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Research Article

Development and Validation of a Questionnaire Measuring Functioning Abilities of Older Adults Living with Hearing Disability: Implications for Audiologic Rehabilitation

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Abstract

Diagnosis of hearing loss (HL) reveals little about an individual's disability level, particularly in older adults. That is, individuals with the same magnitude of HL on standardized clinical tests may experience very different effects on their day to day quality of life. A variety of factors associated with HL have been found to influence the relationship between HL and auditory capacities needed for daily communication that are incorporated within the ICF –International Classification of Functioning, Disability, and Health (ICF) – Core Sets for Hearing Loss (CSHL). While the ICF CSHL holds great promise, it is unclear how CSHL classifications could be used in daily clinical practice and with the complex concepts of the ICF system (interaction, bidirectional cause-effect). We created and tested the validity of the first hearing questionnaire based on the ICF CSHL in a community-based cohort of 131 independent older adults who complained of social-communication difficulties. This validated questionnaire measures the presence and magnitude of select factors contained in the CSHL that can be used to improve execution of audiological services, treatment, and rehabilitation.

Keywords: age-related hearing loss; hearing disability; International Classification of Functioning, Disability, and Health; ICF Core Sets projects for hearing loss

Introduction

Diagnosis of hearing loss (HL) reveals little about an individual's disability level when evidence is restricted to routine clinical hearing evaluation data, particularly in older adults. That is, individuals with the same magnitude of HL on standardized clinical tests may experience very different levels of disability. A variety of factors associated with HL have been found to influence the relationship between diagnosis of HL and auditory capacities needed for daily communication. For example, tinnitus, whether occurring before or after the HL onset, is one of the most distressing sensations that causes various somatic, psychological, and cognitive disorders. Despite etiology, tinnitus interferes with auditory function (e.g., hearing clearly, understand people, and follow conversations in a group or at meetings) (Meikle, et al., 2012). This makes people attribute their hearing difficulties to the co-morbid condition of tinnitus (Zaugg, et al., 2002; Henry, et al., 2014). Furthermore, dizziness and imbalance are other unpleasant sensations that carry a substantial impact on independence, physical, cognitive, emotion functions, and activities and participation (Smith, et al., 2005; Grill, et al., 2012; Smith & Zheng, 2013). Given that the most social-communication activities require the dynamic integration of hearing, vision, mind, and movements of head or body in complex environments, hearing difficulty induced by dizziness- or balance-based limitations could be possible. However, studies that show this possible relationship are few, if any. Furthermore, several studies demonstrated how and the extent to which the association between HL and social psychological and cognitive disorders (e.g., isolation, depression, lack of social support, mild cognitive decline, incident demntai) or visual impairment (e.g., visual acuity loss) negatively influence speech understanding (Gatehouse, 1990; Gatehouse & Nobel, 2004; Kricos, 2000, 2006; Denmark, 2005; Tye-Murray, et al., 2010; Pronk, et al., 2013, 2014; Cacioppo & Cacioppo, 2014; Pichora-Fuller, 2016; Pichora-Fuller, et al., 2016). Nevertheless, in a physical environment, abnormal response to background noise (e.g., acceptance noise level) was found in some normal listeners, patients with severe HL, and patients who experience difficulty in coping, such as failure to use their emotional and cognitive control (Crowley & Nabelek, 1996). Acceptance of noise level (ANL) is one of the important predictors of hearing aid outcomes such as use but not speech understanding in noise (Harkrider & Smith, 2005). Thus, there was a suggestion that reduced ability to accept noise level is mediated, in part by lack of cortical/cognitive inhibition (non-auditory peripheral factors) (Harkrider & Smith; 2005; Harkrider & Tampas, 2006; Tampas & Harkrider; 2006).

All together, this implies the likelihood of potential synergistic interactions in which the effect of two or more impairments together is greater than the impact of HL alone (Schum & Beck, 2008). Remarkably, a tool that measures the presence and magnitude of these contributing factors in one index and captures the potential synergistic interactions is currently lacking. To develop such a tool, data was collected and operationalized within the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) framework (WHO, ICF, 2001). In the ICF model, *Functioning* denotes the positive aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors). *Disability* denotes the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors).

The ICF is a biopsychosocial model of disabilities proposed to complement the International Statistical Classification of Diseases and Related Health Problems (WHO's International Classification of Disease, ICD: 1992-1994). In hearing healthcare (HHC) services, the ICD approach is crucial to classify ear diseases/disorders and to determine appropriate medical or surgical treatment including hearing aids and implantable technologies (e.g., cochlear implant). However, the ICD approach is not the perfect approach to capture what matters to people living with HL, whether measured or perceived. That is, under optimal conditions, only 20-25% of adults who could benefit from hearing aids actually utilize them, and many hearing aids and non-hearing aids users experience residual communication difficulty in their surrounded social and physical environment (National Academies of Science, Engineering, and Medicine report on hearing healthcare, 2016). In a large-scale study that reported the magnitude of HL, the greater self-reported hearing disability, and the unpleasant sensations were significant predictors of entering a hearing evaluation period (Knudsen, et al., 2010). However, these predictors are somewhat problematic. First, while studies have shown that the magnitude of HL was associated with self-reported hearing disability, their disability level was influenced by impact of social isolation, depression, cognitive decline, dementia, neurotic personality trait, and age (Cox, et al., 2007; Lin, et al., 2011; Banh, et al., 2012, Berg & Johansson, 2014; Mick, et al., 2014). Second, such negative characteristics including the unpleasant sensations have a similar trajectory impact on an individual's mental and cognitive health. Therefore, we argue, there is no reason to think that the psychosocial and cognitive difficulties may differ between the three symptoms of HL, tinnitus, and dizziness. However, stratifying these synergistic effects in one index may make measuring treatment outcomes of HL easier to achieve. Additionally, this approach may allow the establishment of the relative value of treatment alternatives.

The ICF, therefore, provides a multidimensional framework for describing and organizing information on functioning and disability. Within the ICF system, there are more than 1,400 generic categories that can be used to describe a wide range of information about health and health-related area. The ICF categories are hierarchically organized. The letters refer to the components (b: body functions, s: body structures, d: activities and participation; and e: environmental factors), followed by one digit indicating the chapter (first level), followed by the code for the second-level categories (two digits), and the third or fourth (one digit each). Unlike the environmental categories, the personal categories were not completely classified by the ICF system for three important reasons; 1) the personal factors have significant cultural variation, 2) the concept of personal factors continues to evolve, and 3) some of the personal factors are already incorporated by body function and environmental domain. Therefore, using the ICF classification system, hearing disability extends beyond a medical diagnosis of HL or ear disease by its incorporation of the impact of the disorder on an individual activity. An illustration of the ICF framework is presented in Figure 1.

Given that the ICF is a generic framework for all types of health conditions, the WHO proposed the development of "Core Sets" projects through a rigorous scientific process which results in the Comprehensive and Brief ICF Core Sets that reflect the functioning and disability of health condition. There are several existing Core Sets for many different health conditions including the HL (for review see: https://www.icf-research-branch.org/download/category/4-icf-core-sets). The development of the ICF Core Sets for HL (ICF CSHL) followed the WHO guidelines and consisted of a preparatory phase and a consensus phase (Phase I) (Danermark, et al., 2010, 2013; Granberg, et al., 2014a, 2014b, 2014c, & 2014d).

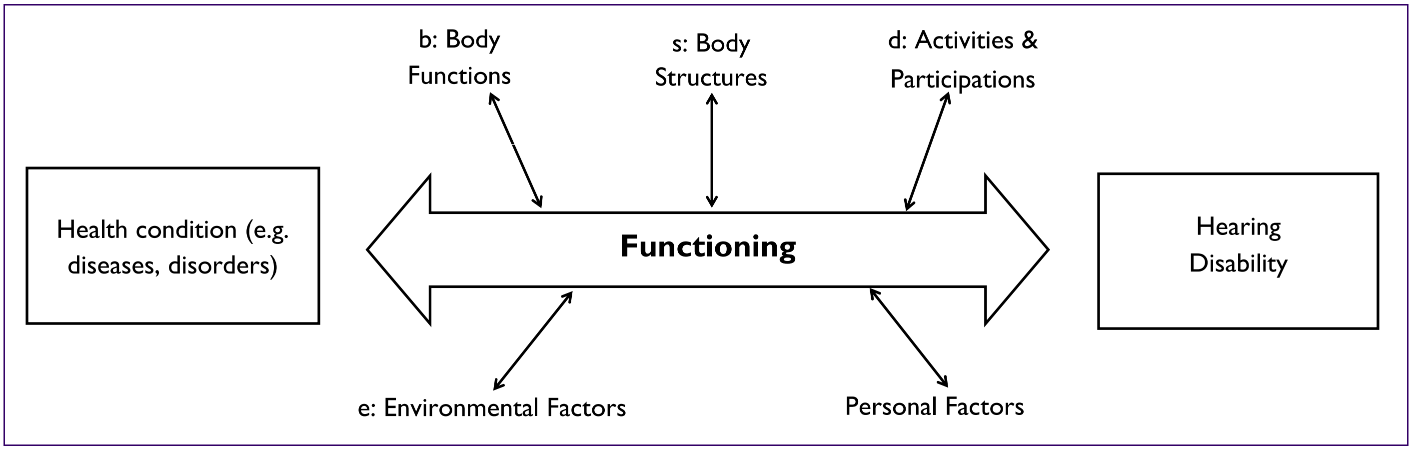

Figure 1: Illustration of the International Classification of Functioning, Disability, and Health framework, which was proposed by World Health Organization in 2001

Phase 1 has been completed and resulted in two Core Sets for HL. The Comprehensive CSHL contains 117 categories and serves as a guide for multi-professional comprehensive assessment. The Brief CSHL includes 27 of the 117 categories and represents the minimal international standard for reporting functioning and disability of persons undergoing hearing evaluation. Phase II is currently ongoing and covers the validation of the CSHL to test if the ICF CSHL could be a useful tool for implementation in clinical practice (Selb et al., 2015). The two differences between the Brief and Comprehensive ICF CSHL are related to 1) the ICF categories that are denoted by the unique alphanumeric codes and 2) by the organization of stem -branch-leaf scheme and interlinked levels. An example is provided in Figure 2.

