Examining the consequences of tinnitus using the multidimensional perspective

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Abstract

Background: Tinnitus is one of the most frequent chronic conditions in adults with wide range of consequences.

Aims/Objectives: The aim of the current study was to determine the problems and life effects reported by individuals with tinnitus using the International Classification of Functioning, Disability and Health (ICF) framework.

Material and Methods: The study used a cross-sectional survey design. 344 individuals with tinnitus completed a series of questionnaires. The responses to open-ended questions were linked to ICF categories.

Results: Activity limitations and participation restrictions were most dominant consequence of tinnitus followed by effect on the body function with limited emphasis on the contextual factors. Frequently reported responses to body function involved emotional functions (b152), attention function (b140), and sleep functions (b134). Commonly reported responses to activity limitations and participation restrictions were recreation and leisure (d920), conversation (d350), communicating with—receiving—spoken messages (d310), listening (d115), and remunerative employment (d850). Sound intensity (e2500) and sound quality (e2501) were the frequently reported responses to environmental factors. Coping styles, past and present experiences, and lifestyle were the most frequently occurring personal factors.

Conclusions and Significance: The study highlighted some key influencing factors of tinnitus in different ICF domains which can be helpful in rehabilitation planning.

Key Words

Tinnitus, ICF, Biopsychosocial perspective, Body function, Activity limitations, Participation restrictions, Open-ended questions

Introduction

Tinnitus is a common condition affecting roughly 10-15% of adults. Of those with tinnitus, not all have severe tinnitus, however, for a proportion (estimated 2-10% in the general population) tinnitus interferes with daily life [1]. Tinnitus can affect various aspects of life including sleep, mood, concentration, and can lead to indirect psychological and psychosocial effects, such as depression and anxiety [2]. These effects negatively impact relationships and the ability to work effectively, which in turn has an impact on the health economy [3].

Considering the wide range of consequences experienced by individuals with tinnitus, applying the multidimensional perspective to examine the impact of tinnitus may help uncover the effects of this hidden disability. The World Health Organizations (WHO) - International Classification of Functioning, Disability and Health (ICF) is a framework and/or classification that is based on biopsychosocial models of disability and provides comprehensive framework to study and understand health and disability [4]. The ICF classification has been used to examine various forms of health conditions. It broadly includes two main parts: functioning and disability; and contextual factors. Functioning is an umbrella term and is described with the positive concepts such body structure (*s*), body function (*b*), and activity and participation (*d*), while the umbrella term disability is described with the negative terminology (i.e., impairment, activity limitation and participation restriction). The contextual factors include the components: environmental factors (e) and personal factors.

Only two previous studies have examined consequences of tinnitus using the International Classification of Functioning, Disability and Health (ICF) framework. Ramkumar and Rangasayee [5] mapped the items of the Tinnitus Handicap Inventory (THI) framework and examined which aspects of tinnitus were more problematic using this structured questionnaire. Their study showed that body function was significantly more affected when compared to activity limitations and participation restrictions. In another study, Manchaiah et al. [6] examined responses to open-ended questions focusing on problems and life effects as a result of tinnitus in the UK population using the ICF classification. This study also showed that body function was more affected than the participation restrictions. The most frequent responses related to body function involved emotional functions (b152), sleep functions (b134), hearing functions (b230), and sustaining attention (b1400). Communicating with-receiving-spoken messages (d310), socialization (d9205), handling stress and other psychological demands (d240), and recreation and leisure (d920) were the commonly reported responses for activity limitations and participation restrictions. The study also highlighted various contextual factors such as environmental factors (i.e., sound intensity e2500; sound quality e2501; general products and technology for communication e1250) and personal factors (i.e., coping styles) which could mediate the experiences of tinnitus. These studies have identified some important consequences of tinnitus. Moreover, the ICF framework provides a culture neutral language to examine the consequences of health conditions and is easy to compare across populations. However, there could be differences in populations in the way in which they express their symptoms and consequences.

The aim of the current study was to identify key problems and life effects reported by individuals with tinnitus in the US. The response to open-ended questions were mapped to ICF classification. In addition, we compared the number of responses to both problem and life effects questions as well as examined the association between number of responses to open-ended questions and tinnitus related variables. We also compared the current study results with similar study on the UK population to examine similarities and differences [6].

Method

Study Design

The study used a cross-sectional survey design. Study participants were seeking online psychological interventions for tinnitus (Clinical Trials.gov registration numbers NCT04004260, NCT04335812) and completed a series of pre-intervention measures [7-9].

