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Functional Index

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## Abstract

**Purpose:** Tinnitus frequently causes disability as it affects daily living, which is objectified using several tinnitus questionnaires. To what extent they cover domains of the International Classification of Functioning, Disability and Health (ICF) is currently unknown. Therefore, this study aims to investigate which ICF domains are measured by two questionnaires and to describe the health status of somatic tinnitus patients in ICF terms.

**Materials and methods:** All questions of the Tinnitus Questionnaire (TQ) and Tinnitus Functional Index (TFI) were linked to the ICF using linking rules. A count-based method was used to link all individual answers of 80 tinnitus patients, to the ICF categories.

**Results:** Most of the linked questions concerned 'body functions'. TFI covered more categories of 'activity and participation' than TQ.

Patients reported severe impairments in 'mental functions', 'sensory functions and pain' and 'sleep functions'. Additionally, severe limitations were scored in 'focusing attention'.

**Conclusions:** The TFI and TQ measure distinct domains but can be used complementary or solely, depending on the research question. The TFI identifies a broad spectrum of problems, where the TQ focusses on the psychological impact of tinnitus. Somatic patients in our study reported impairments and disabilities in all covered domains, especially in 'onset of sleep' and 'sound detection'.

**Keywords:** ICF classification, disability, tinnitus, health status, participation

## Introduction

Tinnitus, defined as a perception of sound in the absence of an external acoustic stimulus, is a common symptom with a prevalence ranging from 5.1% to 42.7% of the adult population [1, 2]. Tinnitus can be quite debilitating and often causes disability due to its large influence on daily living [1]. According to a review of Hall et al. [3] the most common problems are aspects of quality of life such as psychological or emotional effects, impact on lifestyle, sleep disturbance, auditory and health effects. As such, tinnitus can also interfere in social relationships.

In general, tinnitus can be divided into objective and subjective tinnitus [4]. When the tinnitus sound originates from an internal source within the patient's body, the tinnitus is called "objective". This form of tinnitus is rare (less than 5%) and can be caused by middle ear tumors, turbulent blood flow or myoclonus of middle-ear palatal muscles [1]. In case of subjective tinnitus, no source can be found for the perceived sound, neither externally nor internally. The pathophysiological mechanism of subjective tinnitus is often multifactorial. The main risk factor for developing tinnitus is hearing loss, but other factors, diseases and malfunctions leading to tinnitus may be otologic (i.e. hearing loss, noise trauma, Meniere's disease, acoustic neurinoma, and ototoxic medications or substances), neurologic (i.e. multiple sclerosis and head injury), metabolic (i.e. thyroid disorder, hyperlipidemia, and vitamin B12 deficiency), psychogenic (i.e. depression and anxiety), or somatogenic [1, 4, 5]. In case a patient's tinnitus is influenced by altered somatosensory afference from the cervical spine or temporomandibular area it is called somatic or somatosensory tinnitus [6]. In this type of tinnitus, dysfunctions in the cervical spine or temporomandibular area, such as restricted mobility or muscle tension, can change the tinnitus loudness and/or pitch or can even cause the tinnitus in some cases [6, 7].

Due to the different etiologies and influencing factors, tinnitus complaints can differ enormously between individuals [3]. For this reason, there are various questionnaires developed to assess the impact of tinnitus on daily living, each covering possible complaints that can influence a patient's quality of life. However, it is still unclear which outcome domains are critical and important to measure for therapy outcome [3]. Therefore, a group of tinnitus experts developed "Core Outcome Domain Sets" representing a consensus which tinnitus-related outcome domains should constitute the common standard in specific tinnitus treatments as sound-based interventions, psychology-based interventions and pharmacology-based interventions [8]. However, it is still unknown which outcome domains should be covered by patients with somatic tinnitus.

In 2001, the World Health Organization (WHO) developed the International Classification of Functioning, Disability and Health (ICF) to compare and describe the health of populations in an international context. It also helps to understand a person's health and perceived disability [9]. The ICF is an international framework providing a standard language and hierarchical concept for documenting information on functioning and disability in relation to a health condition. The ICF model (figure 1) is divided into two main parts: (1) 'functioning and disability' described as impairments of body functions and structure, activity limitations and participation restrictions and (2) 'contextual factors' described as personal and environmental barriers. These two parts are further divided into four components: (b) body functions and (s) body structures (b and s are together one component), (d) activities and participation and (e) environmental factors. The fourth component, personal factors, is not classified in ICF because of the large social and cultural variance associated with them [10].

