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Predictors of hearing loss disability: a multinational study using the ICF core set

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ABSTRACT

Purpose: Objective audiological assessments provide valuable insights on physiological dimensions of hearing loss (HL), but not on lived experiences and functional limitations perceived by individuals. This study employed the multidimensional ICF framework to explore how demographic and diagnostic variables predict self-reported disability in adults with HL.

Method: This cross-sectional study included 571 participants from India (94), South Africa (79), Sweden (219), and the USA (179). Responses from structured interviews based on the ICF were measured against demographic and diagnostic variables.

Results: 74.6% of the participants were hearing aid (HA) users with moderate-to-severe HL. Five statistically significant predictors were identified; HA usage, degree of HL, level of education, age, and income bracket. The predictors were associated with the ICF components; body functions (b126, b210, b230, b240), activity and participation (d310, d350) and environmental factors (e125, e250, e310, e355, e410, e460).

Conclusions: This study emphasises that an individual's experience with HL is significantly influenced by various factors beyond the severity of the HL itself. This underscores the ICF's utility in capturing the complex interplay of biopsychosocial factors on HL. Identifying significant predictors could aid in tailoring interventions to improve health outcomes and quality of life for individuals with HL.

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Self-experience; disability; hearing loss; ICF; associated predictors

Introduction

Disability is commonly perceived as an inherent and inescapable consequence stemming from an individual's alteration or deterioration in health, deviating from the established norm (Goering 2015). Society typically views individuals with disabilities as requiring interventions or care to rectify the disability, reinstate regular functioning, or facilitate their adaptation and acquisition of skills to navigate life despite the disability (Falvo and Holland 2017). Regrettably, many of these conditions are not curable, and those affected often do not experience complete alleviation of their symptoms (Goering 2015). For numerous individuals grappling with disabilities, including hearing loss (HL), the sources of frustration do not primarily emanate from intrinsic bodily factors but rather stem from the unwelcome reception these individuals encounter within society. This phenomenon can be attributed to various factors, such as physical infrastructure, institutional conventions, and societal attitudes, which tend to either exclude or denigrate individuals with disabilities (Heffernan et al. 2016). To gain an improved understanding of how a disability impacts an individual's life, it is important to closely examine the subjective effect of the disability on the affected individual/s and its ramifications in their daily life.

HL is a complex disability with profound implications for communication, a pivotal element that underpins societal inclusion and daily functioning. From a biopsychosocial perspective, HL affects individuals biologically, psychologically, and socially. Biologically, HL causes functional impairment, with no definitive cure for sensorineural hearing loss (WHO 2021). Rehabilitation includes hearing devices, ranging from invasive options such as cochlear implants, bone-anchored hearing aids, and auditory brainstem implants, to more commonly used non-invasive alternatives like hearing aids and assistive listening devices. Physiological and psychological impacts of HL can include anxiety, depression (Contrera et al. 2017), listening fatigue (Davis et al. 2021), and cognitive decline (Michalowsky, Hoffmann, and Kostev 2019). Socially, HL can give rise to challenges in interpersonal relationships with partners and children, leading to isolation, stigmatisation, constrained career choices, and occupational stress (Shukla et al. 2020).

Addressing HL through rehabilitation necessitates a person-centred, multidimensional approach. The International

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Classification of Functioning, Disability and Health (ICF) model presents a comprehensive biopsychosocial model of health and disability that focuses on an individual in a given context. The ICF was endorsed by the WHO in 2001 and is a classification and conceptual model of health and disability. Moreover, the ICF acknowledges that while the potential for experiencing disability may arise from a difference or impairment in an individual's health, the experience of disability is a complex phenomenon. It moves beyond the diagnosed degree or cause of the HL and focuses on the extent it affects the individual's daily functioning (Rauch et al., 2012). The ICF follows a hierarchical approach and consists of two parts: (i) functioning and disability, and ii) contextual factors (Figure 1). Functioning and disability consist of the components *body functions and body structures* and *activity and participation* with contextual factors including *environmental* and *personal components*. It currently serves several purposes, such as a foundation for policymaking, clinical work, instrument development and education, and as a scientific base for studying health.