Data Collection

The data were collected using online questionnaire which included questions about (a) demographical factors (e.g., age, gender, education, work status), (b) tinnitus-related variables (e.g., duration of tinnitus) as well as standardized questionnaires, and (c) open-ended questions. The standardized questionnaires assessed the tinnitus severity using the Tinnitus Functional Index (TFI; [10]), anxiety using the Generalized Anxiety Disorder – 7 (GAD7), depression using the Patient Health Questionnaire – 9 (PHQ-9), insomnia using the Insomnia Severity Index (ISI), and the health-related quality of life (HRQoL) using the EQ-5D-5L VAS scale. The two open-ended questions focusing on problems and life effects associated with tinnitus and has been used in previous studies related to hearing loss and tinnitus [6,11,12]. The questions were worded as:

(a) Problem question (PQ): “Make a list of difficulties, which you have as a result of your tinnitus. Write down as many as you can think of;” and (b) “Life effects question (LEQ): Make a list of the effects your tinnitus has on your life. Write down as many as you can think of.”

Data Analysis

Quantitative Analysis

The number of responses to PQ and LEQ by individual participant were determined.

The Shapiro–Wilk test suggested that the number of responses violated the assumption of normality. A Wilcoxon signed-rank test was therefore used to examine the differences in number of responses between the PQ and LEQ. The Spearman’s rho correlation was performed to examine the relationship between number of response and the tinnitus-related variables. A two-tailed significance of 0.05 was considered statistically significant, although a more stringent Bonferroni corrected significance level of 0.01 (i.e., 0.05/5 comparisons) were used to interpret the significance levels in multiple comparisons.

Qualitative Analysis and ICF Mapping

The mapping of responses to open-ended questions to the ICF classification followed the procedure to manage qualitative data suggested by Granberg et al. [13] The procedure is based on qualitative content analysis and follows a procedure including meaningful concepts, latent interpretation and linking (mapping) data to the ICF. The ICF linking was performed using the well-established linking rules [14,15]. ICF classification does not provide a detailed classification for personal factors. For this reason, personal factors were classified using the classification proposed by audiology researchers [14,16,17]. According to the linking rules, any

responses that was not possible to assign to ICF categories was labeled *nd* (not definable), *nc* (not covered by ICF), or *hc* (health condition). To increase the reliability of the procedure, the linking was conducted independently by two researchers (S.G. and E.K.). A third researcher (V.M.) was consulted to resolve any disagreements between the two independent coders.

Results

Of the 440 people who enrolled for the online psychological interventions, 334 participants provided the response to open-ended questions (76% response rate). Of these, 53.5% of the participants (n=186) were females. Most of the participants were non-Hispanic and whites (nearly 90%). The mean tinnitus duration was 12.4 years and the mean TFI scores was 53.4 which suggested participants had severe tinnitus requiring interventions. Table 1 provides detailed demographic information including their work status, education, as well as scores for anxiety, depression, insomnia and quality of life measures.

Table 1: Demographic information (n=344)

Variable	**N (%)**	**Mean (SD); Score range**
Age (in yrs)	-	55.1 (13.2); 19 to 84
Gender ▪ Male ▪ Female	 160 (46.5) 184 (53.5)	-
Race ▪ American Indian/Alaska Native	 1 (0.3)	-

▪ Asian ▪ Native Hawaiian/Other Pacific Islander ▪ Black or African American ▪ White ▪ More than One race	7 (2) 0 (0) 9 (2.6) 313 (91) 14 (4.1)	
Ethnicity ▪ Hispanic or Latino ▪ Not-Hispanic or Latino	 36 (10.5) 308 (89.5)	-
Work ▪ Entry level or unskilled work, ▪ Skilled or professional work ▪ Retired ▪ Not working	 8 (2.3) 210 (61) 101 (29.4) 25 (7.3)	-
Education ▪ Less than high school ▪ High School ▪ Some college but not degree ▪ A university degree	 0 (0) 35 (10.2) 101 (29.4) 208 (60.5)	-
Tinnitus duration (in years)	-	12.4 (13.3); 0.17 to 70
Tinnitus severity (TFI)	-	53.4 (20.7); 6.4 to 100
Anxiety (GAD-7)	-	7.4 (5.8); 0 to 21
Depression (PHQ-9)	-	7.5 (5.9); 0 to 27
Insomnia (ISI)	-	11.5 (6.8); 0 to 28

Health-related quality of life (EQ-5D-5Q VAS)	-	74.8 (15.4); 9 to 100

Number of Responses Open-ended Questions

The two open-ended questions generated 2,261 (i.e., 1,345 from the PQ and 885 from the LEQ). Of these, 32 responses were categorized as *nc* (n=25) or *hc* (n=7) as they could not be categorized using the ICF classification. The number of meaningful responses for PQ ranged from 0 to 16 and ranged from 0 to 10 for LEQ. The median responses for PQ and LEQ were 3 and 2, respectively. Table 2 provides the mean number of responses to PQ and LEQ in all the four ICF domains. The number of responses to PQ were significantly more when compared to LEQ in all the four ICF domains as shown in Table 2.