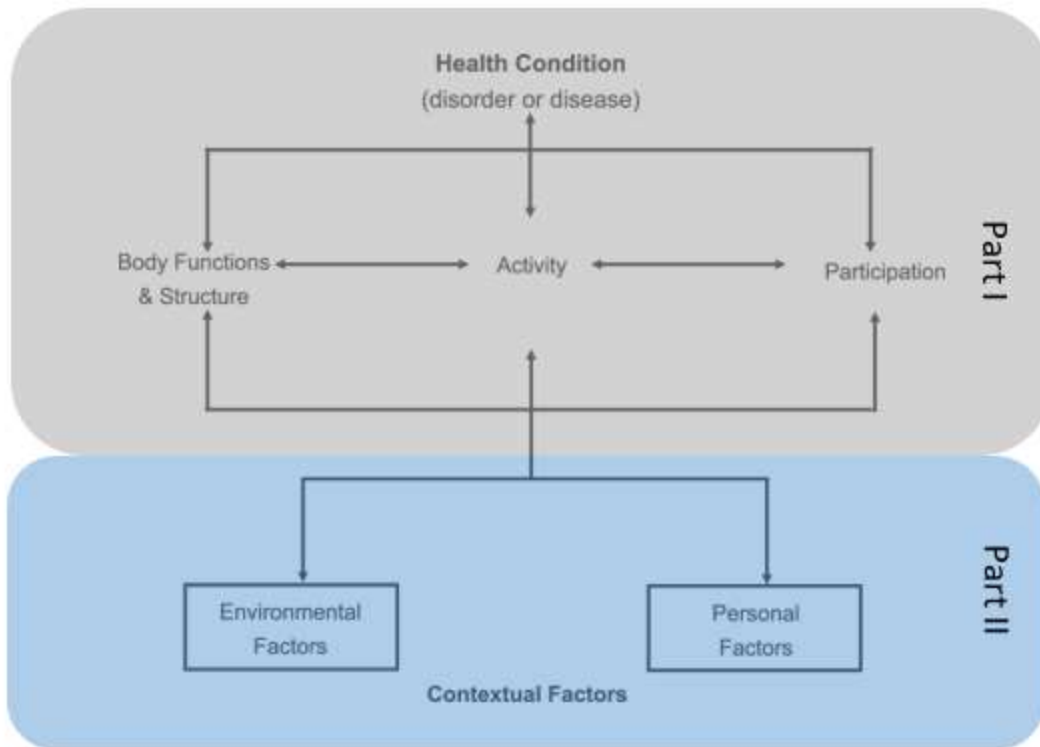


Figure 1: Illustration of the International Classification of Functioning, disability and Health model, created by the World Health Organization.

Health outcome measures can be connected to the ICF classification in a standardized way by using a method called “linking rules” [11-13]. Since 2002, this method has been applied in several health conditions such as sleep disorders, neurological disorders and musculoskeletal disorders, to identify the patient’s dysfunctions from existing outcome measures and to classify these dysfunctions in the four different domains of the ICF.

There are many different assessment tools for measuring the impact tinnitus has on a patient’s daily living. Two frequently used questionnaires to evaluate the severity of a patient’s tinnitus or the annoyance the tinnitus causes, are the Tinnitus Questionnaire (TQ) and the Tinnitus Functional Index (TFI) [3, 14-16]. Although both TQ and TFI are used to investigate the impact tinnitus has on patients’ daily living, it is currently unclear which domains they cover of the patients’ disability. In addition, it is also not clear which domain has the greatest impact on a patient’s life.

Therefore, the aim of our study is twofold. First, to investigate which domains of disability of the ICF are measured by the TQ and TFI. Second, to describe the health status and perceived disability of patients with tinnitus in terms of the ICF.

## Method

The current study is a cross-sectional study conducted at the Antwerp University Hospital.

Questionnaires were filled out as part of baseline data in a randomized controlled trial (RCT) [17]. In the

RCT we investigated the effect of orofacial treatment in patients with somatic tinnitus on their subjective tinnitus complaints [17]. In our study a patient's tinnitus was called somatic, when the somatosensory system was one of the major influencing factors.

### *Patients*

Adult patients were recruited from the tertiary tinnitus clinic at the University Hospital Antwerp, Belgium. Before entering the study, patients were thoroughly tested by otolaryngologists, audiologists, dentists and physical therapists to objectify all the possible influencing factors, diseases and malfunctions for the tinnitus. Patients were included in the study when suffering from moderate to severe (defined as a TFI score between 25 and 90) subjective tinnitus which had been stable for three months. Furthermore, the somatosensory influence from the cervical spine and temporomandibular area should be one of the major influencing factors [6]. Apart from tinnitus, patients had TMD pain (i.e. arthralgia or myalgia) according to the diagnostic criteria for TMD [18] and/or oral parafunctions. More information about the in- and exclusion criteria can be found in our study protocol and RCT [17, 19].

