken their symptom with levity until it causes some form of irritation or become associated with other symptoms [36]. And sometimes, they only visit the hospital when it has developed into a chronic condition [37].

The average duration of tinnitus in our study population was 17.9 months. Ukaegbe et al. [38] in their study of the effect of tinnitus on the audiometric threshold of tinnitus patients, found a similar average tinnitus duration of 17.3 months. Although, a high average tinnitus duration of 35.2 months was reported by Kim et al. [39] A higher number of subjects experienced worse tinnitus sensations at night. This was also in line with previous research works where most of the tinnitus experienced by patients was more at night [3,32]. It is justifiable that during the day, the effect of ambient noise may mask the sensation of tinnitus symptoms. However, some tinnitus patients still continually experience tinnitus disturbance despite other sources of noise in the environment. The predominance of tinnitus in the left ear is by chance. No reason was found for the predominant tinnitus ear in previous studies [3,9,11]. Our study reported a steady rise in the number of subjects from low frequency to high frequency in TPM as well as the loudness increases above the hearing thresholds in the TLM of subjects. This appeared different from the findings of Martines et al. [23] where there was a gradual reduction in the number of tinnitus patients as the loudness increases. TLM above the hearing level ranges from 4 - 60dB with an average of about 18dB may suggest that most of the patients presented to ENT clinic when their symptom was

already causing some levels of distress and affecting their QoL.15 The average tinnitus loudness reported in our study was within the bracket of what was found in previous studies done in Nigeria and beyond [33,39-41]. High TFI scores indicate greater adverse effects on the QoL of tinnitus patients. In our study, tinnitus constituted one level of health problem or the other in all subjects resulting into their presentations to ENT clinic. More of the subjects in this study described their tinnitus as big. This was closely followed by those who described it as moderate. In a multi centered hospital-based study and a questionnaire-based study by Okhakhu et al. [31] and Prabhu [42] respectively; it was found that the degree of tinnitus distress was scored as moderate in many of tinnitus patients. This further corroborated the report that most patients seek for specialist care when the symptom has already caused some form of disturbance or became associated with other ear symptoms [23]. It was however found that in some community studies, greater than 70% of subjects had little or no tinnitus impact on their QoL [32,43].

The association between TFI scores and tinnitus localization was inconsequential. This confirmed the fact that the influence tinnitus impact had on QoL of patient is not a measure of whether it is unilateral or bilateral tinnitus, but it is an intrinsic individualized characteristic. There was a significant positive correlation between TFI grading and pure tone average as well as the tinnitus loudness match above hearing thresholds of the subjects. The findings of Dziendzie et al. [26] also showed a positive correlation between TFI scores and the mean air conduction levels. The significant association of TFI score with TLM reported in our study may submit that a rise in tinnitus loudness might result into a worsened effect on the QoL of tinnitus patient. The tinnitus loudness is therefore an important variable that can explain individual differences with tinnitus distress [44]. Okhakhu et al. [31] and Probst et al. [45] also reported similar findings. They noticed that there was a significant effect of loudness of tinnitus on the impact of tinnitus on QoL. In a work done on the correlation between hearing level, TPM and loudness with QoL of patients with tinnitus, Savitri E et al. [44] found a significant positive correlation between loudness and its impact on QoL. They strongly suggested the need for psychoacoustic measurement of tinnitus to become a routine assessment for tinnitus patients [44]. Martines et al. [23] and Fuller et al. [46] however found no significant correlation between the psychoacoustic measurements (and hearing levels) and their effect of tinnitus on QoL. Rabau et al. [47] also affirmed that the loudness of tinnitus is not always the same as tinnitus impact. In fact, in the study done on TLM in relation to annoyance and grading of tinnitus distress, Hiller et al. [48] reported a low tinnitus annoyance despite high tinnitus loudness.

They therefore proposed that tinnitus loudness and annoyance are not necessarily harmonious and should be assessed differently [48]. It is noteworthy that most of these research works were based on the use of the tinnitus handicap inventory (THI), tinnitus questionnaire (TQ) and visual analog scale (VAS) in the measurement and assessment of tinnitus effect on QoL. Although,

there is presently no objective means of measuring tinnitus impact; researchers and specialists can only depend on tinnitus self-reported measures. More studies where TFI will be used for measurement of tinnitus influence on QoL and correlated with psychoacoustics measures are therefore needed in West African sub region to establish the strength of the association between tinnitus annoyance and tinnitus psychoacoustic match. Although, the advantage of both the tinnitus psychoacoustic match procedures and the measurement of QoL in the comprehensive management and monitoring of treatment of a tinnitus patient cannot be over emphasized; high frequency TPM (and sometimes the magnitude of TLM above the hearing level) does not necessarily imply a worse effect on QoL. This concurs with the belief that a patient's response to the effect of tinnitus cannot be categorised into a simple function of its psychoacoustic measures but rather as a complex interconnection between acoustic phantom symptoms, psychological/somatic factors and depressive symptoms [48,49]. This might explain why some patients are disabled by the effect of tinnitus while others could cope with it comfortably [49].

In conclusion, more of the patients in our study described their experience of tinnitus as a big problem. The PTA<sub>v</sub> and TLM have been positively correlated with the health related QoL measurement. It was therefore recommended and advocated to measure the tinnitus intensity and distress routinely with TFI and tinnitus matching procedures. However, the implementation of all-inclusive management of tinnitus should be highly personalized. In addition, more studies are needed to be carried out on a larger sampled population for evaluation of the socioeconomic impact of tinnitus on Africans.

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