Table 2: Number of responses in each of the ICF domains listed in the problem and life-effects questions

Category	**PQ Mean (SD)**	**LEQ Mean (SD)**	**Wilcoxon Z**	**P-value**
All responses	3.9 (2.5)	2.6 (1.7)	-10.1	< .001
Functional impairment (body function)	1.2 (1.1)	1.4 (1.2)	-3.0	.003
Activity limitations and Participation restriction	1.8 (1.7)	0.88 (1.1)	-9.4	< .001
Environmental factors	0.64 (0.8)	0.27 (0.5)	-7.0	< .001
Personal factors	0.26 (0.5)	0.03 (0.2)	-7.9	< .001

Relationship Between Number of Responses to Open Questions and Tinnitus-related Variables

Table 3 presents the results of Spearman's rho correlation between number of responses to PQ and LEQ and tinnitus-related variables. There was a statistically significant weak positive correlation between the variables tinnitus severity, anxiety, depression, and insomnia with number of responses to both PQ and LEQ. There was a weak negative correlation between age and number of responses to PQ, but not with number of responses to LEQ. The correlation between quality of life and number of responses was not statistically significant after applying the Bonferroni corrected significance level for interpretation. These results suggest that individuals with tinnitus report more problems and life effects when they have more severe tinnitus, anxiety, depression, and insomnia. Also, negative association between age and number of responses to open-ended questions suggest that younger participants reported more problems.

Table 3: Relationship between number of responses to problem and life-effects question and the demographic and tinnitus-related variables

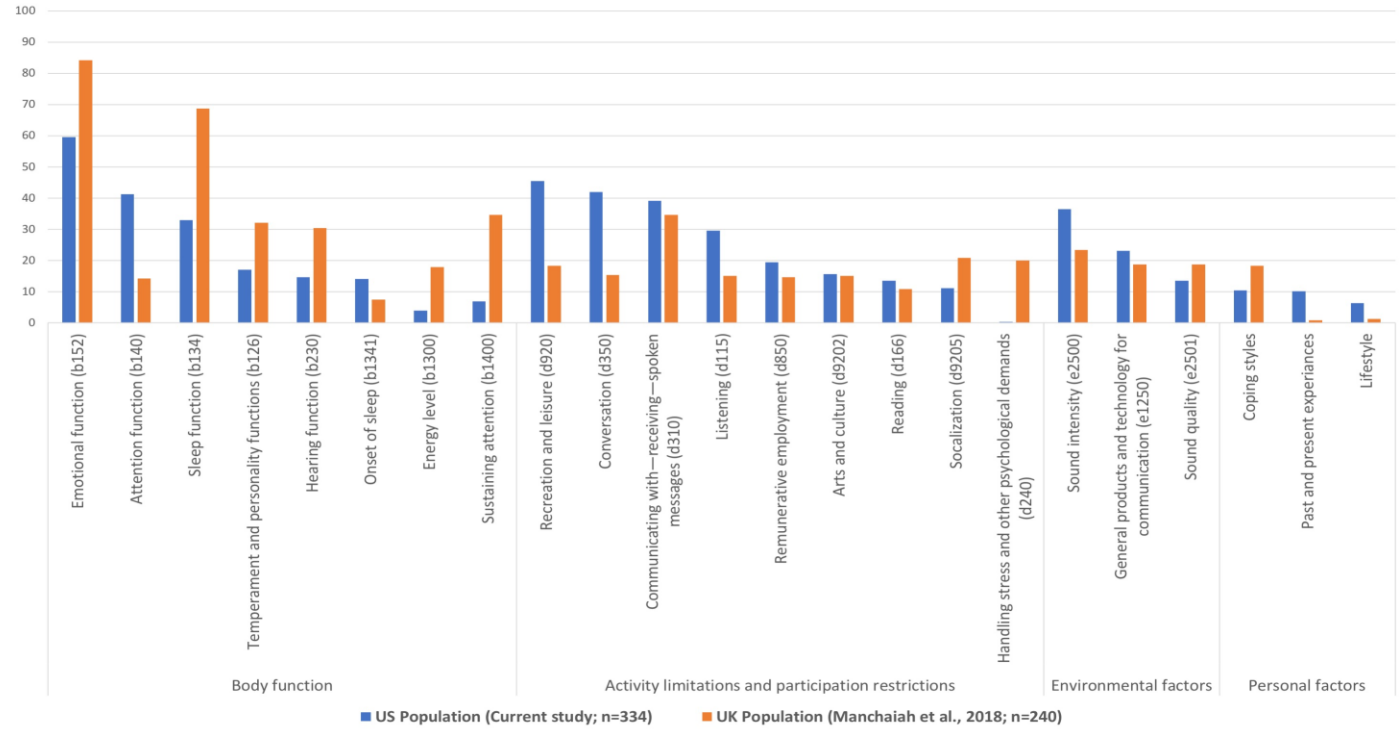
Variables	**PQ (all)**	**LEQ (all)**
Age	-.15**	-.07
Tinnitus duration	-.05	-.07
Tinnitus severity	.28**	.23**
Anxiety	.25**	.28**
Depression	.24**	.27**
Insomnia	.2**	.24**
Quality of life	-.11*	-.09