### *Study design*

The individual answers of 80 patients on two disease-specific questionnaires, the TQ and TFI, were collected [17]. Then, the questions of the TQ and TFI were linked to the ICF model. To use a systematic and standardized approach when linking these health-status measures, the linking rules described by Cieza et al. were used as a guideline [11-13]. Finally, the individual answers on the questions of TQ and TFI were linked to the ICF model to define the severity of the perceived disability of the patients.

### *Questionnaires*

Multiple tinnitus questionnaires are available to describe the perceived disability of a patient's tinnitus. We included the TQ and TFI, since both questionnaires are frequently recommended and used in trials to objectify the influence tinnitus has on a patients' daily life (appendices 1 and 2). The TFI is currently the most recommended. The TQ is a little older, but was selected for our population as it contains a specific somatic subscale [14, 15, 20]. The TQ specifically aims to measure annoyance caused by the tinnitus and consists of 52 questions that are answered on a 3-point scale (ranging from "true" scoring 0, "partly true" scoring 1 to "not true" scoring 2). The total score of the TQ ranges from 0 to 84, with higher scores indicating higher levels of annoyance. The test-retest reliability of the TQ is excellent and the internal consistency, convergent and discriminant validity is high [21, 22]. In addition, the TQ has a somatic subscale with three questions on somatic complaints. It has been hypothesized that patients with somatic tinnitus might have higher scores on this subscale. The TFI is designed to cover a broad spectrum of tinnitus-related complaints [14]. It aims to measure the severity and negative impact of tinnitus and consists of 25 questions that are answered on an 11-point Likert scale going from "no disturbance" to "maximal disturbance". A TFI score of 25 or less indicates relatively mild tinnitus with little or no need for intervention, whereas a score ranging from 25-50 indicates a moderate tinnitus and possible need for intervention [14]. A TFI score above 50 indicates severe tinnitus with a clear need for professional attention [14]. The TFI has good convergent and discriminant validity and also a good reliability [23].

### *Linking procedure*

According to the linking rules created by Cieza et al. [11-13], two researchers (A.v.d.W, J.d.P) independently linked each question of the questionnaires to the ICF model, using the English digital

version of the ICF browser [24]. Before starting the actual linking process, both authors acquired appropriate knowledge of the domains, chapters and categories of the ICF classification.

The following steps were made during the linking process: First, each question of the questionnaires was classified to one of the four corresponding ICF domains: impairment in body functions/structures, limitation in level of activity, restriction of participation and personal and environmental factors (step 1). Then, the corresponding chapter within the domain was chosen (step 2). After that, the adequate category was indicated (step 3). For example: for the question of the TQ “I wake up more in the night because of my noise”, ‘maintenance of sleep’ is identified as linkable concept (B1342). The steps in the ICF browser for this question are described below and shown in figure 2.

Step 1: domain B (body functions)

Step 2: chapter B1 (mental functions)

Step 3: category B1342 (maintenance of sleep)

If a question encompassed more than one linkable construct, each construct was linked. During a consensus meeting, inconsistencies were discussed and discrepancies eliminated.

If a question could not be linked to the ICF, this was noted. After linking each question to the specific ICF category, the number of questions linked to a predefined ICF category of each questionnaire were counted and represented by a percentage of the contribution to the total score. For example, looking at the abovementioned category ‘maintenance of sleep’, two questions of the TQ were linked to this category. So, two of the fifty-two questions means that ‘maintenance of sleep’ covered 4% of the total score of the TQ.



Figure 2: Screenshot of the ICF browser. 1: domain B (body functions) 2: chapter B1 (mental functions) 3: category B1342 (maintenance of sleep).

### *Determination the severity of impairment*

To determine the severity of perceived disability and health status of our patient sample, for each patient, each question was scored as: no impairment (score of 0 points on TQ and 0-2 points on TFI), mild impairment (score of 1 point on TQ and 3-5 points on TFI) or severe impairment (score of 2 points on TQ and > 5 points on TFI). This allowed us to compare both questionnaires each using a specific scoring system.

Afterwards, a count-based method was used to calculate the severity of the impairment for each question. Then, per ICF category, the percentage of patients reporting 'no impairment', 'mild impairment' and 'severe impairment' was calculated.

## Results

### *Study population*

Data from 80 patients was used in the analysis. All patients suffered from a moderate to severe somatic tinnitus. The average baseline TFI score was 52 points (SD 16) and the average baseline TQ score was 36 points (SD 16). From this group of 80 patients, 36.8% had hearing loss and 82.5% were diagnosed with myalgia according to the Diagnostic Criteria of Temporomandibular Disorders [18]. More information about the general patient characteristics are shown in table 1.