While the ICF CSHL holds great promise, there are several obstacles to the translation of it into useful clinical tools. For example, the ICF CSHL framework only offers a descriptive system, namely the "ICF coding approach," for classifying health-related information on individuals that can be incorporated into administrative records and databases (ICF manual, 2001; online ICF browser). Grenness, et al., (2016) applied the ICF coding strategy and mapped the ICF categories that matter for an 82-year-old female patient who visited an audiology unit to discuss her hearing difficulties. The mapped ICF categories included the following:

- Among the Body functions: auditory function (b230), tinnitus (b2400), poor attention in background noise (b140, e250), and emotion function (b152), some vision impairment (wears glasses for close-up viewing) (b210, e115).
- Among the Activity limitations and participation restrictions: Conversations with family and friends (d115, d350, d310, d760), Using communication devices and techniques (d360), Communicating with - receiving - spoken messages (d310), Listening (d360), Family relationships (d760) [e.g., reduction in attendance at social events such as dinner with friends].

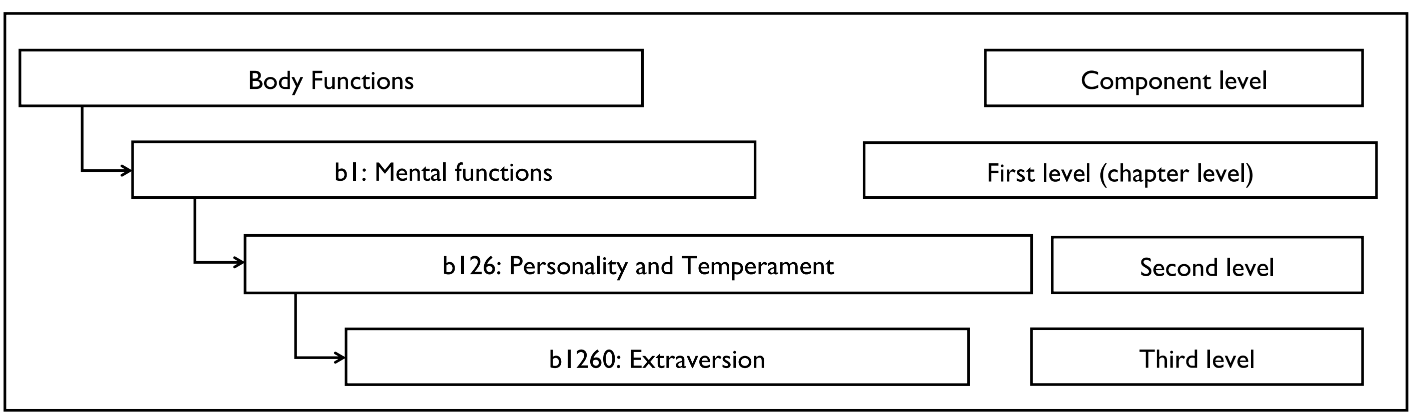

Figure 2: The hierarchical structure of the ICF with examples from the component level body functions. b126: Personality and Temperament is part of the Brief ICF CSHL, while the b1260: Extraversion is part of the Comprehensive ICF

- Among the environmental factors: *Support from immediate family* (e310) [e.g., Lives in an assisted living apartment with husband], *Individual attitudes of immediate family members* (e410).
- Among the personal factors: female, 82-year-old, some arthritis, particularly in right hand (right-handed), three adult children; five grandchildren, two children live nearby; one out of town.

The coding strategy described above is an important analysis system process to identify key elements that facilitate the enablement rehabilitative process and patient- and family-centered hearing care. However, a more structured analysis system to classify and stage functional status across the ICF domains based on the ICF concepts (i.e., synergistic interaction, bidirectional cause-effect) is needed because it will provide a more in-depth reflection of what causes auditory dysfunction beyond hearing loss only.

To classify and stage functional status, the ICF offers a unique "quantitative scaling approach" or "qualifiers" for each domain. The ICF primary qualifier for the classification of body structure and body function domains indicate the degree of impairment on a 5-point rating scale ranging from 0 to 4, with 0 (no difficulty), 1 (mild difficulty, 25% of the time), 2 (moderate difficulty, 50% of the time), 3 (severe difficulty, 75% of the time), and 4 (complete difficulty, 95% of the time). There are two additional qualifiers for non-applicable or non-specified information that can be used by clinicians or patients. The qualifiers for the environmental factors are somewhat unique to quantify barriers and facilitate aspects. This system uses a 9 point scale: –4 (complete barrier, 95% of the time), –3 (severe barrier, 75% of the time), –2 (moderate barrier, 50% of the time), –1 (mild barrier, 25% of the time), 0 (neutral), +1 (25% a facilitator), +2 (50% a facilitator), +3 (75% a facilitator), +4 (95% a facilitator).

Al Fakir, et al. (2015a, 2015b) applied the "ICF coding approach" and the "ICF quantitative scaling approach" to identify the CSHL categories described in the patients' records of a university clinic specializing in amplification and cochlear implantation. Additionally, authors sought to determine if the identified categories support the ICF concept. They found the ICF measurement strategies to have a sufficient internal consistency (Cronbach's $\alpha = .72$). More importantly, beside the hearing aid use, authors identified the CSHL categories that discriminate between successful versus unsuccessful treatments for individuals with HL which are, speech reading [*Using communication techniques* (d3602)] and active social life [(*community life* (d910), s*ocializing* (d9205)]. These findings provided preliminary evidence that the quantitative scaling approach has discriminant validity, which provides a method to segregate and categorize hearing healthcare outcomes according to their measured value. However, a less resource intensive method that reflects real patient's perspective about their health status would be a desirable method to implement the ICF CSHL. One solution would be to develop some form of a self-assessment tool. The primary goal of this paper was to report on the creation of ICF CSHL-based questionnaire and to test its feasibility, internal consistency and validity. Other aims were to assure the questionnaire was clinically useful, and to validate the questionnaire developed.

Methods

Study design

This cross-sectional study was approved by the University of Florida Institutional Review Board according to the Declaration of Helsinki on the statement on ethical principles for medical research involving human participants. Individuals who experienced social-communication difficulties in their daily life, the age between 60-89, who had adequate command of the English language, and independent to complete the tasks were included in the study. Individuals who were unable to complete the study because of the cognitive barrier were excluded. Participants were recruited from the community through flyers and postcards sent to the University of Florida Audiology clinics, University of Florida-Institute of Aging, University of Florida Health-Street program that gives people a voice in ongoing health research, local senior citizen centers, local audiology clinics, and senior living housing developments. One hundred and thirty-one independent-living older adults between 60 and 89 years of age (mean [SD], 72.32 [6.83]), participated in this investigation. After providing written informed consent, participants completed a pen-paper version of the ICF-based questionnaire and comprehensive, standardized and clinically accepted measures similar to the global construct of single-item scale. All testing was completed in one session according to participants' daily functioning (e.g., use of hearing aid, eyeglasses, and contact lenses), with a break period. For hearing-aid users, the function of hearing aids was checked either by real ear measurement or a listening check to verify that the hearing aid was working appropriately. However, the speech recognition test as a measure to verify performance with actual hearing aids was considered as part of the hearing aid evaluation process. Sample characteristics are presented in Table 1.

Materials

Creation of the ICF CSHL-based questionnaire

A group of audiologists consisted of two experts (RA and AH), and four Doctors of Audiology worked collaboratively and developed the ICF CSHL-based questionnaire. Authors

Table 1. Participant Characteristics (N =131)

Characteristics	N = 131	Mean	SD
Age		72.32	6.83
60-69	52		
70-79	55		
80-89	24		
Sex			
Male	55		
Female	76		
Education level			
12 years	26		
14 - 16 years	53		
>16 years	52		
Work status			
Retired	94		
Employed	28		
Volunteer	9		
Living arrangement			
Live with spouse	86		
Live with relatives	13		
Live alone	32		
Health condition*			
No medical disorder	31		
Chronic medical disorder*	100		
Corrected vision			
Distance	100		
Close	115		
Hearing aids users	38		
Intellectual function (MoCA)			
Normal cognition > 26	77		
MCI < 26	48		
Severe cognitive Decline < 21	6		

* Chronic medical disorders ranked based on most reported: High blood pressure and heart disorders, Arthritis, Thyroid disorders, Glaucoma, Meniere's disease, Cancer and its management, Psychological problems (Depression, Anxiety, and Sleep disorder).

determined that a large number of categories in the ICF comprehensive CSHL (n = 117) was too extensive for the purposes of this study. Fortunately, the ICF Brief CSHL (n = 27) is more clinically applicable. Thus, the ICF Brief CSHL was adopted to initiate development of the questionnaire. However, the ICF CSHL-based questionnaire was designed to sample 22 of the 27 ICF categories of the Brief CSHL. In some cases, the ICF second-level category (b240) *sensations associated with hearing and vestibular function* was parsed to allow for a question addressing *"tinnitus"* (b2400) and *"dizziness"* (b2401) sensations. In other cases, the ICF third-level categories were unparsed, such as *Personality and Temperament function* (b126), in which the single-item scale was defined with fewer details as compared to comprehensive personality measure that classifies personality traits listed in the comprehensive ICF CSHL. Also, some categories were excluded, because authors perceived that it was not feasible to be measure such as [*Structure of brain* (s110), *Structure of external ear* (s240), *Structure of middle ear* (s250), *Structure of inner ear* (s260)]. Also was deemed irrelevant to older adults *School education* (d820).

Operationalization of the data model was guided by feasibility rather than the efficiency and granularity. For feasibility, the questions were created by using the standardized ICF terminology (textual definitions) and inclusion/exclusion criteria for each category after considering as described in ICF manual, 2001 and online ICF browser (http://apps.who.int/classifications/icfbrowser/). Also, we applied the single item scale approach using the ICF qualifiers specified for each domain as described above. Each item was formulated as a question on a 5-point Likert scale based on the "ICF quantitative scaling approach" described above. For efficiency and granularity, we selected a clinically accepted measurement similar to each single-item scale. For example, *Hearing Functions* (b230) have five sub-categories [*Sound detection* (b2300), *Sound discrimination* (b2301), *Localization of sound source* (b2302), *Lateralization of sound* (b2303), *Speech discrimination* (b2304)]. In terms of feasibility, we used one single-item scale "What is the extent to which you can understand the speech of significant others in noise or over distance?" in terms of efficacy, we selected three instruments, the pure-tone audiometry, speech audiometry, and self-reported measure of hearing function. Another example, *Personality and Temperament function* category have five-sub categories [*Extraversion* (b1260), *Agreeableness* (b1261), *Conscientiousness* (b1262), *Psychic stability or Neuroticism* (b1263), and *Openness* (b1264)]. In terms of feasibility, *Personality and Temperament function* was measured by the ICF single-item scale "What is the extent to which your personality or mood distinguish you from others?" In terms of efficiency and granularity, the Big Five Personality Inventory 44 -item was selected to provide an in-depth reflection of the five -sub categories.