Note: **<0.01; *<0.05

Understanding Consequences of Tinnitus Using the ICF Classification

Figure 1 presents a summary of the consequences of tinnitus in the ICF domains in comparison with a UK population in percentages [6]. More detailed presentation of ICF codes for each of the domains is provided in supplementary tables. There was a total of 864 ICF codes (397 for PQ and 467 for LEQ), on body function, 950 codes (614 for PQ and 309 for LEQ) on activity limitations and participation restrictions, 314 codes (220 for PQ and 94 for LEQ), and 101 codes (90 for PQ and 11 for LEQ) from the open-ended responses. Activity limitations and participation restrictions seem to be most frequently affected followed by body function. Moreover, the study participants also reported various contextual factors (i.e., environmental and personal factors) influencing their tinnitus experience.

Figure 1: The most frequently reported factors impacted due to tinnitus



Tinnitus Impact on Bodily Aspects

The most frequently occurring categories were emotional functions (b152) with 199 responses. Other frequently occurring categories included: attention function (b140) with 138 responses, sleep functions (b134) with 110 responses, temperament and personality function (b126) with 57 responses, hearing functions (b230) with 49 responses, and onset of sleep (b1341) with 47 responses. Sustaining attention (b1400) with 23 responses and energy level (b1300) with 13 responses were less frequently reported when compared to UK population [6].

Influence of Tinnitus on Activities and Participation

The most frequently occurring ICF categories for activity limitations and participation restrictions were: recreation and leisure (d920) with 152 responses, conversation (d350) with 140 responses, communicating with—receiving—spoken messages (d310) with 131 responses, listening (d115) with 99 responses, remunerative employment (d850) with 65 responses, arts and culture (d9202) with 52 responses, and reading (d166) with 45 responses. Socialization (d9205) with 37 responses and also handling stress and other psychological demands (d240) with 1 response were less frequently reported when compared to UK population [6].

The Impact of Environmental Factors

Environmental factors are contextual factors that may influence an individual and the daily activities one might have. Sound intensity (e2500) with 122 responses, sound quality (e2501) with 21 responses, and general products and technology for communication (e1250) with 21 responses were the commonly reported responses about environmental factors.

The Impact of Personal Factors

Personal factors codes occurred least frequently when compared to other ICF domains. The frequently occurring personal factors included coping styles (35 responses), past and present experiences (34 responses), and lifestyle (21 responses). These factors are specific to an individual and could potentially mediate their tinnitus experiences positively or negatively.

Discussion

The current study examined the impact of tinnitus by examining the responses to problem and life effects open-ended questions by linking the responses to ICF classification. The study used

similar methodology as in the previous UK study [6]. Both studies also had similar population of participants with bothersome tinnitus seeking psychological interventions who were comparable in terms of age and tinnitus severity.

Both problem and life effects question elicited a range of responses from study participants. However, number of responses to problem questionnaire were significantly higher when compared to life effects questionnaire. These findings are contrary to our previous study on tinnitus which showed no difference in number of responses elicited for problem and life effects questionnaire [6], although comparable to studies on hearing loss populations [11,12]. Moreover, the number of responses were associated with age, tinnitus severity, anxiety, depression, and insomnia. This was expected as tinnitus severity as well as its comorbidities show how significantly the participants were affected by their tinnitus. Overall, the findings suggest that responses to both open-ended and standardized outcome measures may provide insights into consequences of tinnitus.

In the current study, aspects of activities and participation were most commonly affected when compared to body function. This is contrary to previous studies which have shown that body function was most frequently affected by individuals with tinnitus [5,6]. This could potentially highlight differences in populations on how disease may impact different aspects of life. Emotional function (b152) was the most frequently reported consequence of body function. This is understandable as stress, anxiety and depression associated with tinnitus is likely to negatively impact the thinking patterns [3]. Moreover, attention function (b140), sleep functions (b134), temperament and personality function (b126), and hearing functions (b230) were the other key

body functions affected by tinnitus as noted in numerous qualitative studies on tinnitus [18]. Recreation and leisure (d920), conversation (d350), and communicating with—receiving—spoken messages (d310), listening (d115), and remunerative employment (d850) were the most frequently reported activity limitations and participation restriction items. Avoiding certain social situations as well as not being able to work as a result are more severe consequences of tinnitus [19]. It is noteworthy that participants also reported a series of contextual factors (i.e., environmental factors such as sound intensity [e2500], sound quality [e2501], general products and technology for communication [e1250] and also personal factors such as coping styles, past and present experiences, and lifestyle). These factors can mediate the tinnitus experience positively or negatively at an individual level and are important when considering the management strategies for tinnitus.