Characteristic	
Gender male/female (n)	42/38
Mean age in years (SD)	45 ( $\pm 14$ )
Mean duration of the tinnitus in months	64 ( $\pm 86$ )
Mean TQ-score (SD)	36 ( $\pm 16$ )
Mean TFI-score (SD)	52 ( $\pm 16$ )
% patients with hearing loss	36.8%
% diagnosed with TMD myalgia	82.5%
% diagnosed with both myalgia and arthralgia	25.0%
% only oral parafunctions	17.5%

Table 1: Description of the study population

### *Linked categories*

Each question of the TFI and TQ could be linked to a predefined category of the ICF model as shown in table 2 to 4. The overlap in the domains and chapters between the two questionnaires is shown in figure 3. A total of 77 questions were linked to 36 different categories. The domain 'body functions' could be linked to 20 categories; 13 questions were linked to 'activity and participation' and 3 questions were linked to 'environmental factors'. No items were linked to the domain 'body structures'.



### ICF domains covered by the TFI

In the TFI, questions covering the domain 'body functions' could be linked to a total of 14 categories: 10 categories of the chapter 'mental functions' and 4 categories of the chapter 'sensory functions and pain' (table 2). The TFI measures 9 categories of the domain 'activity and participation'. Two specific ICF categories are most represented: 'regulation of emotion' (4 questions) and 'recreation and leisure unspecified' (3 questions). The chapters 'domestic life', 'interpersonal interactions and relationships' and 'major life areas' are only measured by the TFI.

### ICF domains covered by the TQ

In the TQ, questions concerning the domain 'body functions' covered the chapters 'mental functions' (with 13 categories), 'sensory functions and pain' (with 4 categories) and 'neuromusculoskeletal and movement-related functions' (with 1 category) (table 2). The category 'content of thought' is most represented (17 questions). The domain 'activity and participation' is measured in 3 chapters with 5 categories. In this domain, the category 'communication' is only covered by the TQ. The 'environmental factors' are also only covered by the TQ with one question that is linked to 3 categories of the ICF.

### Prevalence and severity of impairments

The prevalence of impairments identified by the TFI and TQ are presented in table 2 respectively. Patients show severe impairments in 'mental functions' (between 28.1% and 62.5% on TFI and between 11.5% and 53.8% on TQ) and 'sensory functions and pain' (between 27.5% and 68.8% on TFI and between 14.1% and 67.5% on TQ). Looking closer to the TFI data, between 45.0% and 62.5% of the patients have severe impairments in 'sleep functions' (B134). This percentage is lower on the TQ, where between 20.5% and 53.8% of the patients has severe impairments in 'sleep functions'. Additionally, the percentage of patients with a severe impairment on 'content of thought' (B1602) is also higher on the TFI in comparison with the TQ (43.8% on TFI and 25.3% on TQ).

#### Legend

- B1: mental functions
- B2: sensory functions and pain
- B3: voice and speech functions
- B4: functions of the cardiovascular, haematological, immunological and respiratory systems
- B5: functions of the digestive, metabolic and endocrine systems
- B6: genitourinary and reproductive functions
- B7: neuromusculoskeletal and movement-related functions
- B8: functions of the skin and related structures

- D1: learning and applying knowledge
- D2: general tasks and demands
- D3: communication
- D4: mobility
- D5: self-care
- D6: domestic life
- D7: interpersonal interactions and relationships
- D8: major life areas
- D9: community, social and civic life

- E1: products and technology
- E2: natural environment and human-made changes to environment
- E3: support and relationships
- E4: attitudes
- E5: services, systems and policies

- S1: structures of the nervous system
- S2: the eye, ear and related structures
- S3: structures involved in voice and speech
- S4: structures of the cardiovascular, immunological and endocrine systems
- S5: structures related to the digestive, metabolic and endocrine systems
- S6: structures related to the genitourinary and reproductive systems
- S7: structures related to movement
- S8: skin and related structures

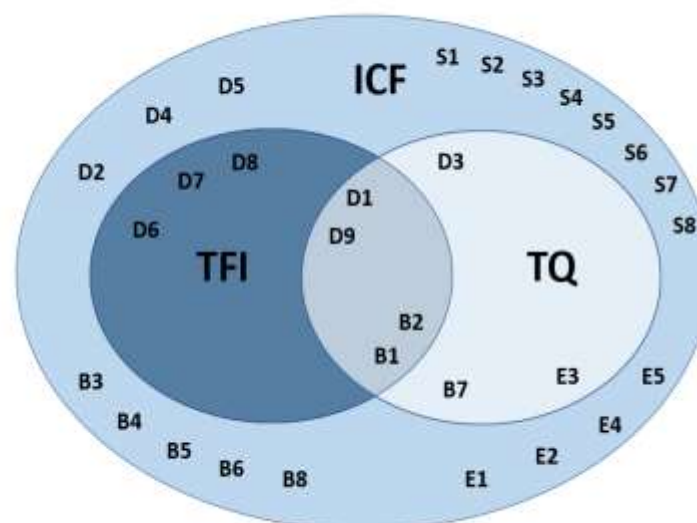


Figure 3: The overlap in the domains and chapters between the TFI and TQ. TFI: Tinnitus Functional Index. TQ: Tinnitus Questionnaire.