The ICF Core Sets for Hearing loss were established in 2013 and were developed according to ICF research branch recommendations (ICF Research Branch 2017). A core set is a short version of the ICF especially designed for a specific health

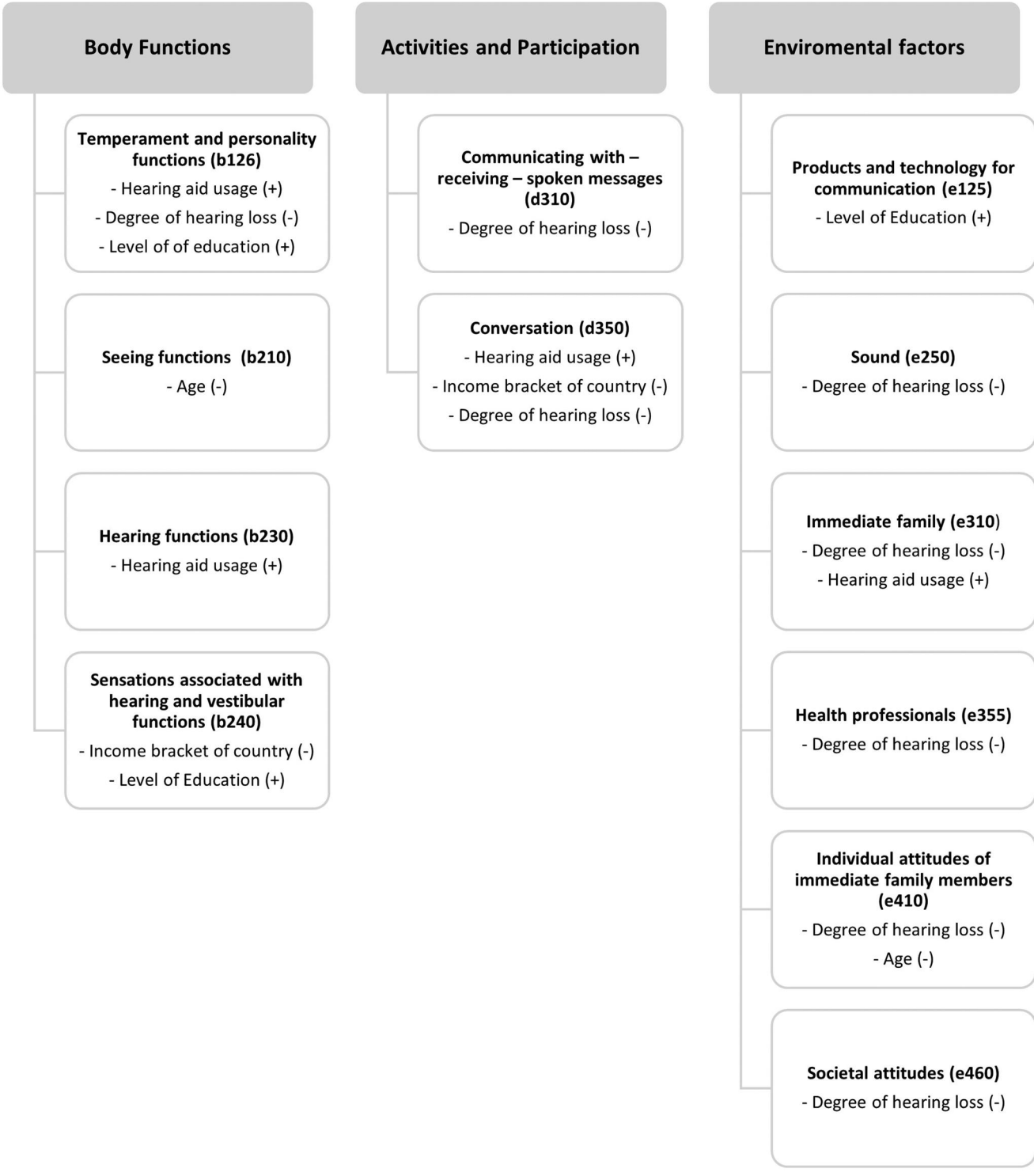

Figure 1. Significant ($p<.05$) predictors across ICF components.