The authors chose this procedure for three main reasons: 1) to validate the ICF CSHL-based questionnaire, 2) to test the effectiveness of this procedure, and 3) to guide the enhancement of questionnaire that can be made as to the correlation with the corresponding measure in the future study. The standardized and clinically accepted measurement instruments are classified and described below. The selection of clinically accepted measurements was conducted based on available psychometric information (e.g., internal consistency, reliability, test-retest reliability, validity), correlation with HL, self-reports, audiologic outcomes, and guidelines provided by American Academy of Audiology Clinical Practice in 2015, which is beyond of description in this paper.

Self-Assessments ICF Core Sets for Hearing Loss Questionnaire

Instructions: The purpose of this questionnaire is to identify problems you are having that may affect your daily listening-conversational activities (communicative interaction). Please circle the number that corresponds with the severity and restriction level of the problem. *If you use hearing aids, please answer the way you hear while using the hearing aids.

Body function domain

What is the extent to which your personality or mood distinguish you from others?

0= Never   1= 25% of the time   2= 50% of the time   3= 75% of the time   4= 95% of the time

What is the extent to which you can maintain your focus for a period of time or on two or more things at the same time?

0= Never   1= 25% of the time   2= 50% of the time   3= 75% of the time   4 = 95% of the time

What is the extent to which you can remember things and recall new information?

0 = Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you feel unhappy or depressed?

0= Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you can see friends over a distance (within 6 feet)?

0= Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you can understand the speech of significant others in noise or over distance?

0= Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you have ringing in your ears

0= Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you feel dizzy or imbalanced?

0 = Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

Activities limitations and participation restrictions domain

What is the extent to which you have difficulty listening to the television, radio, or movies?

0 = Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you have difficulty understanding a statement or question during communication activity?

0 = Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you have difficulty starting, continuing, or ending a conversation, or speaking with several people in a group?

0 = Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you have difficulty to use coping communication strategies (e.g., ask to repeat, rephrase, read lips, reposition your body or head, etc.)?

0 = Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you have difficulty maintaining family relationships?

0 = Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

What is the extent to which you have difficulty socializing with your family or friends?

0 = Never   1 = 25% of the time   2 = 50% of the time   3 = 75% of the time   4 = 95% of the time

Environmental domain

If you think about your environment, how would you rate the usefulness of the hearing technology you use during listening-conversation activities? (☐I am not a hearing aids user)

No, it was barrier				Neutral	Yes, it was facilitator			
-4	-3	-2	-1		+1	+2	+3	+4
95%	75%	50%	25%	0	25%	50%	75%	95%

If you think about your environment, how would you rate the level of background noise during listening-conversation activities?

It was barrier				Neutral	It was acceptable			
-4	-3	-2	-1		+1	+2	+3	+4
95%	75%	50%	25%	0	25%	50%	75%	95%

If you think about your environment, how would you rate the support you received from the close family members during listening-conversation activities?

No, it was barrier				Neutral	Yes, it was facilitator			
-4	-3	-2	-1		+1	+2	+3	+4
95%	75%	50%	25%	0	25%	50%	75%	95%

The instruments were a combination of objective and subjective measurement instruments.

Measures

1. Hearing function

- ***Sound detection (b2300):*** The Pure-tone average (PTA) test was conducted using the Hughson Westlake technique with a GSI-61 audiometer (Grason-Stadler Inc). Air conduction thresholds (250 Hz to 8.00 KHz) were determined with ER-3A Insert earphone or supra-aural headphones (TDH-39). Before audiometry test, otoscopy was completed at the beginning of the session using a Welch Allyn otoscope. Hearing thresholds were averaged for the four speech frequencies (500, 1,000, 2,000, and 4,000Hz).
- ***Speech discrimination (b2304):*** The Bamford-Kowal-Bench speech-in-noise test (BKB-SIN) developed by the Etymotic Research group (2005) to estimate a person's auditory capacity/performance in recognizing the spoken-language in everyday listening conditions with and without hearing aids The BKB-SIN test was presented via a wall-mounted speaker in the sound field that was routed through the GSI-61 audiometer and positioned at 00 Azimuth at a distance of one meter from the participant's approximate head position. BKB-SIN recordings were presented in the sound field at 70 dB HL. All participants completed the two pair list (No. 3 and 4). Participants' scores of each list were recorded as Signal-to-Noise Ratio (SNR). The SNR Scores of the two pair were averaged, and SNR loss was calculated. Scores above 3dB indicated impaired hearing.
- **Activities limitations-related hearing categories: [*Listening (d115), Communication-receiving-spoken-message (d310), Conversation (d350), and Using communication techniques (d3602)]:*** The 49-items version of the Speech, Spatial, and Quality of Hearing Scale (SSQ) developed by Gatehouse and Noble (2004) to measure a range of hearing disabilities across several domains, including hearing speech, spatial hearing, and quality of sound. The SSQ test was completed via pen-paper administration. Lower scores indicate a high level of hearing disability.

2. Sensations associated with hearing and vestibular function

- ***Tinnitus (b2400):*** The Tinnitus Functional Index (TFI) developed by Meikle, et al., (2012) to measure the impact of bothersome tinnitus sensation that could be associated with HL. The subscales include emotional and cognitive stress, the intrusiveness of tinnitus, hearing problems, sleep disorders, and somatic symptoms. The TFI test was completed via pen-paper administration. Scores of 18 and higher indicated mild to severe bothersome tinnitus sensation and greater functional impairment.
- ***Dizziness (b2401):*** The Dizziness Handicap Inventory (DHI) developed by Jacobson and Newman (1990) to evaluate the self-perceived handicapping effects across physical, functional, and emotional, domains imposed by dizziness and unsteadiness sensation. DHI test was tested in patients with peripheral and central vestibular disorders, multiple sclerosis, brain injury, and movement and gait disorders. The DHI was completed via pen-paper administration. Scores of 16-34 indicated mild handicap, of 36-52 indicated moderate handicap, and 54+ indicated severe handicap.

3. Visual Acuity Function

- ***Binocular acuity of distant vision (b2100):*** An Ultimate Snellen eye chart was completed according to their functioning with eyeglasses or contact lenses as used on a daily basis. The Ultimate Snellen eye chart was presented at six feet from the eye. Low visual acuity test scores indicated good binaural eyesight.

4. Mental (Cognitive, psychological) Functions

- ***Global mental functions categories (b110-b139):*** The Montréal Cognitive Assessment version 7.1 (MoCA) developed by Nasreddine, et al., (2005) to assess different cognitive domains: attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. The MoCA test is a cognitive screening tool that evaluates global mental capacity and detects mild cognitive impairment and determines who is at risk for Alzheimer's disorder. The MoCA test was administered via researcher and participant interface according to the recommendations presented by Dupuis and colleagues (2015). Scores less than 26 (25.2 – 19.0) indicate mild cognitive impairment and any score range from (21.0 – 11.4) is considered at risk for Alzheimer's disorder.
- ***Attention function (b140): divided attention (b1402):*** The Brief Test of Attention (BTA) developed by Schretlena, et al. (1996) to provide a rapid assessment of divided attention capacity in different age-band. BTA test consists of two parallel forms: Form N (Numbers) and Form L (Letters). The respondent's task is to disregard the letters presented in Form N (Numbers) and cognitively count how many numbers were read aloud; whereas in the Form L (Letters) the respondent must disregard the numbers and cognitively count how many letters were read aloud. The number of correctly monitored lists is summed across both forms, with raw scores ranging from 0-20. The BAT was presented via a wall-mounted speaker in the sound field that was routed

through the GSI-61 audiometer and positioned at 0° azimuth at a distance of one meter from the participant's approximate head position. The BAT recordings were presented in the sound field at 70 dB HL. High BTA scores indicate a good capability of divided attention.

- ***Attention function (b140) and Memory function (b144):*** The Digit Span Test-Backward (DSB) developed by Wechsler (1997) to measure working memory function. However, Groth-Marnat and Baker (2003) suggested that higher DSB scores can be used to measure everyday attention function and scores would indicate excellent attention and good working memory. The DSB was presented by visual-only modality at a rate of one digit per second via a desktop Dell computer. The recording list consisted of eight sets or 16 trials. The score was the total number of correct trials before failing two consecutive trials at any one span size.
- ***Emotional function (b152):*** The Geriatric Depression Scale (GDS) developed by Yesavage, et al., (1983) to screen for clinical depression among the elderly. The GDS test was completed via pen-paper administration. Higher scores above 10 indicate the presence of depressive symptomatology.

5. *Personality and Temperament function (b126):*

- The Big Five Personality Inventory 44-item (BFPI) developed by Goldberg (1993) to measure the following sub-categories: *Extraversion* (b1260), *Agreeableness* (b1261), *Conscientiousness* (b1262), *Psychic stability or Neuroticism* (b1263), and *Openness* (b1264). The PFPI test was completed via pen-paper administration. Higher scores in extraversion, agreeableness, conscientiousness, and openness, indicate independence, cognitive flexibility, and emotional stability and energy. Higher scores in neuroticism indicate negative emotions such as anger, embarrassment, depression, stress, and anxiety.

6. Social Function

- ***Family relationships (d760):*** The Relationship Assessment Scale (RAS) developed by Hendrick (1988) to assess family relationship. The RAS test was completed via pen-paper administration. Higher scores indicate the ability to maintain relationships with family members, including significant others as well as extended family relationships such as siblings and cousins.
- ***Community life and Socializing (d910):*** The De Jong Gierveld Loneliness and Social Isolation Scale (DJG-LSIS) developed by De Jong Gierveld and Kamphuis (1985) to gauge social and emotional isolation that encompasses a sense of emptiness and missing having people around, with the presence of people to rely on, trust and feel close to them. The DJG-LSIS test was completed via pen-paper administration. Thus, lower scores may indicate an inadequate social network.