Chapter	TFI						TQ					
	ICF category	Number of questions	Contribution to total score	No impairment	Mild impairment	Severe impairment	ICF category	Number of questions	Contribution to total score	No impairment	Mild impairment	Severe impairment
<b>B1: Mental functions</b>							B1266: confidence	1	2%	64.1%	24.4%	11.5%
							B134: sleep functions	1	2%	39.7%	24.4%	35.9%
	B1340: amount of sleep	1	4%	15.0%	32.5%	52.5%						
	B1341: onset of sleep	1	4%	15.0%	22.5%	62.5%	B1341: onset of sleep	1	2%	32.1%	26.9%	41.0%
	B1342 Maintenance of sleep	1	4%	15.0%	22.5%	62.5%	B1342 Maintenance of sleep	2	4%	53.2%	26.3%	20.5%
	B1343: Quality of sleep	1	4%	15.0%	40.0%	45.0%	B1343: Quality of sleep	1	2%	28.2%	17.9%	53.8%
	B1400: sustaining attention	1	4%	18.8%	38.8%	42.5%	B1400: sustaining attention	2	4%	24.4%	51.3%	24.4%
	B1401: shifting attention	1	4%	18.8%	47.5%	33.8%	B1401: shifting attention	1	2%	15.4%	42.3%	42.3%
	B:1521: regulation of emotion	4	16%	18.8%	34.1%	47.2%	B:1521: regulation of emotion	3	6%	55.6%	23.9%	20.5%
	B1522: range of emotion	1	4%	30.0%	41.3%	28.1%	B1522: range of emotion	2	4%	33.3%	29.5%	37.2%
							B1560: auditory perception	2	4%	37.2%	33.3%	29.5%
							B1601: form of thought	1	2%	25.6%	44.9%	29.5%
	B1602: content of thought	1	4%	12.5%	43.8%	43.8%	B1602: content of thought	17	33%	42.2%	32.4%	25.3%
	B1643: cognitive flexibility	1	4%	5.0%	35.0%	60.0%	B1643: cognitive flexibility	2	4%	41.0%	46.8%	12.2%
<b>B2: sensory function and pain</b>	B2300: sound detection	1	4%	2.5%	28.8%	68.8%						
	B2301: sound discrimination	1	4%	46.3%	26.3%	27.5%	B2301: sound discrimination	1	2%	44.9%	15.4%	39.7%
	B2304: speech discrimination	2	8%	42.5%	26.3%	31.3%	B2304: speech discrimination	1	4%	61.5%	24.4%	14.1%
	B2400: ringing in ears or tinnitus	1	4%	1.3%	31.3%	67.5%	B2400: ringing in ears or tinnitus	3	6%	28.2%	38.0%	33.8%

							B28010: pain in the head and neck	2	4%	64.7%	16.0%	19.2%
B7: neuromusculoskeletal and movement related functions							B7350: tone of isolated muscles and muscle groups	1	2%	23.1%	38.5%	38.5%

Table 2: The prevalence and severity of impairments identified by the Tinnitus Functional Index and Tinnitus Questionnaire

#### *Prevalence and severity of activity limitations and participation restrictions*

The severity of activity limitations or participation restrictions based on the TFI and TQ are shown in table 3. Looking at the TFI, severe activity limitations or participation restrictions were present in 62.5% of the patients in 'focusing attention' (D160). This is in contrast with the scores of the TQ were only 9.0% of the patients stated to have severe activity limitations or participation restrictions in 'focusing attention' (D160). Additionally, on TFI 73.3% of the patients had severe activity limitations or participation restrictions in 'recreation and leisure' (D920) while on TQ only 3.9% and 35.9% indicated to have severe restrictions.