While the current study used a cross-sectional data of the clinical trials, a sub-sample of participants from the current study were included in two separate clinical trials who were all provided with the internet-based cognitive behavioral therapy intervention. The outcomes of these trials have been presented in our recent manuscripts [8,9]. Our recent studies from the UK sample have shown that the baseline tinnitus severity (i.e., TFI scores) and also education level was found to be the key prognostic factors of ICBT intervention [20].

Clinical Implications

The study has direct clinical and practice implications. It highlights the impact of tinnitus with a multidimensional perspective and could be helpful when planning management strategies to

address the consequences of tinnitus. Tinnitus management should be based on the key concerns of patients as well as considering the contextual modifying factors (i.e., environmental and personal factors). For instance, if an individual with tinnitus report sleep functions (b134) as the main problem and if they were unable to cope. The management plan should focus on providing detailed information about sleep hygiene as well as suggestions about sleep aids (e.g., tinnitus relief pillow with masker). It is also important to consider the pathophysiology of tinnitus when developing the management plan, although the current study failed to examine the consequences of tinnitus based on the etiological as well as pathophysiological factors. Nevertheless, it is important for clinicians and researchers to consider the key outcome domains to be measured when performing clinical trials. The study could also contribute to the development of core outcome sets for tinnitus. Finally, as the ICF provides a culture neutral framework to capture the disease consequences and is easier to compare across countries and populations.

Study Limitations

The study has three key limitations. First, the study included individuals with tinnitus seeking online psychological interventions and were of higher tinnitus severity. The study population was hence not representative of the general tinnitus population. Second, participants were self-selected and enrolled themselves for the intervention which may have caused sampling bias. For these reasons, the results should be viewed with caution and are most likely not generalizable to general tinnitus population. Third, the consequences reported by tinnitus patients could vary because of the etiological factors. However, we did not gather information about the possible etiological factors in the current study.

Conflict of Interest

The authors have no conflict of interest.

Ethical Approval

Ethical approval was obtained from the Institutional Review Board at Lamar University (IRB-FY17-209 and IRB-FY20-200).

Data Availability

The data that support the findings of this study are openly available in Figshare at http://doi.org/10.6084/m9.figshare.13681924

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References

[1] Oosterloo, B. C., Croll, P. H., de Jong, R. J. B., et al. Prevalence of Tinnitus in an Aging Population and Its Relation to Age and Hearing Loss. Otolaryngology–Head and Neck Surgery, 2021;164(4), 859–868. https://doi.org/10.1177/0194599820957296

[2] Bartels, H, Middel, B. L., van der Laan B. F., et al. The additive effect of co-occurring anxiety and depression on health status, quality of life and coping strategies in help-

seeking tinnitus sufferers. *Ear & Hearing*, 2008;29(6), 947-956. https://doi.org/10.1097/aud.0b013e3181888f83

[3] Langguth, B. A review of tinnitus symptoms beyond 'ringing in the ears': a call to action. *Current Medical Research and Opinion*, 2011;*27*(8), 1635–1643. https://doi.org/10.1185/03007995.2011.595781

[4] World Health Organization. *International Classification of Functioning, Disability and Health*. Geneva, Switzerland: World Health Organisation, 2001.

[5] Ramkumar, V., & Rangasayee, R. Studying tinnitus in the ICF framework. *International Journal of Audiology*, 2010;*49*(9), 645–650. https://doi.org/10.3109/14992027.2010.484828

[6] Manchaiah, V., Beukes, E. W., Granberg, S., et al. Problems and Life Effects Experienced by Tinnitus Research Study Volunteers: An Exploratory Study Using the ICF Classification. *Journal of the American Academy of Audiology*, 2018;*29*(10), 936–947. https://doi.org/10.3766/jaaa.17094

[7] Beukes, E.W., Aronson, E.P., Andersson, G., et al. Internet-based Cognitive Behavioral Therapy for tinnitus in the United States: A pilot trial. *American Journal of Audiology*, 2021; Published Online.