condition, circumstance, or situation (e.g. hearing loss, vocational rehabilitation) (Selb et al. 2015). There are two types of core sets: (a) the comprehensive core set which includes the vast majority of ICF categories relevant to the specific health condition and (b) the Brief Core Set is a shortened version of the Comprehensive Core Set covering the most central aspects (Selb et al. 2015). The content and construct validity of ICF Core Sets for hearing loss have also been evaluated across several studies indicating satisfaction (Alfakir, Holmes, and Frans 2015; Karlsson et al. 2021; Van Leeuwen et al. 2017). The ICF core sets have also been used across several audiology studies focusing on older adults with sensorineural hearing loss (Alfakir et al. 2019), individuals with dual sensory loss (Jaiswal et al. 2019), single-sided deafness (Durisala et al. 2017), tinnitus (Beukes et al. 2018), Meniere's disease (Levo et al. 2010) and with clients who are cochlear implant users (Morettin 2013). There are also questionnaires developed based on the ICF Core sets for HL (Afghah et al. 2022; Afghah et al. 2024; Karlsson et al. 2023).

Despite the ICF's importance in audiological rehabilitation, there remains an unexplored relationship between diagnostic findings and perceived challenges within the ICF framework. The impact of HL should not be determined solely by the audiometric severity of the loss but should be measured by the extent to which the individual and their environment are affected by it. Understanding how demographic and diagnostic variables predict self-reported disability can inform tailored interventions and improve patient outcomes. This study hypothesises that factors such as hearing aid usage, degree of HL, age, education, and income may be significant predictors of self-reported disability, influencing various components of the ICF framework, including body functions, activity and participation, and environmental factors. This study therefore employed the multidimensional International Classification of Functioning, Disability, and Health (ICF) framework to explore the relationship between demographic and diagnostic variables and self-reported disability in adults with HL.

Method

The study used a cross-sectional design and included secondary data collected from an international clinical population (Karlsson et al. 2021). Ethical approval was obtained from all local institutional review boards within each countries including Sweden (The Swedish Ethical Review Authority; 2018/252), India (Manipal Academy of Higher Education; 844/2018), South Africa (University of Pretoria; 495/2018) and the United States (Lamar University; IRB-FY18-387).

Participants

The study sample comprised participants from India ($n = 94$), South Africa ($n = 79$), Sweden ($n = 219$) and the US ($n = 179$). Participants data was included if they were adults (aged $>$ 18 years) with mild to profound HL (as defined by the WHO 2021). Participants were recruited in accordance with the hearing health care services provided in each of the specific countries. Participants from India and South Africa were recruited using convenience sampling and were recruited using stratified sampling in Sweden based on their audiograms, for the USA they were recruited using consecutive sampling.

Materials

An interview guide which was made up of two sections included: (i) demographic data, and (ii) an operationalised version of the Brief ICF Core Set for HL (Supplementary digital content 1) developed by Karlsson et al., (2021). The demographic data consisted of five items, including, year of birth, gender, residential country (based on income bracket), if the participant was using hearing aid/s, and the highest level of education. The operationalised version of the Brief ICF Core Set for HL comprises 27 of second-level ICF categories covering the most central aspects of disability and functioning in relation to HL. These included seven body function categories (b126, b140, b144, b152, b210, b230, b240), four body structure categories (s110, s240, s250, s260), nine activity and participation categories (d115, d240, d310, d350, d360, d760, d820, d850, d910), and seven environmental factors (e125, e250, e310, e355, e410, e460, e580) (For full description of the items, see Supplementary digital content 2). As the ICF categories were not designed as a measurement tool, but rather consists of descriptions of each category, they were operationalised into more specific questions with a hearing focus to enhance its applicability in clinical settings. This adaptation included reducing the categories from 27 to 23, removing 'body structures' due to its impracticality in an interview format and removal of "listening" (d115) due to measurement difficulties (Karlsson et al. 2021). The category "recreation and leisure" (d920) was added to complement "community life" (d910).