Chapter		TFI					TQ					
	ICF category	Number of questions	Contribution to total score	No activity limitation or participation restriction	Mild activity limitation or participation restriction	Severe activity limitation or participation restriction	ICF category	Number of questions	Contribution to total score	No activity limitation or participation restriction	Mild activity limitation or participation restriction	Severe activity limitation or participation restriction
<b>D1: Learning and applying knowledge</b>							D160: focusing attention	1	2%	65.4%	25.6%	9.0%
	D1601: focusing attention on the environment	1	4%	1.3%	36.3%	62.5%	D1601: focusing attention on the environment	1	2%	42.3%	42.3%	15.4%
	D163: thinking	1	4%	26.3%	42.5%	31.3%						
<b>D3: communication</b>							D3600: using telecommunication devices	1	2%	64.1%	25.6%	10.3%
<b>D6: domestic life</b>	D649: household tasks	1	4%	41.3%	33.8%	25.0%						
	D660: assisting others	1	4%	41.3%	33.8%	25.0%						
<b>D7: interpersonal interactions and relationships</b>	D7100: respect and warmth in relationships	1	4%	36.3%	35.0%	28.8%						
	D729: general interpersonal interactions	1	4%	48.8%	30.0%	21.3%						
<b>D8: major life areas</b>	D839: education unspecified	1	4%	41.3%	33.8%	25.0%						
	D850: remunerative employment	1	4%	41.3%	33.8%	25.0%						
<b>D9: community, social and civic life</b>							D9202: arts and culture	2	4%	59.0%	37.2%	3.8%
							D9208: recreation and leisure, other specified	1	2%	12.8%	51.3%	35.9%

	D9209: recreation and leisure, unspecified	3	12%	5.5%	21.3%	73.3%						
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Table 3: The prevalence and severity of activity limitations and participation restrictions identified by the Tinnitus Functional Index and Tinnitus Questionnaire

### *Influence of environmental factors*

Only the TQ registered the influence of environmental factors (table 4). Three categories of the ICF were asked in one question (i.e. “I wish someone understood what this problem is like”). Around 40% of the patients indicated severe influence of environmental factors on ‘immediate family’ (E310), ‘friends’ (E320) and ‘acquaintances, peers, colleagues, neighbors and community members’.

Chapter	ICF category	Number of questions	Contribution to total score	No influence of environmental factors	Mild influence of environmental factors	Severe influence of environmental factors
<b>E3: support and relationships</b>	E310: immediate family	1	2%	26.9%	33.3%	39.7%
	E320: friends	1	2%	26.9%	33.3%	39.7%
	E325: acquaintances, peers, colleagues, neighbors and community members	1	2%	26.9%	33.3%	39.7%

Table 4: The prevalence of influence of environmental factors identified by the Tinnitus Questionnaire.

## Discussion

The first aim of the study was to investigate which domains of the ICF are measured by the TFI and TQ. In general, the two questionnaires cover most of the domains and chapters. The chapter ‘mental functions’ was questioned most, 52% (or 13 questions) on TFI and 71% (or 36 questions) on TQ. Additionally, the categories within the domain ‘body functions’ were linked most (20 of the total 36 categories). ‘Body functions’ are described in the ICF as ‘physiological functions of body systems’ and represent chapters as ‘mental functions’ and ‘sensory functions and pain’ which are, in most cases, affected in patients with tinnitus. Since tinnitus is a conscious perception of an auditory sensation, it is understandable that most limitations are found in ‘body functions’. No questions were linked to the ICF domain ‘body structures’ that encompasses ‘anatomical parts of the body such as organs, limbs and their components’. This seems logical, since tinnitus and TMD are rarely linked to disturbances in the patient’s anatomy [1, 18].

The two questionnaires show overlap in the domains and chapters covered. However, the linked categories differ between the TFI and TQ. First, the category ‘content of thought’ (B1602) is linked to far more questions in the TQ than in the TFI (33% compared to 4%). This means that the focus of the TQ is

more on the measurement of mental and psychological coping compared to the TFI. The fact that the TQ is more suitable to measure the psychological impact of tinnitus, is reasonable because the TQ was originally designed to be used in studies on psychologically based treatments [16, 25]. This difference between the two questionnaires was also pointed out by Jacquemin et al. [25]. Second, looking at the domain 'activity and participation', the TFI measures 9 categories of this domain compared to 5 categories measured by TQ. Additionally, both questionnaires cover different chapters and categories of the domain 'activity and participation' which means that they measure different components of the same domain. Where the TQ is better suited to measure the psychological impact of the tinnitus, the TFI covers a broader spectrum of ICF categories which makes this questionnaire more suitable to measure a more general impact of tinnitus [14]. These results are consistent with the findings of other studies [25-27].

Overall, the TQ and TFI cover different categories of the ICF. The TFI can be used identifying a broad spectrum of problems in the domains 'body functions' and 'activity and participation'. The TQ, on the other hand, is more applicable for measuring the psychological impact of tinnitus, particularly in the category 'content of thought'.