[8] Beukes, E. W., Andersson, G., Fagelson, M. A., et al. Internet-based audiologist-guided cognitive behavioral therapy tinnitus in the United States: A randomized controlled trial. *Journal of Medical Internet Research*, 2021, In Press. https://preprints.jmir.org/preprint/27584

[9] Beukes, E. W., Andersson, G., Fagelson, M. A., et al. Dismantling internet-based cognitive behavioral therapy for tinnitus. The contribution of applied relaxation: A

randomized controlled trial. *Internet Interventions*, 2021;*25*, 100402. https://doi.org/10.1016/j.invent.2021.100402

[10] Meikle, M. B., Henry, J. A., Griest, S. E., et al. The tinnitus functional index: development of a new clinical measure for chronic, intrusive tinnitus. *Ear and Hearing*, 2012;*33*(2), 153–176. https://doi.org/10.1097/AUD.0b013e31822f67c0

[11] Durisala N, Manchaiah V, Granberg S, et al. Determination and classification of the problems experienced by adults with single-sided deafness using ICF classification: an exploratory study using 26 participants. Clin Otolaryngol 2017;42(3), 748–752.

[12] Stephens D, Gianopoulos I, Kerr P. Determination and classification of the problems experienced by hearing-impaired elderly people. Audiology, 2001;40(6):294–300.

[13] Granberg, S., Pronk, M., Swanepoel, D. W., et al. The ICF core sets for hearing loss project: Functioning and disability from the patient perspective. *International Journal of Audiology*, 2014;*53*(11), 777–786. https://doi.org/10.3109/14992027.2014.938370

[14] Granberg, S., Möller, K., Skagerstrand, A., et al. The ICF Core Sets for hearing loss: researcher perspective, Part II: Linking outcome measures to the International Classification of Functioning, Disability and Health (ICF). *International journal of audiology*, 2014;*53*(2), 77–87. https://doi.org/10.3109/14992027.2013.858279

[15] Cieza A, Geyh S, Chatterji S, et al. ICF linking rules: an update based on lessons learned. J Rehabil Med 2005;37(4):212–218.

[16] Stephens D. Audiological rehabilitation. In: Luxon L, Furman JM, Martini A, eds. Textbook of Audiological Medicine. London, UK: Martin Dunitz, 2002;513–531.

[17] Stephens D, & Danermark B. The international classification of functioning, disability and health as a conceptual framework for the impact of genetic hearing impairment. In: Stephens D, Jones L, eds. The Impact of Genetic Hearing Impairment. London, UK:Whur, 54–67, 2005.

[18] Hall, D. A., Fackrell, K., Li, A. B., Thavayogan, R., et al. A narrative synthesis of research evidence for tinnitus-related complaints as reported by patients and their significant others. *Health and quality of life outcomes*, 2018;*16*(1), 61. https://doi.org/10.1186/s12955-018-0888-9

[19] Beukes EW, Manchaiah V, Andersson G., et al. Situationally influenced tinnitus coping strategies: a mixed methods approach. Disabil Rehabil. 2018;40(24):2884-2894.

[20] Rodrigo HS, Beukes EW, Andersson, G., et al. Exploratory data mining techniques (decision tree models) for examining the impact of internet-based cognitive behavioral therapy for tinnitus: Machine learning approach. *Journal of Medical Internet Research*. 2021;23(11):e28999. https://doi.org/10.2196/28999

Supplementary Table 1: Impairments of body functions

Impairment of body functions	US Population			UK Population (Manchaiah et al., 2018)		
	PQ	LEQ	Total	PQ	LEQ	Total
b1252: Activity level	0	1	1	0	0	0
b1260: Extraversion	0	0	0	1	0	1
b126: Temperament and personality functions	1	56	57	6	5	11
b1263: Psychic stability	14	1	15	8	7	15
b1265: Optimism	1	3	4	2	1	3
b1266: Confidence	2	0	2	5	3	8
b1300: Energy level	11	2	13	23	20	43
b1301: Motivation	3	0	3	1	2	3
b1302: Appetite	1	0	1	3	1	4
b134: Sleep functions	66	44	110	71	94	165
b1340: Amount of sleep	0	8	8	0	1	1
b1341: Onset of sleep	39	8	47	5	13	18
b1342: Maintenance of sleep	14	2	16	1	1	2
b1343: Quality of sleep	2	5	7	0	0	0
b1348: Sleep functions, other specified	0	9	9	0	0	0
b140: Attention functions	95	43	138	12	22	34
b1400: Sustaining attention	3	20	23	38	45	83
b144: Memory functions	0	1	1	0	1	1
b1448: Memory functions, other specified	0	1	1	0	0	0
b152: Emotional functions	54	145	199	108	94	202
b160: Thought functions	0	0	0	15	8	23
b164: Higher-level cognitive functions	2	0	2	0	0	0
b1640: Abstraction	1	0	1	0	0	0