The ICF categories were assessed using a 5-point rating scale recommended by the WHO (2001), with response options ranging from "no problem" to "total problem". Additional options included "not enough information" and "not applicable". For body function and activity/participation components, the ratings reflected self-experienced problems, while environmental categories reflected impact. Impact can however be perceived as either facilitative or a barrier depending on the environment and situation (WHO 2001), although the positive impact was not captured using the rating scale (Manchaiah et al. 2015).

Data collection

Data were collected from 2018 to 2019. Participants underwent diagnostic audiometry and a structured interview based on the Brief ICF Core Set for HL. Diagnostic testing adhered to ISO standards (ISO 8253-1), and degree of hearing loss was categorised according to WHO guidelines (2021) into better-ear four frequency pure tone averages (4fPTA). To ensure the reliability of the interviews, all participating professionals received a one-hour online training session created by the project group (led by the last author) before data collection commenced. Across all included centres, hearing health care professionals recruited participants and performed the data collection, and all participants signed an informed consent prior to participation.

Data analysis

Data were analysed using SPSS version 29. Descriptive statistics summarised demographics and ICF category ratings. Frequency analysis across categories for the distribution of the response options is available in Supplementary digital content 2. Ordinal logistic regression models were employed to analyse ordered dependent variables, providing interpretable results in terms of odds ratios (Exp). These models help elucidate the relationship between predictor variables and the ordered outcome categories.

The analysis included 22 models, each initially comprising six predictors: country (high-income vs. low- and middle-income), age (continuous), degree of HL (seven categories from no hearing loss to complete hearing loss), education level (three categories from low to high), gender (male vs. female), and hearing aid use (user vs. non-user). It should be noted that, in Table 1, five levels of education are shown; however, for data analysis purposes, the first three categories were combined and called "Less than high school" due to the sparse data in the first three categories.

A systematic stepwise procedure was used to refine each model. This involved iteratively removing the least significant predictor variable ($p > 0.05$) to achieve a final model containing only significant predictors. The goodness of fit for each model was evaluated using the Akaike Information Criterion (AIC), with lower AIC values indicating better-fitting models. In all cases, AIC values decreased from the full models to the final models (range of decrease: 533.71 to 2057.31), demonstrating improved fit.

Multiple imputations were performed to address missing data, as recommended by Van Ginkel et al. (2020). This method ensures robustness regardless of the type or amount of missing data. However, for the ICF category d820 (school education), only 25 valid responses (less than 30) were available. Given the limited dataset, multiple imputations were not practical, and no model was constructed for this variable. It should be noted that, b240 (Sensations associated with hearing and vestibular functions), d850 (remunerative employment) and e125 (Products and technology for communication) (see Supplementary digital content 2), were included in the analysis, as they had more than 30 valid responses which was sufficient based on the central limit theorem (Field 2018).

Results

Five hundred and seventy-one participants with an average age of 66.6 (13.9 SD, 18 - 100 range) participated in the study. Almost three-quarters (74.4%) were hearing aid users, with 40.3% presenting with a moderate degree of HL with a sensorineural origin (51.3%). Table 1 presents the summary of demographic variables.

Table 1. Demographics of the participants across all participating countries ($n = 571$).

Demographics	% (*n*)
Gender	
Male	51.0 (291)
Female	49.0 (280)
Education	
No education	0.5 (3)
Primary school	4.6 (26)
Secondary school	15.8 (90)
High school	40.3 (230)
University	38.8 (222)
Income bracket	
High income countries	69.7 (398)
Low- and middle-income countries	30.3 (173)
Degree of hearing loss	
Mild hearing loss	19.4 (111)
Moderate hearing loss	40.3 (230)
Moderately severe hearing loss	26.0 (149)
Severe hearing loss	10.0 (57)
Profound hearing loss	3.2 (18)
Complete or total hearing loss/deafness	1.1 (6)
Type of hearing loss	
Sensorineural	51.3 (293)
Conductive	10.0 (57)
Combined	38.7 (221)
Hearing aid users*	
Yes	74.4 (425)
No	24.4 (139)

* The total does not equate to 571 as 7 (1.2%) were unknown

Across the 3 components, there were five common predictors (Figure 1). In terms of body functions, four of the seven categories had significant ($p < 0.05$) association with predictor variables (Table 2), which included temperament and personality functions (b126), seeing functions (b210), hearing functions (b230) and sensations associated with hearing and vestibular functions (b240). The remaining three which included attention functions (b140), memory functions (b144) and emotional functions (b152) had no significant predictors.