7. Personal and environmental factors

- ***Personal factors:*** A short survey attached to the ICF-based questionnaire and includes information about age, gender, education level, work status, living arrangement, health condition, hearing assistive technologies (use per hour, per day, per year) and overall satisfaction.
- ***Environmental factors (e125)***
  - ***Products and technology for communication:*** The hearing aid benefit was indicated by BKB-SIN test and SSQ scores.
  - ***Sound (e250): Sound (noise) intensity (e2500):*** The Acceptable Noise Level test (ANL) was developed by Nabelek and colleagues (1991). The ANL test was conducted in the sound field. The setup was similar to BKB-SIN test. Lower scores indicate background noise intolerance. The rationale for selecting this measure is based on the ANL studies that showed no correlation between personal factors (e.g., age, gender), hearing tests (e.g., hearing sensitivity, acoustic reflex thresholds or contralateral suppression of otoacoustic emissions, speech understanding in noise scores), and the type of noise background noise distraction or preference for background sounds (Freyaldenhoven et al., 2006; Freyaldenhoven, 2007).
  - ***Support and relationship: Immediate family (e310), Extended family (e315), Friends (e320):*** The Lubben Social Network Scale-Revised version of the 12-items scale (LSNS-R-12) was developed by Lubben and Gironda (2004) to measure perceived social support received by family and friends and to gauge social isolation in older adults. The LSNS-R-12 test was completed via pen-paper administration. Higher scores indicate positive support and an adequate social network.

Statistical Analyses

All the statistical analyses were completed using the SPSS version 24 IBM software. We computed the mean, standard deviation, and score range for ICF single-item scales per groups (normal listeners, hearing-aid users, and non-hearing-aid users) as well as for independent instrument measurements. The feasibility of using the questionnaire was measured by the percent of patients who filled out the questionnaire without assistance, and when completed, whether there were any missing items. We checked validity by Pearson correlation coefficient and exploratory factor analyses (EFA). Concurrent validity was evaluated by whether the scores of each single-item of ICF CSHL-based questionnaire aligned and correlated with scores of the corresponding measurement. Construct validity was determined by whether the questions of the ICF CSHL-based questionnaire correlated with the audiologic measures used in this study (PTA: audiometric thresholds, BKB-SIN: laboratory measure of speech understanding in the presence of background noise, and SSQ: self-reported measures of performance in speech, spatial, and qualities of hearing in daily life). The overall validity was determined by how well the questionnaire items captured potential synergistic interactions.

Results

Feasibility and Internal consistency

All the participants completed an ICF CSHL-based questionnaire without assistance in its entirety. The 23 items of an ICF CSHL-based questionnaire have a good internal consistency (Cronbach's α = .83) (Al Fakir's doctoral dissertation, 2016). In this paper, however, we used the same dataset and only a subset of an ICF CSHL-based questionnaire, consisting of 17 single-item scales, based on the availability of standardized and clinically accepted measurement instruments that are similar to the global construct of each single item scale. The internal consistency of the 17 items remains intact (Cronbach's α = .83). Table 2 shows the included and excluded second-level categories of the ICF Brief CSHL.

Table 2. The 23 ICF categories of the Brief CSHL included in Al fakir's doctoral dissertation (2016). The italic formant represents the 17 ICF categories included in this paper

Chapter	Number	Category Description	Included	Excluded
		Body Structure and Body Function		
s	110	Structure of brain		x
s	240	Structure of external ear		x
s	250	Structure of middle ear		x
s	260	Structure of inner ear		x
b	*125*	*Temperament and personality function*	x	
b	*140*	*Attention function*	x	
b	*144*	*Memory function*	x	
b	*152*	*Emotional function*	x	
b	*210*	*Seeing function*	x	
b	*230*	*Hearing function*	x	
b	*240*	*Sensations associated with hearing and vestibular function*	Parsed to	
b	*2400*	*Tinnitus*	x	
b	*2401*	*Dizziness*	x	
		Activities and Participation		
d	115	Listening	x	
d	240	Handling stress and other psychological commands	x	
d	*310*	*Communicating with–receiving–spoken messages*	x	
d	*350*	*Conversation*	x	
d	*360*	*Using communication devices and techniques*	x	
d	*760*	*Family relationships*	x	
d	820	School education		x
d	850	Ruminative employment	x	
d	*910*	*Community life*	x	
		Environmental Factors		
e	*125*	*Products and technology for communication*	x	
e	*250*	*Sound*	x	
e	*310*	*Support from Immediate family*	x	
e	355	Support from Health professionals	x	
e	410	Individual attitudes of immediate family members	x	
e	460	Societal attitudes	x	
e	580	Health services, systems, and policies	x	

*ICF Chapter Key: "b" = body function, "d" = activity and participation, "e" = environment, "s" = structure

Validity

1. Criterion Validity

The percentage of the responses to the ICF 17-items among the 131 participants was calculated. The complaints reported most often among participants within the body functions domain were: working memory (ICF-Q3: 81%), understanding speech in noise or over distance (ICF-Q6: 75.6%), and personality and temperament (ICF-Q1: 64%). The complaints reported most often among participants within the activity limitation/participation restriction domain were: using communication techniques (ICF-Q12: 60%), listening and communication with-receiving-spoken messages (ICF-Q9 and ICF-Q10: 52%), and conversation (ICF-Q11: 46%). Within the environmental domain, the majority of participants reported that perceived level of background noise was a substantial barrier. These complaints were found in (normal listeners, untreated HL, and treated HL). Full details of these findings are presented in Table 3.

2. Concurrent validity

2.1 Descriptive statistics for the ICF CSHL-based questionnaire and clinically accepted measurement instruments

Table 3. Percentage of the responses to the ICF 17-items among the 131 participants

Item Summary	Frequency Distribution and Percentage (N=131)				
Body Functions	0	1	2	3	4
b126 Temperament and personality function	67 (51.1%)	47 (35.9%)	11 (8.4%)	5 (3.8%)	1 (.8%)
b140 Attention function	71 (54.2%)	48 (36.6%)	6 (4.6%)	5 (3.8%)	1 (.8%)
b144 Memory function: *b1440* Short-term memory	25 (19.1%)	76 (58%)	22 (16.8%)	7 (5.3%)	1 (.8%)
b152 Emotional function	73 (55.7%)	40 (30.5%)	9 (6.9%)	6 (4.6%)	3 2.3%)
b210 Seeing function: *b2100* Binocular acuity of distant vision (within 6 feet)	94 (71.8%)	27 (20.6%)	6 (4.6%)	3 (2.3%)	1 (.8%)
b230 Hearing function: *b2304* Speech discrimination	32 (24.4%)	49 (37.4%)	32 (24.4%)	14 (10.7%)	4 (3.1%)
b240 Sensation associated with hearing function: *b2400* Tinnitus	78 (59.5%)	22 (16.8%)	14 (10.7%)	7 (5.3%)	10 (7.6%)
b240 Sensation associated with vestibular function: *b2401* Dizziness	107 (80.2%)	17 (13%)	5 (3.8%)	3 (2.3%)	1 (.8%)
Activity limitations and participation restriction					
d115 Listening	56 (42.7%)	46 (35.1%)	17 (13%)	8 (6.1%)	4 (3.1%)
d310 Communicating with-receiving- spoken-message	62 (47.3%)	52 (39.7%)	12 (9.2%)	4 (3.1%)	1 (.8%)
d350 Conversation	71 (54.2%)	42 (32.1%)	8 (6.1%)	8 (6.1%)	2 (1.5%)
d360 Using communication techniques	52 (39.7%)	39 (29.8%)	15 (11.5%)	18 (13.7%)	7 (5.3%)
d760 Family relationship	94 (71.8%)	31 (23.7%)	5 (3.8%)	1 (.8%)	0
d850 Remunerative employment	125 (95.4%)	5 (3.8%)	1 (.8%)	0	0
d910 Community life: *d9205* Socializing	97 (74%)	25 (19.1%)	4 (3.1%)	5 (3.8%)	0

ICF qualifiers for body functions domain: [0 (no impairment), 1 (mild impairment), 2 (moderate impairment), 3 (severe impairment), and 4 (complete impairment)]. ICF qualifiers for activity limitations domain: [0 (no difficulty), 1 (mild difficulty), 2 (moderate difficulty), 3 (severe difficulty), and 4 (complete difficulty)].

Table 3 cont.

Environmental Factors	Barrier				Neutral	Facilitator			
	-4	-3	-2	-1	0	+1	+2	+3	+4
e125 Products and technology for communication: Hearing aid users (*n*=38)	0 (0%)	2 (5%)	1 (5%)	4 (10%)	3 (7%)	3 (7%)	10 (26%)	10 (26%)	5 (13%)
e250 Sound: *e2500* Sound (noise) intensity (*n*=131)	4 (3%)	18 (14%)	46 (35%)	42 (32%)	21 (16%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
e310 Support from immediate family (*n*=131)	1 (1%)	0 (0%)	1 (1%)	12 (9%)	49 (37%)	19 (14%)	15 (11%)	16 (12%)	18 (14%)

ICF qualifiers for environmental factors: [–4 (complete barrier, 95% of the time), –3 (severe barrier, 75% of the time), –2 (moderate barrier, 50% of the time), –1 (mild barrier, 25% of the time), 0 (neutral), +1 (25% a facilitator), +2 (50% a facilitator), +3 (75% a facilitator), +4 (95% a facilitator)

The mean, standard deviation (SD), and scores range for the 17-items ICF CSHL-based questionnaire and the clinically accepted measurement instruments were calculated per stratified groups. The participants stratified into three groups: normal listeners, untreated HL (non-hearing aid users), and treated HL (hearing aid users). Thirty-seven participants had normal hearing thresholds (< 25dB Hearing Level) for frequencies ranging between 0.25-8.00 kHz in both ears). Fifty-six participants within the untreated HL group demonstrated a range of hearing thresholds, averaged across 500, 1, 2, 4 kHz of each ear, from 10 dB HL to over 47 dB Hearing Level as defined by the better ear. Thirty-eight participants within the treated HL group demonstrated a range of hearing thresholds, averaged across 500, 1, 2, 4 kHz of each ear, from 10 dB HL to over 88 dB Hearing Level as defined by better ear. Full details of scores are presented in Table 4 and 5.