The second aim of the study was to describe the health status and perceived disability of patients with somatic tinnitus in terms of the ICF. Both TFI and TQ can be linked to the ICF to describe patients' health status and perceived disability. A broad set of impairments in the domains of body functioning, activities and participation is present. Most severe impairments were found in 'mental functions' and 'sensory functions and pain'. Specifically, in the categories 'onset of sleep' (severe impairments in between 41.0% and 62.5% of the patients) and 'sound detection' (severe impairments in 68.8% of the patients). This is in line with a previous research where impairments of speech comprehension, high impact of cognition and sleep quality were found in patients with tinnitus [28-31].

Furthermore, there was a discrepancy between the questionnaires in the severity of activity limitations or participation restrictions within our group of tinnitus patients. Looking at the TFI, between 62.5% and 73.3% of the patients scored severe activity limitations or participation restrictions on 'focusing attention' and 'recreation and leisure'. This is in contrast with the TQ where between 9.0% and 35.9% of the patients stated to have no or mild limitation or restriction in these categories. A reason for these differences in severity of limitations between the two questionnaires might be that the TQ uses a 3-point scale to rate each question, while the TFI uses an 11-point Likert scale. Thus, the TQ has limited options to choose from as a patient [25]. A second reason might be that both questionnaires are based on self-report by the patient, but they do differ from each other in the way the questions are prepared. For example, one of the questions about concentration of the TFI is "over the past week, what was your ability to concentrate?". The TQ, on the other hand, formulates a question about concentration as follows: "the noises have affected my concentration" which might be interpreted differently.

It must be noted that the influence on environmental factors is only measured by one question (i.e. "I wish someone understood what this problem is like") of the TQ, covering the domain 'support and relationships' of the ICF. About 40% of the patients reported to have severe influence on these environmental factors because of the tinnitus. Measuring the influence on environmental factors can be important to gain information about the support at work and at home. Since these factors play a role in maintaining work and a patients' experience of their mental health, it also influences the persistence and severity of a condition [32] [33].



In 2017, as part of the COMIT study (i.e. Core Outcome Measures in Tinnitus study), several scientists, health professionals and patient representatives stated that determining the best core outcome set in patients with chronic subjective tinnitus is difficult and depends on the intervention [8, 34]. So before starting a clinical trial, it should be clear which specific tinnitus-related complaints are critical to evaluate [8]. However, in the COMIT study only sound-based interventions, psychology-based interventions and pharmacology-based interventions were evaluated. So, orofacial treatment, which is often the treatment for patients with somatic tinnitus complaints, was not analyzed in the study. Looking at our data of somatic tinnitus patients, the chapters 'mental functions', 'sensory functions and pain', 'sleep functions', 'learning and applying knowledge' and 'community, social and civic life' are important to measure. In general, it is likely that somatic tinnitus patients have a higher score on the chapter 'sensory functions and pain' in comparison with other tinnitus patients, since somatic tinnitus is often accompanied by pain in the neck and temporomandibular area. So, future studies should investigate which specific 'outcome domains' for patients with ST are necessary. The second step will be to develop an evaluative measurement tool, based on these outcome domains.

Another possible difference is that the patients in our dataset had no or limited hearing loss. As hearing loss might have influence on the answers given on some of the questions (i.e. "how much has your tinnitus interfered with your ability to hear clearly?", "how has your tinnitus interfered with your ability to understand people who are talking" and "I have more difficulty following a conversation because of the noises"), it is unknown if our results can be generalized to all tinnitus patients. Therefore, future studies should explore the perceived disability in patients with other etiologies of the tinnitus, such as massive hearing loss.

In conclusion, the TQ and TFI questionnaires cover different domains and categories of the ICF and can be used complementary or solely depending on the research question. The TFI is the best option to choose for identifying problems in the domains 'body functions' and 'activity and participation' since it covers a broad spectrum of ICF categories. The TQ, on the other hand, provides more information about the psychological impact of a patient's tinnitus on daily life. Somatic tinnitus patients have impairments and disabilities in all domains of the ICF, particularly in the categories 'onset of sleep' and 'sound detection'.

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## Ethical approval

Ethical approval was obtained from the ethics committee of the Antwerp University Hospital (reference number: B300201730825, date: 9 January 2017).