For the activities and participation component, only two categories related to communication—communicating with receiving spoken messages (d310) and conversation (d350)—had significant predictors ($p < 0.05$) (See Table 3). These predictors were linked to the degree of hearing loss (HL) and hearing aid usage. Specifically, the degree of HL significantly predicted outcomes in both categories, while hearing aid usage was a significant predictor for d310. The remaining six categories—handling stress and other psychological demands (d240), using communication devices and techniques (d360), family relationships (d760), remunerative employment (d850), community life (d910), and recreation and leisure (d920)—did not have any statistically significant predictors. The category school education (d820) was excluded from the analysis due to an insufficient number of cases.

For environmental factors, the category health services, systems and policies (e580) were the only category not associated with any predictors (Table 4). The degree of HL was the most commonly significant predictor across the five other categories: sound (e250), immediate family (e310), health professionals (e355) and individual attitudes of immediate family members (e410) and societal attitudes (e460).

Discussion

The impact of HL should not be determined solely by the audiometric severity of the loss but should be measured by the extent to which the individual and their environment are affected by it. This study investigated the intricate interplay between demographic variables and diagnostic findings and their consequential association to the subjective experiences and reported disabilities among individuals with HL using a multidimensional approach such as the Brief ICF Core Set for Hearing Loss. Among the six included variables, five showed statistically significant associations across the various ICF categories which included four categories (b126, b210, b230, b240) for body functions, two categories (d310, d350) for activity and participation and six (e125, e250, e310, e355, e410, e460) for environmental factors. Only gender, which was almost evenly distributed, did not emerge as a significant predictor for any of the ICF categories. Other non-significant predictors, across the included categories, for the body function categories: attention functions (b140), memory functions (b144) or emotional functions (b152). The same was found for the environmental factor health services, systems and policies (e580). In terms of activity and participation, six categories including handling stress and other psychological demands (d240); using communication devices and techniques (d360); family relationships (d760); remunerative employment (d850); community life (d910); recreation and leisure (d920) did not have any significant associated predictors.

Table 2. Statistically Significant Predictors from Ordinal Regression Models for Body Function Categories in Adults with Hearing Loss.

ICF category (code)	Predictors	Beta (SE)	*p*-value	Odds ratio	95% CI
Temperament and personality functions (b126)	Hearing aid use	−0.393 (0.188)	0.037	0.675	[0.467, 0.976]
	Degree of HL	0.242 (0.073)	0.001	1.274	[1.104, 1.469]
	Level of Education	−0.299 (0.103)	0.004	0.742	[0.606, 0.908]
Seeing functions (b210)	Age	0.014 (0.006)	0.015	1.014	[1.003, 1.026]
Hearing functions (b230)	Hearing aid use	−0.405 (0.168)	0.016	0.667	[0.480, 0.927]
Sensations associated with hearing and vestibular functions (b240)	High income country	0.399 (0.175)	0.023	1.490	[1.057, 2.102]
	Level of Education	−0.260 (0.106)	0.014	0.771	[0.626, 0.949]

Table 3. Statistically Significant Predictors from Ordinal Regression Models for activities and participation.

ICF category (code)	Predictors	Beta (SE)	*p*-value	Odds ratio	95% CI
Communicating with – receiving – spoken messages (d310)	Degree of HL	0.215 (0.072)	0.003	1.240	[1.077, 1.428]
Conversation (d350)	Hearing aid usage	−0.555 (0.223)	0.013	0.574	[0.371, 0.888]
	High income country	0.453 (0.207)	0.028	1.572	[1.049, 2.357]
	Degree of HL	0.193 (0.073)	0.008	1.213	[1.051, 1.399]

Table 4. Statistically significant predictors from ordinal regression models for environmental factors.