Table 4. Mean, standard deviation (SD), and scores range for the 17-items ICF CSHL-based questionnaire

ICF categories	Groups								
	Normal (n= 37) HL (mean=14, SD =4.7 defined by BE)			Untreated HL (n= 56) HL (mean=28, SD =7.7 as defined by BE)			Treated HL (n= 38) HL (mean=44, SD =17.3 defined by BE)		
	Min-Max	Mean	SD	Min-Max	Mean	SD	Min-Max	Mean	SD
Temperament & Personality Function	0 – 4	.46	.86	0 – 3	.70	.78	0 – 3	.84	.88
Attention Function	0 – 3	.38	.63	0 – 3	.59	.75	0 – 4	.84	.97
Memory Function	0 – 3	.92	.68	0 – 3	1.0	.72	0 – 4	1.4	.91
Emotional Function	0 – 3	.54	.80	0 – 3	.61	.80	0 – 4	.89	1.2
Hearing Function	0 – 3	.57	.76	0 – 4	1.3	.94	0 – 4	1.9	1.0
Seeing Function	1	.11	.31	0 – 3	.50	.78	0 – 4	.53	.92
Tinnitus sensation	0 – 3	.35	.75	0 – 4	.91	1.3	0 – 4	1.2	1.4
Dizziness and Imbalance sensation	1	.05	.22	0 – 3	.30	.65	0 – 4	.55	1.0
Listening	2	.27	.50	0 – 4	1.1	1.0	0 – 4	1.2	1.1
Communication	1	.19	.39	0 – 3	.77	.78	0 – 4	1.1	.92
Conversation	0 – 3	.30	.70	0 – 3	.73	.86	0 – 4	1.0	1.1
Using Communication Techniques	0 – 4	.41	.86	0 – 4	1.3	1.2	0 – 4	1.6	1.2
Family Relationship	1	.27	.45	0 – 3	.30	.63	0 – 2	.45	.64
Community Life	0 – 3	.30	.66	0 – 3	.29	.68	0 – 3	.55	.83
Technology	NA	.00	.00	NA	.02	.48	-3 – 4	1.5	1.8
Background noise	-3 – 0	-1.0	.85	-3 – 0	-1.4	.95	-4 – -1	-2.2	.88
Family Support	-1 – 4	1.0	1.6	-1 – 4	1.0	1.4	-4 – 4	1.3	2.0

Table 5. Mean, stranded deviation, and scores range for the independent measurements linked to the I7-items of the ICF CSHL-based questionnaire

ICF categories	Groups								
	Normal (n= 37) HL (mean=17.0, SD=4.7)			Untreated HL (n= 56) HL (mean=37.3, SD=9.7)			Treated HL (n= 38) HL (mean=54.4,SD=17.4)		
	Min-Max	Mean	SD	Min-Max	Mean	SD	Min-Max	Mean	SD
BFPI (Extroversion)	11 – 39	26.0	6.8	12 – 40	26.1	7.2	14 – 40	27.4	6.3
BFPI (Agreeableness)	21 – 45	37.2	5.5	27 – 44	36.6	4.3	18 – 45	35.9	5.4
BFP (Conscientiousness)	24 – 45	35.6	5.3	22 – 45	35.5	5.8	24 – 46	35.0	5.37
BFPI (Neuroticism)	8 – 32	19.5	6.5	8 – 37	19.0	7.2	8 – 43	20.0	7.1
BFPI (Openness)	23 – 50	37.6	7.0	20 – 48	37.1	7.1	23 – 47	38.5	5.8
Brief Test of Attention	11– 20	17.11	2.5	2 – 20	15.6	4.4	2 – 20	12.5	4.6
Digit Span Test-Backward Visual	4 – 12	7.2	1.9	3 – 12	6.8	2.0	3 – 13	6.8	2.2
Montreal Cognitive Assessment	22 – 30	27.0	2.0	20 – 30	26.3	2.6	18 – 30	26.3	2.7
Geriatric Depression Scale	0 – 20	4.8	5.5	0 – 23	4.8	4.9	0 – 27	6.0	5.8
Bamford-Kowal-Bench-Speech-in-noise	-2.7 –.75	-1.2	.82	-3.0 –6.5	.07	2.0	-2 – 23.5	2.5	5.7
Visual acuity at distance	.4 – 1.0	.86	.18	.4 – 1.0	.83	.19	.4 – 1.0	.83	.20
Tinnitus Functional Index	.0 – 34	2.4	6.4	.0 – 58.8	8.0	14.2	.0 – 53.6	10.9	15.9
Dizziness Handicap Inventory (Total)	0 – 24	4.4	7.0	0 – 58	7.9	11.9	0 – 62	10.8	14.3
Physical Subscale	0 – 8	1.5	2.4	0 – 18	2.8	5.2	0 – 18	3.8	4.2
Functional Subscale	0 – 12	1.8	3.3	0 – 22	3.2	4.5	0 – 28	4.3	5.8
Emotional Subscale	0 – 12	.9	2.4	0 – 22	2.3	4.1	0 – 16	2	3.6
Speech, Spatial, and Qualities Scale (Total)	6.4–9.7	8.41	.95	4.3 – 9.6	7.3	1.4	1.1 – 9.4	6.3	1.8
Speech Subscale	4.0 – 10	7.8	1.4	2.7 – 10	6.4	1.9	.7 – 9.5	5.9	2.1
Spatial Subscale	5.1–10	8.4	1.3	2.6 – 10	7.1	1.6	.9 – 10.3	6.9	2
Qualities of Hearing Subscale	5.5 – 10	8.7	1	4.3 – 9.8	7.8	1.2	1.6 – 10	7.2	2
Relationship Assessment Scale	– 35	31.3	5.0	17 – 35	29.8	5.3	20 – 35	32.1	3.4
DJG-Loneliness and Social Isolation Scale	0 – 11	2.9	3.0	0 – 10	3.1	2.5	0 – 11	3.7	2.9
Acceptable Noise Level	-2 – 12	2.6	3.7	-2 – 12	3.3	4.2	-2 – 12	4.4	3.9
Lubben Social Network Scale -Revised	19– 54	38.7	8.1	9 – 56	37.2	9.9	22 – 51	36.1	7.7

Abbreviations: BFPI: Big Five Personality Inventory, SD: standard deviation, Min: minimum, Max: maximum.

2.2 Pearson Correlation Coefficient between an ICF CSHL-based questionnaire and the instrument measurements

Based on definitions by McLeod (2008) about correlation size, strong (*r* = ± 0.70 and ± 0.9) or moderate (*r* = ± 0.40 and ± 0.69) correlations were found among several questions, while remaining questions fell in the weakly correlated range (*r* < ± .29). Full details of significant and non-significant correlations coefficients between the ICF CSHL items and the scores of other measures are presented in Table 6.

Significant, strong correlations were found between 1) ICF -Q6 and SSQ; 2) ICF-Q7 and tinnitus functional index (TFI). Significant, moderate correlations were found between 1) ICF-Q6 and pure-tone average or BKB-SIN; 2) ICF-Q8 and dizziness handicap inventory (DHI); 3)ICF-Q4 and Geriatric Depression Scale (GDS) and Loneliness sub scale of De Jong Gierveld Isolation Scale (DJG-LSIS), respectively; 3) ICF-Q5 and Snellen chart (far distance); 4) ICF-Q9 trough ICF-12 and SSQ. Additional significant, but weak correlations are also described in Table 6.

Table 6. Pearson correlation coefficient between the items of the ICF CSHL-based questionnaire and the independent measurements

ICF Items	Measure	r (n=131)
Body Functions domain		
Q1.What is the extent to which your personality or mood distinguish you from others?	BFPI: Openness	-.03
	BFPI: Extroversion	-.18*
	BFPI: Agreeableness	-.30**
	BFPI: Conscientiousness	-.23**
	BFPI: Neuroticism	.32**
Q2. What is the extent to which you can maintain your focus for a period of time or on two more things at the same time?	BTA	.34**
	DSB-V	-.30**
	MoCA	-.17*
Q3. What is the extent to which you can remember things and recall new information?	DSB-V	-.21**
	BTA	-.32**
	MoCA	-.25**
Q4. What is the extent to which you feel unhappy or depressed?	GDS	.50**
	LSIS-DJG (Loneliness subscale)	.44**
Q5. What is the extent to which you can see friends over a distance (within 6 feet)?	Snellen chart (far distance)	-.40**
Q6. What is the extent to which you can understand the speech of significant others in noise or over distance?	PTA (average of both ears)	.64**
	BKB-SIN	.57**
	SSQ	-.71**
Q7. What is the extent to which you have ringing in your ears?	TFI	.83**
Q8. What is the extent to which you feel dizzy or imbalanced?	DHI	.51**
	DHI Physical subscale	.48**
	DHI Functional subscale	.50**
	DHI Emotional subscale	.38**
Activities and Participation domain		
Q9. What is the extent to which you have difficulty listening to the television, radio, or movies?	PTA (average of both ears)	.55**
	BKB-SIN	.58**
	SSQ	-.62**
Q10. What is the extent to which you have difficulty understanding a statement or question during communication activity?	PTA (average of both ears)	.62**
	BKB-SIN	.64**
	SSQ	-.65**
Q11. What is the extent to which you have difficulty starting, continuing, or ending a conversation, or speaking with several people in a group?	PTA (average of both ears)	.50**
	BKB-SIN	.53**
	SSQ	-.63**

Table 6 continued

Activities and Participation domain continued		
Q12. What is the extent to which you have difficulty to use coping communication strategies (e.g., ask to repeat, rephrase, read lips, reposition your body or head, etc.)?	PTA (average of both ears) BKB-SIN SSQ	.48** .42** -.50**
Q13. What is the extent to which you have difficulty maintaining family relationships?	RAS LSNS-12 DJG-LSIS (Social subscale)	-.20* -.21* .23**
Q14. What is the extent to which you have difficulty socializing with your family or friends?	DJG-LSIS (total scale) DJG-LSIS (Social subscale) DJG-LSIS (Loneliness subscale) LSNS-12 RAS	.32** .30** .30** -.12 .89
Environment domain		
Q15. If you think about your environment, how would you rate the usefulness of the hearing technology you use during listening-conversation activities? (n=38)	BKB-SIN SSQ	-.18 .22
Q16. If you think about your environment, how would you rate the level of noise background during listening-conversation activities?	ANL	-.30**
Q17. If you think about your environment, how would you rate the support you received from the close family members during listening-conversation activities?	LSNS-12 DJG-LSIS (Social subscale) RAS	.20* -.22* .16