b210: Seeing functions	0	1	1	0	0	0
b230: Hearing functions	30	19	49	36	37	73
b2300: Sound detection	14	1	15	0	0	0
b2301: Sound discrimination	6	5	11	1	3	4
b2302: Localisation of sound source	0	0	0	0	3	3
b2304: Speech discrimination	0	0	0	0	1	1
b2308: Hearing functions, other specified	12	0	12	0	0	0
b2351: Vestibular function of balance	3	0	3	1	1	2
b240: Sensations associated with hearing and vestibular function	0	0	0	2	0	2
b2400: Ringing in ears or tinnitus	10	45	55	0	0	0
b2401: Dizziness	0	3	3	1	1	2
b2403: Nausea associated with dizziness or vertigo	0	0	0	1	1	2
b2405: Aural pressure	0	0	0	0	1	1
b280: Sensation of pain	2	2	4	2	1	3
b28010: Pain in head and neck	8	15	23	1	9	10
b310: Voice functions	0	1	1	0	0	0
b330: Fluency and rhythm of speech functions	0	1	1	0	0	0
b398: Voice and speech functions, other specified	1	2	3	0	0	0
b4500: Production of airway mucus	0	1	1	0	0	0
b4552: Fatiguability	0	18	18	0	0	0
b5102: Chewing	0	1	1	0	0	0
b530: Weight maintenance functions	0	1	1	0	0	0
b640: Sexual functions	1	1	2	1	1	2
b730: Muscle power functions	1	0	1	1	1	2
b740: Muscle endurance functions	0	0	0	1	0	1
b6702: Discomfort associated with menopause	0	1	1	0	0	0
Total	397	467	864	347	378	725

Supplementary Table 2: Activity limitations and participation restrictions

Activity limitations and participation restrictions	US Population			UK Population (Manchaiah et al., 2018)		
	PQ	LEQ	Total	PQ	LEQ	Total
d110: Watching	0	0	0	1	1	2
d115: Listening	71	28	99	19	17	36
d130: Copying	0	1	1	0	1	1
d155: Acquiring skills	0	0	0	1	0	1
d159: Basic learning, other specified and unspecified	0	1	1	0	0	0
d160: Focusing attention	27	0	27	1	1	2
d1601: Focusing attention to changes in the environment	2	0	2	0	0	0
d163: Thinking	11	0	11	0	0	0
d166: Reading	44	1	45	8	18	26
d177: Making decisions	0	0	0	1	0	1
d179: Applying knowledge, other specified and unspecified	2	0	2	0	0	0
d210: Undertaking a single task	0	1	1	1	0	1
d2100: Undertaking a simple task	2	0	2	0	0	0
d220: Undertaking multiple tasks	0	0	0	0	3	3
d2200: Carrying out multiple tasks	2	0	2	0	0	0
d230: Carrying out daily routine	0	0	0	2	0	2
d240: Handling stress and other psychological demands	1	0	1	26	22	48
d2401: Handling stress	1	9	10	0	0	0
d2402: Handling crisis	0	1	1	0	0	0
d310: Communicating with - receiving - spoken messages	104	27	131	35	48	83
d3108: Communicating with - receiving - spoken messages, other specified	3	0	3	0	0	0
d315: Communicating with - receiving - nonverbal messages	0	1	1	0	0	0
d330: Speaking	1	0	1	1	0	1
d350: Conversation	67	73	140	14	23	37

d3501: Sustaining a conversation	0	1	1	0	0	0
d3503: Conversing with one person	0	0	0	1	1	2
d3504: Conversing with many people	19	1	20	6	3	9
d355: Discussion	0	1	1	0	0	0
d360: Using communication devices and techniques	9	11	20	1	0	1
d3600: Using telecommunication devices	2	1	3	4	12	16
d3602: Using communication techniques	6	0	6	6	3	9
d410: Changing basic body position	0	1	1	0	0	0
d450: Walking	2	0	2	0	1	1
d4554: Swimming	1	1	2	0	0	0
d460: Moving around in different locations	0	0	0	1	2	3
d470: Using transportation	0	0	0	2	5	7
d4700: Using human-powered vehicles	0	0	0	1	0	1
d4702: Using public motorized transportation	0	0	0	1	0	1
d475: Driving	8	0	8	1	3	4
d550: Eating	2	1	3	0	0	0
d560: Drinking	0	0	0	1	0	1
d570: Looking after one's health	4	0	4	0	0	0
d6200: Shopping	3	0	3	0	4	4
d640: Doing housework	1	0	1	0	0	0
d649: Household tasks, other specified and unspecified	4	0	4	0	0	0
d698: Domestic life, other specified	1	0	1	0	0	0
d710: Basic interpersonal interactions	0	1	1	2	0	2
d720: Complex interpersonal interactions	0	0	0	0	1	1
d7203: Interacting according to social rules	0	0	0	2	0	2
d7208: Complex interpersonal interactions, other specified	1	0	1	0	0	0
d729: General interpersonal interactions, other specified and unspecified	5	0	5	0	0	0
d730: Relating with strangers	1	0	1	0	0	0
d740: Formal relationships	1	0	1	0	0	0