## Conflicts of interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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## Appendix 1: Tinnitus Questionnaire

#	ICF category	Tinnitus Questionnaire
1	D1601	I can sometimes ignore the noises even when are there
2	D9202	I am unable to enjoy listening to music because of the noises
3	B1602	It's unfair that I have to suffer with my noises
4	B1342	I wake up more in the night because of my noises
5	B2400	I am aware of the noises form the moment I get up to the moment I sleep
6	B1602	Your attitude to the noise makes no difference to how it affects you
7	B1560	Most of the time the noises are fairly quiet
8	B1602	I worry that the noises will give me a nervous breakdown
9	B1560	Because of the noises I have difficulty in telling where sounds are coming from
10	B1602	The way the noises sound is really unpleasant
11	B1602	I feel I can never get away from the noises
12	B1342	Because of the noises I wake up earlier in the morning
13	B1601	I worry whether I will be able to put up with this problem forever
14	B2301	Because of the noises it is more difficult to listen to several people at once
15	B2400	The noises are loud most of the time
16	B1602	Because of the noises I worry that there is something seriously wrong with my body
17	B1521	If the noises continue my life will not be worth living
18	B1266	I have lost some of my confidence because of the noises
19	E310 E420 E425	I wish someone understood what this problem is like
20	B1400	The noises distract me whatever I am doing
21	B1643	There is very little one can do to cope with the noises
22	B28010	The noises sometimes give me a pain in the ear or head
23	B1522	When I feel low or pessimistic the noise seems to worse
24	B1521	I am more irritable with my family and friends because of the noises
25	B7350	Because of the noises I have tension in the muscles of my head and neck
26	B2304	Because of the noises other people's voices sound distorted to me
27	B1602	It will be dreadful if these noises never go away
28	B1602	I worry that the noises might damage my physical health
29	B1602	The noises seem to go right through my head
30	B1602	Almost all my problems are caused by these noises
31	B134	Sleep is my main problem
32	B1602	It's the way you think about the noise – NOT the noise itself which makes you upset
33	B2304	I have more difficulty following a conversation because of the noises
34	D9208	I find it harder to relax because of the noises
35	B1401	My noises are often so bad that I cannot ignore them
36	B1341	I takes me longer to get to sleep because of the noises
37	B1521	I sometimes get very angry when I think about having the noises
38	D3600	I find it harder to use the telephone because of the noises
39	B1522	I am more liable to feel low because of the noises
40	D160	I am able to forget about the noises when I am doing something interesting

41	B1602	Because of the noises life seems to be getting on top of me
42	B1602	I have always been sensitive about trouble with my ears
43	B1602	I often think about whether the noises will ever go away
44	B1602	I can imagine coping with the noises
45	B2400	The noises never 'let up'
46	B1602	A stronger person might be better at accepting this problem
47	B1602	I am a victim of my noises
48	B1400	The noises have affected my concentration
49	B1643	The noises are one of those problems in life you have to live with
50	D9202	Because of the noises are one of those problems in life you have to live with
51	B28010	The noises sometimes produce a bad headache
52	B1343	I have always been a light sleeper

## Appendix 2 Tinnitus functional index

#	ICF category	Tinnitus Functional Index
<b>Over the past week:</b>		
1	B2300	What percentage of your time awake were you consciously AWARE OF your tinnitus?
2	B2400	How STRONG or LOUD was your tinnitus?
3	B1602	What percentage of your time awake were you ANNOYED by your tinnitus?
4	B1643	Did you feel IN CONTROL in regard to your tinnitus?
5	B1521	How easy was it for you to COPE with your tinnitus?
6	D1601	How easy was it for you to IGNORE your tinnitus?
7	B1400	Your ability to CONCENTRATE?
8	D163	Your ability to THINK CLEARLY?
9	B1401	Your ability to FOCUS ATTENTION on other things besides your tinnitus?
10	B1341 B1342	How often did your tinnitus make it difficult to FALL ASLEEP or STAY ASLEEP?
11	B1340	How often did your tinnitus cause you difficulty in getting AS MUCH SLEEP as you needed?
12	B1343	How much of the time did your tinnitus keep you from SLEEPING as DEEPLY or as PEACEFULLY as you would have liked?
<b>Over the past week, how much has your tinnitus interfered with:</b>		
13	B2301	Your ability to HEAR CLEARLY?
14	B2304	Your ability to UNDERSTAND PEOPLE who are talking?
15	B2304	Your ability to FOLLOW CONVERSATIONS in a group or at meetings?
16	D9209	Your QUIET RESTING ACTIVITIES?
17	D9209	Your ability to RELAX?
18	D9209	Your ability to enjoy "PEACE AND QUIET"?
19	D7100	Your enjoyment of SOCIAL ACTIVITIES?
20	B1522	Your ENJOYMENT OF LIFE?
21	D729	Your RELATIONSHIPS with friends, family and other people?

22	D850 D649 D839 D660	How often did your tinnitus cause you to have difficulty performing your WORK or OTHER TASKS such as home maintenance, school work or caring for children or others?
<b>Over the past week:</b>		
23	B1521	How ANXIOUS or WORRIED has your tinnitus made you feel?
24	B1521	How BOTHERED or UPSET have you been because of your tinnitus?
25	B1521	How depressed were you because of your tinnitus?