Abbreviations: BFPI: Big Five Personality Inventory; PTA, pure tone audiometry; BKB-SIN, Bamford-Kowal-Bench; TFI, Tinnitus Functional Index; DHI, Dizziness Handicap Inventory; MoCA, Montreal Cognitive Assessment; ANL, acceptable noise level; SSQ, Speech, Spatial, and Qualities of Hearing Scale; GDS, Geriatric Depression Scale; LSNS-12, Lubben Social Network Scale-Revised; Digit Span Test-Backward via Visual modality (DSB-V); DJG-LSIS, De Jong Gierveld Loneliness and Social Isolation Scale; RAS: Relationship Assessment Scale. **Significant $p \leq 0.01$ (2-tailed) *Significant $p \leq 0.05$ (2-tailed)

3. Construct validity

3.1 Pearson Correlation Coefficient between ICF CSHL-based questionnaire along with some personal factors (age, gender, education, living arrangement, health conditions) and (pure tone average, BKB, and SSQ test results)

All the items showed a significant correlation with the PTA, SSQ and BKB-SIN except of the ICF-Q17 (If you think about your environment, how would you rate the support you received from the close family members during listening-conversation activities?) and ICF-Q15 (If you think about your environment, how would you rate the usefulness of the hearing technology you use during listening-conversation activities?) among hearing aids users. We found a significant correlation between age, PTA, and BKB-SIN but not SSQ and between gender and PTA only. Other variables showed no significant correlations. The highest correlation coefficient between the BKB-SIN and ICF items were related to *working memory function* (ICF-Q3), *background noise barrier* (ICF-Q16), *dizziness and imbalance sensations* (ICF-Q8). Whereas the highest correlation coefficient between the SSQ and ICF visual items were related to *attention function* (ICF-Q2), *working memory function* (ICF-Q3), *emotional function* (ICF-Q4), *visual acuity (eyesight) at a distance* (ICF-Q5), *dizziness and imbalance sensations* (ICF-Q8), and *background noise barrier* (ICF-Q16). The correlation coefficients between the ICF CSHL items and the values of specified measures are presented in Table 7.

3.2 Exploratory factor analyses (EFA)

The purpose of this multivariate statistical approach is to explore the underlying structure among this large set of variables related to hearing. To identify common key factors and potential synergistic interactions we ran the EFA by adding variables that cover ICF domains related to hearing. For example, to cover the body structure, we added the pure-tone average (PTA) for worst and better ear. To cover the body functions, activities limitations and participation restrictions, environmental factors, we added the 17 items of the ICF- CSHL-based questionnaire. Since we only had 38 hearing aids users, the ICF-Q15 was replaced by binary classification (1=non hearing aids users, 2=hearing aids users). The Kaiser-Meyer-Olkin measure verified marvelous sampling adequacy (KMO=.90) for the analysis as indicated by Kaiser (1974). Bartlett's test of Sphericity (approximate $\chi 2$ [171, n=131] =1169.1; p<.001) indicated that the relation between items was sufficiently large for the analysis. The Goodness-of-Fit test was adequate [$\chi 2$ (86, n=131) = 70.9, p = .87].

Table 7. Pearson correlation coefficient between 17 ICF items, personal factors, and pure-tone average (PTA), Bamford-Kowal-Bench Speech-In-Noise (BKB-SIN), and SSQ, Speech, Spatial, and Qualities of Hearing Scale

ICF items	Audiologic outcomes		
Body Functional Domain	PTA r (n=131)	BKB-SIN r (n=131)	SSQ r (n=131)
Q1. What is the extent to which your personality or mood distinguish you from others?	.21*	.21*	-.31**
Q2. What is the extent to which you can maintain your focus for a period of time or on two more things at the same time?	.35**	.32**	-.48**
Q3. What is the extent to which you can remember things and recall new information?	.37**	.41**	-.55**
Q4. What is the extent to which you feel unhappy or depressed?	.17*	.23**	-.40**
Q5. What is the extent to which you can see friends over a distance (within 6 feet)?	.26**	.28**	-.52**
Q6. What is the extent to which you can understand the speech of significant others in noise or over distance?	.64**	.60**	-.71**
Q7. What is the extent to which you have ringing in your ears?	.26**	.18*	-.24**
Q8. What is the extent to which you feel dizzy or imbalanced?	.42**	.36**	.46**
Activities and Participation Domain			
Q.9 What is the extent to which you have difficulty listening to the television, radio, or movies?	.54**	.55**	-.62**
Q.10 What is the extent to which you have difficulty understanding a statement or question during communication activity?	.62**	.53**	-.65**
Q.11 What is the extent to which you have difficulty starting, continuing, or ending a conversation, or speaking with several people in a group?	.50**	.41**	-.63**
Q.12 What is the extent to which you have difficulty to use coping communication strategies (ask to repeat, rephrase, read lips, reposition your body or head, etc.)?	.48**	.40**	-.50**
Q.13 What is the extent to which you have difficulty maintaining family relationships?	.17*	.22*	-.40**
Q.14 What is the extent to which you have difficulty socializing with your family or friends?	.25**	.21*	-.35**
Contextual Domain			
Q.15 If you think about your environment, how would you rate the usefulness of the hearing technology you use during listening-conversation activities? (n=38)		-.18	.22
Q.16 If you think about your environment, how would you rate the level of noise background during listening-conversation activities?	-.50**	-.42**	.50**
Q.17 If you think about your environment, how would you rate the support you received from the close family members during listening-conversation activities?	.05	-.11	-.05
Age	.31**	.31**	-.15
Gender	-.23**	-.07	.12
Education	-.08	-.09	.00
Living arrangement	.04	.06	.08
Health condition	.00	.05	.06

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at the 0.05 level (2-tailed)

The model provided a five latent factors solution, which explained 56.4% of hearing disability variances. The first four factors represent a *disability aspect*, while the fifth factor represents a *functioning* aspect of the ICF:

- The key predictors in Factor 1 were: *self-reported hearing impairment/difficulty* (ICF-Q6, ICF-Q9 through Q12), *background noise barrier* (ICF-Q16), and *tinnitus* (ICF-Q7) respectively.
- The key predictors in Factor 2 were: *cognitive and psychosocial impairments* (ICF-Q1 through Q4), *maintaining family relationship difficulty* (ICF-Q13), and *socializing difficulty* (ICF-Q14) respectively.
- The key predictors in Factor 3 were: the *magnitude of HL* as indicated by PTA (hearing sensitivity level) in hearing aids users.
- The key predictors in Factor 4 were: *dizziness and imbalance sensations* (ICF-Q8) and *visual acuity (eyesight) at a distance* (ICF-Q5).
- The key predictors in Factor 5 were: *absence of reported impairments, activities limitations and restrictions, and physical environment and social context barriers.*

The rotated structure matrix demonstrated the inter-correlations between the magnitude of HL as measured by the PTA (hearing sensitivity level) and ICF items:

- Factor 1 showed the involvement of *background noise barrier* (ICF-Q16), *working memory* (ICF-Q3), *visual acuity (eyesight) at distance* (ICF-Q5), *attention* (ICF-Q2), *dizziness and imbalance sensations* (ICF-Q8), *emotion* (ICF-Q4), and *tinnitus* (ICF-Q7) on the connection between magnitude of HL as indicated by measured the PTA (hearing sensitivity level) and self-reported hearing impairment/difficulty as indicated by [ICF-Q6, ICF-Q9 through ICF-Q12). The loading of these items on Factor 1 was > .40 and was ordered respectively.
- Factor 2 showed the involvement of cognitive-psychological difficulties [*Personality and temperament* (ICF-Q1), *attention* (ICF-Q2), *emotion* (ICF-Q4), and *working memory* (ICF-Q3)], *socializing* (ICF-Q14)], *family relationship* (ICF-Q13), *background noise barrier* (ICF-Q16*), visual acuity (eyesight) at a distance* (ICF-Q5), and *dizziness and imbalance sensations* (ICF-Q8) on the connection between magnitude of HL as indicated by the PTA (hearing sensitivity level) and self-reported hearing impairment/difficulty [ICF-Q6, ICF-Q9 through Q12). The loading of these items on Factor 1 was > .40 and was ordered respectively.
- Factor 3 showed the involvement of hearing aid use, *background noise barrier* (ICF-Q16), and *dizziness and imbalance sensations* (ICF-Q8) on the connection between the magnitude of HL as indicated by the PTA (tween the hearing sensitive ty level) and the self-reported hearing impairment/ difficulty [ICF-Q6, ICF-Q9 through Q12). The loading of these items on Factor 1 was > .40 and was ordered re spectively.
- Factor 4 showed the involvement of *dizziness and imbalance sensations* (ICF-Q8), *visual acuity (eyesight) at a distance* (ICF-Q5), *socializing* (ICF-Q14), *emotion* (ICF-Q4), *working memory* (ICF-Q3), *attention* (ICF-Q2) on the connection between magnitude of HL as indicated by the PTA (hearing sensitivity level) and the self-reported hearing impairment/ difficulty [ICF-Q6, ICF-Q9 through Q12). The loading of these items on Factor 1 was > .40 and was ordered respectively.

The factors correlational matrix showed a modest correlation between Factor 1 and Factors 2, 3, 4 (r = .54, .61, .57 respectively), a modest correlation between Factor 2 and Factors 1, 3, 4 (r = .54, .32, .50 respectively), a modest correlation between Factor 3 and Factors 1, 2, 4 (r = .57, .50, .41 respectively); while Factor 5 showed no correlation with other factors. The rotated pattern matrix (regression coefficients of the factor model equation), structure loading matrix (correlations between factors and variables), and correlation matrix between factors are presented in Table 8.

Discussion

The questionnaire appears to be a valid method to identify a pattern of hearing related deficits and several fundamental elements. Additionally, it appears to capture potential interactions among the variables based on the ICF concepts despite the presence of weak or non-significant correlations of some ICF CSHL single-item scales with the standardized validating measures. The important concept to recognize in this analysis is that the ICF categories are hierarchically organized, which makes the qualitative nature of factors linked either directly or indirectly. Therefore, because of this hierarchical organization, it is not surprising that there are variations in size of the correlations between ICF CSHL with some being quite large and others relatively small in comparison to the single-item scales. In this study, we used a horizontal and vertical approach to assess each category. For example, when patients reported some degree of perceived hearing disability in clinical practice, pure tone audiometry, self-report questionnaires and/or speech audiometry were used to verify patients' complaints. Similarly, when patients complained of bothersome sensations related to HL, specific-condition self-report questionnaires were used to verify patients' complaints accompanied with other objective measures. Furthermore, to measure the non-audiologic factors such as visual, psychosocial-cognitive, and their environmental determinants such assessment may require additional referral or testing. This method was reflected on some observed strong, weak, and non-significant correlations which are equally important to discuss.