d750: Informal social relationships	2	0	2	2	0	2
d7500: Informal relationships with friends	1	0	1	0	1	1
d760: Family relationships	3	10	13	8	5	13
d7600: Parent-child relationships	1	1	2	0	1	1
d7601: Child-parent relationships	0	0	0	1	2	3
d7603: Extended family relationships	0	0	0	1	0	1
d770: Intimate relationships	3	0	3	1	0	1
d7701: Spousal relationships	0	0	0	3	0	3
d798: Interpersonal interactions and relationships, other specified	3	0	3	0	0	0
d799: Interpersonal interactions and relationships, unspecified	0	0	0	1	1	2
d810: Informal education	0	1	1	0	0	0
d820: School education	2	1	3	0	0	0
d830: Higher education	0	1	1	0	0	0
d839: Education, other specified and unspecified	0	1	1	0	0	0
d845: Acquiring, keeping and terminating a job	0	1	1	0	0	0
d850: Remunerative employment	30	35	65	17	18	35
d910: Community life	0	0	0	4	0	4
d920: Recreation and leisure	81	71	152	25	19	44
d9200: Play	0	2	2	0	0	0
d9201: Sports	2	5	7	3	1	4
d9202: Arts and culture	50	2	52	20	16	36
d9204: Hobbies	2	0	2	1	0	1
d9205: Socializing	32	5	37	27	23	50
d9208: Recreation and leisure, other specified	2	4	6	0	0	0
d930: Religion and spirituality	4	7	11	2	3	5
d9300: Organized religion	5	0	5	0	0	0
d9301: Spirituality	10	0	10	0	0	0
Total	641	309	950	255	259	514

Supplementary Table 3: Environmental factors

Environmental factors	US Population			UK Population (Manchaiah et al., 2018)		
	PQ	LEQ	Total	PQ	LEQ	Total
e1100: Food	1	1	2	1	3	4
e1101: Drugs	2	0	2	1	2	3
e1108: Products or substances for personal consumption, other specified	1	0	1	0	0	0
e115: Products and technology for personal use in daily living	0	0	0	5	4	9
e1150: General products and technology for personal use in daily living	0	1	1	1	2	3
e125: Products and technology for communication	6	6	12	3	7	10
e1250: General products and technology for communication	73	4	77	21	24	45
e1251: Assistive products and technology for communication	4	3	7	4	4	8
e1259: Products and technology for communication, unspecified	1	0	1	0	0	0
e130: Products and technology for education	0	0	0	1	0	1
e1300: General products and technology for education	1	0	1	0	0	0
e1401: Assistive products and technology for culture, recreation and sport	0	0	0	1	0	1
e150: Design, construction and building products and technology of buildings for public use	11	0	11	4	2	6
e210: Physical geography	0	1	1	0	0	0
e2108: Physical geography, other specified	3	0	3	0	0	0
e220: Flora and fauna	0	1	1	0	0	0
e2208: Fauna and flora, other specified	1	0	1	0	0	0
e225: Climate	0	0	0	0	1	1
e245: Time-related changes	0	0	0	2	0	2
e250: Sound	1	3	4	5	12	17
e2500: Sound intensity	64	58	122	30	26	56
e2501: Sound quality	44	1	45	21	24	45
e2508: Sound, other specified	0	1	1	0		0

e310: Immediate family	6	9	15	2	1	3
e320: Friends	0	2	2	1	0	1
e355: Domesticated animals	0	1	1	0	0	0
e398: Support and relationships, other specified	0	1	1	0	0	0
e410: Individual attitudes of immediate family members	0	0	0	3	4	7
e420: Individual attitudes of friends	0	0	0	0	1	1
e460: Societal attitudes	0	0	0	1	0	1
e498: Attitudes, other specified	1	0	1	2	1	3
e499: Attitudes, unspecified	0	0	0	4	2	6
e5600: Media services	0	0	0	1	2	3
e5700: Social security services	0	1	1	0	0	0
Total	220	94	314	114	122	236

Supplementary Table 4: Personal factors

Personal factors	**US Population**			**UK Population (Manchaiah et al., 2018)**		
	PQ	**LEQ**	**Total**	**PQ**	**LEQ**	**Total**
Lifestyle	18	3	21	2	1	3
Habits	1	0	1	1	0	1
Coping style	31	4	35	27	17	44
Profession	0	0	0	1	2	3
Past and present experience	32	2	34	2	0	2
Overall behavior pattern and characteristics	8	2	10	3	2	5
Total	90	11	101	36	22	58

Supplementary Table 5: Not categorized

	US Population			UK Population (Manchaiah et al., 2018)		
	PQ	**LEQ**	**Total**	**PQ**	**LEQ**	**Total**
Not covered by ICF (*nc*)	21	4	25	15	7	22
Health condition (*hc*)	7	0	7	6	9	15
Total	28	4	32	21	16	37