The observed strong or moderate correlations were found between ICF scales of ear symptoms/signs (HL, perceived hearing impairment, tinnitus, and dizziness) and ICF scale related emotion function, and their representative outcome measures. In terms of HL, it is well accepted that the magnitude of the HL can impact the following categories related the hearing functions [Sound detection (b2300), Sound discrimination (b2301), Localization of sound source (b2302), Lateralization of sound (b2303), Speech discrimination (b2304)] as well as the categories related skills [Listening (d115), Communication (d310), Conversation (d350), Using Communication Techniques (d360)]. This granular information was reflected in the strong or moderate correlation between ICF-Q6 (What is the extent to which you can understand the speech of significant others in noise or over distance?) and the clinical hearing tests (PTA, BKB-SIN, and SSQ). In terms of perceived hearing impairment, tinnitus, dizziness, and emotion, a strong or moderate

Table 8: The five-factor solution of the ICF CSHL-based questionnaire obtained by principal component analyses with the Promax rotation method

Items Summary		Rotated Pattern Matrix (Regression Coefficients of Factor Model Equation)					Rotated Structure Matrix (Inter-correlation)				
Body Structure		F 1	F 2	F 3	F 4	F5	F 1	F 2	F 3	F 4	F5
PTA: Average of hearing thresholds of better ear		.20	-.04	.75	.07	-.06	.68	.34	.90	.48	-.06
PTA: Average of hearing thresholds of worst ear		.22	-.05	.78	-.01	.02	.67	.31	.90	.40	.03
Short descriptions of ICF CSHL-based questionnaire in Body Function Domain											
Q1	Temperament & Personality function	-.10	.93	.03	-.12	-.25	.32	.81	.22	.33	-.21
Q2	Attention function	-.07	.63	.14	.11	.17	.44	.70	.34	.42	.17
Q3	Working memory function	.18	.40	.05	.16	.20	.54	.60	.35	.45	.25
Q4	Emotional function	.05	.60	-.14	.19	-.06	.40	.67	.16	.47	-.06
Q5	Seeing function	.06	.10	-.16	.71	.14	.47	.47	.22	.73	.05
Q6	Hearing function	.92	.05	.07	-.18	.05	.90	.48	.58	.40	.16
Q7	Tinnitus sensation	.43	-.03	.01	-.05	.02	.40	.17	.24	.18	.06
Q8	Dizziness and imbalance	-.10	.04	.15	.75	.07	.43	.40	.40	.75	-.03
Short descriptions of ICF CSHL-based questionnaire in Activities Limitations and Participation Restrictions Domain											
Q9	Listening	.94	.06	-.10	-.10	-.27	.83	.48	.46	.47	-.17
Q10	Communication	.70	-.01	.07	.16	-.13	.81	.46	.56	.60	-.09
Q11	Conversation	.59	.27	-.03	.02	.02	.70	.60	.41	.48	.08
Q12	Communication techniques	.68	-.25	-.05	.31	.06	.70	.26	.41	.55	.07
Q13	Family relationships	.17	.57	-.08	-.13	.21	.37	.57	.14	.20	.26
Q14	Socializing	-.05	.55	.03	.18	-.26	.34	.62	.25	.48	-.27
Short descriptions of ICF CSHL-based questionnaire Items in Environmental Domain											
Q15	Hearing technology	-.16	.05	.81	-.04	.16	.36	.22	.72	.21	.14
Q16	Sound (noise) intensity	-.46	-.12	-.15	-.00	-.17	-.64	-.43	-.47	-.37	-.22
Q17	Support from family	-.04	-.03	.06	.08	.20	.04	.00	.06	.03	.20

correlation was related to the content of each outcome measure. Usually, psychosocial or cognitive (e.g., attention) or environmental elements are substantially added to the subjective outcome measures to indicate the severity of health problem and to monitor changes of physical and functional-related health problem as in SQQ, DHI, TFI, and GDS outcome measures. This was reflected by the strong correlations between ICF-Q4 (What is the extent to which you feel unhappy or depressed?) and GDS, between ICF-Q7 (What is the extent to which you have ringing in your ears?) and TFI, and between ICF-Q8 (What is the extent to which you feel dizzy or imbalanced?) and DHI. Further, it is well accepted that there is an interchange relationship (cause-effects) between the psychosocial and cognitive functions, thus, collectively categorized under the mental function chapter in the ICF. This along with the EFA model supports our argument in the discussion section that there is no reason to think that the psychosocial and cognitive difficulties may differ between the three conditions (HL, tinnitus, and dizziness) and that stratifying effects can make measuring treatment outcomes of HL easier to achieve.

The observed weak or non-significant correlations can also be interpreted in the light of the EFA model. The first weak correlation was found between ICF-Q1 (What is the extent to which your personality or mood distinguish you from others?) and BFPI that measures the five dimensions of personality. Given that personality traits are etiologically heterogeneous and that the BFPI measure is well defined/detailed as compared to ICF-Q1, weak correlations would be expected. Interestingly, the direction and size of the correlations between ICF -Q1 and BFPI measure highlighted a specific pattern of personality: high on neuroticism, low on agreeableness, low on conscientiousness, and low on extraversion. Individuals with such a pattern are more likely than average to be moody and to experience a wide range of emotional liability and temperamental sensitivity to negative stimuli such as anxiety, depressed mood, and loneliness (Goldberg, 1993; Klein, et al., 2011). Also, they are more susceptible to cognitive decline and may be in the preclinical phase of Alzheimer Disease (Wettstein, et al., 2017; Terracciano, et al., 2017). This may explain why personality and temperament function (ICF-Q1) was highly inter-correlated with emotion (ICF-Q4) and cognitive (ICF-Q2, ICF-Q3) functions (see Factor 2, Table 8). Individuals with such a pattern, are more likely to report social (ICF-Q13 and ICF-Q14), communication difficulties (ICF-Q9 through ICF-Q11), sensory or perceptual impairments (ICF-Q5, ICF-Q6, ICF-Q8), and somewhat abnormal auditory behavior toward noise distraction (ICF-Q16). However, the structure of Factor 2, reminded us of a connection between the mild impact of HL and dementia-like symptoms that encompasses all these problems, as estimated from the size of the correlation coefficient of the hearing sensitivity level. In support of our findings, these possible connections were captured by the ICF Core Sets for Depression (https://www.icf-research-branch.org/icf-core-sets-projects2/mental-health/icf-core-set-for-depression) and by the clinical framework for assessing the patient presenting with altered hearing and cognitive impairment (Hardy, et al., 2016). In Hardy's et al. paper, one of the associated features that may play a role in some syndromes with peripheral or subcortical hearing impairment and dementia was the vestibulopathy and vertigo/dizziness. Those disorders are almost associated with a slight, minimal or normal audiogram, dizziness/imbalance, a heavy burden of psycho-cognitive difficulties, and abnormal behavior to sound. The role of dizziness (ICF-Q8) was much more obvious in Factor 2 than the HL (as estimated from the loading coefficient). Table 5 provided additional support Factor 2.

The second weak correlations were found between ICF-Q2 (What is the extent to which you can maintain your focus for a period of time, or on two or more things at the same time?), ICF-Q3 (What is the extent to which you can remember things and recall new information?), and cognitive measures including: MoCA (Montréal cognitive assessment), DSB-V (working memory via visual modality), and BTA (divided attention) tests. We compare ICF-Q2 and ICF-Q3 with total scores only because the MoCA test was selected to measure the global cognitive ability and not specific cognitive function. Given the broader scope of the MoCA measure, lower correlations would be expected with ICF-Q2 (r = -0.17). In the MoCA test, the working memory domain accounts for 5 points, while attention and working memory account for 13 points, which is equal to 43.3% of total score. The incremental increase in the magnitude of correlation (r = -0.25) suggests that additional cognitive abilities in MoCA domains were negatively impacted. Regarding DSB test, the correlation between ICF-Q2 and DSB found to be better (r = -0.30) than the correlation between ICF-Q3 and DSB (r = -0.21). This finding has two possible interpretations. First, is that the DSB is not a pure memory test, but rather a test for an intertwined relationship between attention and working memory (e.g., higher DSB scores indicate excellent attention and good working memory) as suggested by Groth-Marnat and Baker (2003). Another possible explanation that older adults who perform worse on demanding working-memory tasks requiring cognitive-control show the greatest bias toward negative information about their working memory (Mather & Knight, 2005). Regarding the BTA (divided attention) test, the correlation between and ICF-Q2/ICF-Q3 and BTA test was found to be steady and slightly better than the DSB (r = 0.34 and r = -0.32 respectively). This finding is consistent with studies that have reported older adults engaged in divided-attention tasks display no positivity bias towards information (Wilson, et al., 2004; Yaffe, et al., 1999), are more prone to have neuropsychiatric conditions that are characterized by attentional impairment (Schretlena, et al,. 1996) or to have two levels of chronic conditions (Rook, et al.,2007).

An alternative explanation for lower correlations among ICF-Q2, ICF-Q3 and the three cognitive measures is related to the difference between objective and subjective measures and to the intertwined relationship between cognitive and psychosocial problems as in many multi-items subjective measures (Fiske, et al., 2009). For example, in many multi-items subjective measures, cognitive impairment and dementia have been examined in relation to well-defined episodes of psychosocial problems. Given that the ICF-Q2 or ICF-Q3 is a subjective single-item measure, a lower correlation would be expected. The association between greater psychosocial problems and poorer cognitive functioning as in Factor 2 does support this interpretation.

The third low correlations were found between the ICF-Q16 (If you think about your environment, how you would rate the level of background noise during listening-conversation activities?) and ANL test. One would expect that the low correlation (*r*= .30) was observed because the acceptance of background noise intensity may differ between environments. Here, we argue it does not. Our argument is based on a study that reported a non-significant correlation between ANL test and subjective multiple-item measure based on preference for background sound and the listeners' preference for background sound (Freyaldenhoven, et al., 2006). Despite the correlation size, our single-item scale performed better than the in assessing ANL than the method used in Freyaldenhoven, et al., study. The better performance in our study is related to the hierarchical structure of the ICF and ICF terminology as previously discussed. For example, according to the ICF, (e250) Sound category has two further levels/taxonomies: the Sound intensity (e2500) and Sound quality (e2501) which is differing from the levels/taxonomies of Conversation activity (d350): the Conversing with one person (d3503) and Conversing with many people (d3504). It is well known that there is a relationship between hearing aids and ability to accept a level of background intensities (Freyaldenhoven, 2007). In light of EFA model, the interaction between the magnitude of HL and the extreme barrier of background intensities level is the key factor that induces poorer auditory impairment/difficulty (ICF-Q6, ICF-Q9 through ICF-Q12) as seen Factor 1. Poorer auditory impairment/difficulty can be explained by 1) direct effects of two indicators on auditory limitations, 2) by indirect effect via psycho-cognitive problems associated with HL or with other sensory limitations, and 3) by inadequate hearing aid input due to the quality of fit or hearing aids. More importantly, despite the poorer impairment/difficulty, personality (ICF-Q1), family relationship (ICF-Q13), and participation in the social event (IC-Q14) seem to be less obvious. This indicates the important role of these items in preventing social isolation and dementia. By contrast, when background intensities level was not an extreme barrier the relationship between HL and hearing aid is stronger as in Factor 3. The residual auditory impairment/difficulty in Factor 3 can be judged in several ways: 1) inadequate hearing aid input due to quality of fit or hearing aids, 2) magnitude of HL or hearing disability before hearing aids fitting, 3) co-morbidity with dizziness, and 4) barrier of background intensities level in some circumstances. Understanding all the possible interactions in an integrated method would improve our ability to evaluate and treat patients at risk of developing lower auditory capacity and greater hearing disability at initial diagnosis, before and after the hearing aids fitting. Further, consideration of such problems helps clinicians to overcome the fragmentation of care and to improve inter-professional collaboration across settings.

More importantly, in our previous study, we empirically investigated the relationship between hearing disability and social isolation using our set of measurement instruments (Al fakir, doctoral dissertation, 2016). A structured equation modeling showed a close relationship between SSQ and BKB-SIN and total scores of these measures including, ANL (acceptance noise level), DHI, TFI, and BTA. This relationship is independent of cognitive measures related working memory and has become dependent when mild cognitive decline, as measured by MoCA test, and depressive symptomatology, as measured by GDS (Geriatric depression scale) were combined. Also, Al fakir found that the relationship between ANL and DHI had positive and negative aspect and measured visual acuity was not a significant predictor. This is almost consistent with the EFA model, except for the visual acuity at a distance as measured by the Snellen chart, which found to be a non-significate predictor. The authors attributed this difference to two reasons. The first reason was due to participants' characteristics, in which the majority have had corrected vision and variation in actual visual acuity performance at a distance among groups was absent (see Table 1 and 5). The second reason may be related to impaired visual sensory perception in patients with dizziness, dementia, or visual dysfunction (e.g., Glaucoma) even with corrected vision. In support to our findings, these possible connections were captured by the international works related vestibular, dizziness, and balance (Grill, et al., 2012).

The fourth low correlation was found between the RAS (Family relationship assessment) total score and ICF-Q13 (What is the extent to which you have difficulty maintaining family relationships?). Due to the heterogeneity of living arrangement in our sample size (see Table 1) and significant correlation with LSNS-12 (Lubben Social Network Scale-Revised) and social subscale of the DJG-LSIS (De Jong Gierveld Loneliness and Social Isolation Scale) tests, this low correlation would be somewhat expected. Maintaining family relationships is crucial for participation in conversations, attendance at social events, and reducing negative consequences of HL and subsequent impairments. Based on Hickson and Scarini (2007) and Grenness, et al. (2016) papers, the family relationship may classified as a category within the activity limitations/participation restrictions domain when information directly obtained from hearing-impaired person or may classify as a category within the environmental factors when information obtained from the significant others (the third-party disability concept). Third-party disability is referred to the impaired functioning of family and friends due to the health condition of their significant other (WHO, ICF, 2001). In our study, we have 86 participants who are living with their significate other (spouse) and both have participated in data collection. Subsequently, the correlation between the ICF-Q13 and BKB-SIN and SSQ could be related to both exchange pathways (i.e., the respondents may interpret the single-item in a more personalized manner in relation to their or significant other health problems).

The fifth low correlation was found between ICF-Q17 (If you think about your environment, how you would rate the support you received from close family members during listening-conversation activities?) and the LSNS-12 (Lubben Social Network Scale-Revised) and social subscale of the DJG-LSIS (De Jong Gierveld Loneliness and Social Isolation Scale) measures. We suggest that respondents may interpret the single item in a more personalized manner. For example, some may weigh the importance of certain types of positive social versus negative affect situations of support differently; others may consider scenarios that are explicitly covered by both measures (LSNS-12 or DJG-LSIS) based on the level of chronic conditions they have. This interpretation is consistent with the EFA model in which observed the loading of LSNS-12 was not obvious across factors as compared to the loading of DJG-LSIS total score in Factor 4 and Factor 2. Consequently, a correlation between LSNS-12 and BKB-SIN or SSQ was not significant. Certainly, lack of correlation does not imply lack of social support effect, but it may imply that the DJG-LSIS measure did much better than the LSNS-12 measure. These findings are consistent with Grenness, et al. (2016) case example.

Finally, age and gender correlations with HL are remarkably consistent across the literature. In our study, we found a significant correlation between gender and PTA, in which females could be more sensitive detecting changes in their hearing as compared to males (Kricos 2000). Unlike Banh, et al., (2012) findings, however, a correlation between age and SSQ was lacking. Certainly, lack of correlation does not imply the absence of age effect, but it may imply the mediation/moderation effects of functional problems measured by the ICF items more than the age effect on SSQ.

To our knowledge, this is the first study that creates an ICF CSHL-based questionnaire to measure the presence and magnitude of selected factors contained in the CSHL. Measuring the ICF CSHL using the structured questionnaire format is a feasible and reliable method when completed from patient's perspective and regardless of their cognitive status. This is consistent with Beauchet, et al. (2014) who found that cognitive impairment does not influence older adult's ability to evaluate their health and functional status. Further, the scores of the ICF CSHL-based questionnaire as compared to the corresponding instrument measurements as seen in Table 4 and 5 provided further clinical validity and suggest the potential clinical use of the questionnaire. The ICF CSHL-based questionnaire can be used as a template to screen for functioning and disability aspects before hearing evaluation/consultation. Additionally, it could be used to monitor changes over time after initial ear diagnosis, and to tailor rehabilitative treatment to the individual. Furthermore, this questionnaire could be used to compare a patient's reported functional status reflected by their responses to the ICF CSHL questions with other clinically accepted hearing related outcome measures.

The present study, like all studies, was not without limitations. First, our study was completed in a sample of non-clinical older adults, fairly well educated, and of a higher social, economic status. Second, only 23 categories were used in this study; consequently, a potential contribution of uncovered categories requires an additional study. Third, the argumentative process of questions to operationalize the data model was guided by feasibility rather than the efficiency and granularity. The argumentative process of questions that weighs efficiency and granularity seems to be the next important step to enrich the current version of our data model.

Conclusion

Chronic hearing disability is a complex condition. Identifying which factors may confound each person's disability is a challenge and requires significant effort for clinicians to manage. The ICF-based questionnaire presented here can be one tool that clinicians may be able to use in the future to assist in this process. By using it, we shift our attention from the biomedical perspective to a biopsychosocial perspective, which is essential in considering the whole patient. In addition to the magnitude of HL, tinnitus, and psychosocial-cognitive impact as common factors that can modulate hearing disability, the ICF CHSL-based questionnaire captures the role of dizziness and imbalance sensations on the level of hearing disability. Moreover, by including questions that reflect personal and environmental factors helps to highlight how these areas affect a patient's activity limitations and participation restrictions in daily life. Understanding these possible interactions in our patients should improve our ability to evaluate and treat them holistically at the initial diagnosis and before the hearing aid fitting. We suggest that the ICF-based questionnaire is sufficient to measure functioning and disability in older adults, to identify common factors and fundamental elements, and to capture potential interactions based on the ICF concept. Furthermore, this ICF-CHSL based questionnaire may enhance the delivery of audiological services, treatment, and rehabilitation in the future. Additional research is required, to determine the dual impact of HL and dizziness and balance-based limitations on hearing aid outcomes.

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Appendix "A"

Demographic information

Sex: [ ] Female [ ] Male **Age: …………………**

Years of formal education:
[ ] High school (12 years) [ ] B.S (14 - 16 years) [ ] Professional degree=MS, Ph.D (>16 years)

Current marital status
[ ] Never married [ ] Married [ ] Divorced [ ] Widowed

Do you live alone or with other people?
[ ] Live with spouse
[ ] Live with other relatives or friends
[ ] Live with other unrelated individuals (paid help etc.)
[ ] Live alone

Current occupation
[ ] Retired
[ ] Paid employment
[ ] Self-employed
[ ] Unemployed (health reason)
[ ] Unemployed (other reason)
[ ] Non-paid work, such as volunteer/charity

Medical diagnosis of existing main health conditions:
[ ] No medical condition exists
[ ] Yes there is medical condition exists Specify……………………………………………………………………………………..
……..

Please check one of these options:

1. I have no hearing aid/s [ ]

I have hearing aid/s: I use one hearing aid (left ear) [ ] I use one hearing aid (right ear) [ ]

If you have been using hearing aid/s, for how long?

_______ Years _______ Months ________weeks

Hours: [ ] Less than 1 hour a day [ ] 1 to 4 hours a day [ ] 4 to 8 hours a day [ ] More than 8 hours a day

If you have been using hearing aids, do your hearing aids help you understand the people you speak with most frequently?

Not at all — Extremely
0 1 2 3 4 5 6 7 8 9 10

If you have been using hearing aid/s, do your hearing aids reduce the number of times you have to ask people to repeat?

Not at all — Extremely
0 1 2 3 4 5 6 7 8 9 10

If you have been using hearing aid/s, do you think you're hearing aids working appropriately?

Not at all — Extremely
0 1 2 3 4 5 6 7 8 9 10