ICF category (code)	Predictors	Beta (SE)	*p*-value	Odds ratio	95% CI
Products and technology for communication (e125)	Level of education	−0.215 (0.101)	0.032	0.806	[0.662, 0.982]
Sound (e250)	Degree of HL	0.205 (0.069)	0.003	1.228	[1.072, 1.407]
Immediate family (e310)	Hearing aid usage	−0.350 (0.178)	0.049	0.705	[0.498, 0.999]
	Degree of HL	0.389 (0.074)	0.000	1.476	[1.277, 1.705]
Health professionals (e355)	Degree of HL	0.165 (0.070)	0.018	1.179	[1.029, 1.352]
Individual attitudes of immediate family members (e410)	Degree of HL	0.215 (0.071)	0.003	1.239	[1.078, 1.425]
	Age	0.011 (0.005)	0.040	1.011	[1.001, 1.022]
Societal attitudes (e460)	Degree of HL	0.252 (0.073)	0.001	1.287	[1.115, 1.486]

Age association to ICF categories

While age was not significantly associated with hearing functions (b230), it was a significant predictor for visual functions (b210), aligning with existing research that both hearing and visual impairments worsen with age (Schneider et al. 2011). This investigation also revealed a notable link between advancing age and the influence of family attitudes (e410) on the daily lives of participants. The older the participant was the more the impact of their families' attitudes had on them. This is not an uncommon perception as families tend to take over responsibilities and tasks for the ageing family member which may be perceived negatively or positively by the ageing individual (Davidson and Guthrie 2019; Scarinci, Worrall, and Hickson, 2008; Singh, Lau, and Pichora-Fuller 2015).

Degree of hearing loss association to ICF categories

The severity of HL emerged as a significant predictor of the impact on immediate family (e310) and their attitudes (e410) on the daily functioning of participants. The greater the HL the more aware participants were of their families' attitudes towards them. Research has consistently shown that family attitudes towards individuals with HL tend to be negative due to communication breakdowns (Hickson et al. 2014; Meyer and Hickson 2012). Increased HL severity also led to greater challenges in hearing sounds (e250), communication (d310), and conversation (d350), contributing to withdrawal from essential activities as previously also demonstrated (Bennett et al. 2022).

Personality traits, although not specifically identified in this study beyond the temperament and personality functions (b126) category, were associated with HL severity, suggesting that individuals with more severe HL felt their personality traits supported their ability to handle their condition. It has also been found that the process of making decisions involves being informed, discovering information about hearing, and adjusting to the chronic nature of the HL (Claesen and Pryce 2012) which is dependent on attitudinal beliefs and cues to action (Meyer et al. 2014). Participants reportedly found that health professionals (e355) played a supportive role in their hearing journey, with more severe HL requiring greater clinician support. A recent review highlights that when audiologists use a person-centred approach, it encourages clients to actively collaborate in their hearing healthcare and well-being, thus supporting them in their hearing journey (Oosthuizen et al. 2022).

Hearing aid usage association to ICF categories

Hearing aid usage emerged as the second most common significant predictor, influencing four ICF categories: hearing functions (b230), conversation (d350), immediate family (e310), and temperament and personality functions (b126). Hearing aid users reported better hearing and sound localisation (b230) and fewer challenges in conversation (d350), aligning with the primary goals of hearing aid intervention (WHO 2021). This improvement in communication also affected family dynamics, with hearing aid users relying less on family support (e310) compared to non-users, possibly indicating increased independence due to better speech perception (Tognola et al. 2019).

Additionally, individuals using hearing aids found their personality traits contributed to their ability to cope and adapt to using hearing aids. Traits such as extroversion, positivity, pragmatism, and routine-oriented behaviour were previously found to be supportive of hearing aid usage (Dwarakanath and Manjula 2022). This aligns with empowerment studies suggesting that self-efficacy and a sense of control and management over one's hearing aids and various situations play crucial roles in successful hearing rehabilitation (Gotowiec et al. 2022).

Level of education associated to ICF categories

Personality traits were influenced by participants' education levels. Personality traits are related to life outcomes such as educational attainment, income, and satisfaction with life (Kajonius and Carlander 2017). Higher education levels were significant predictors for temperament and personality functions (b126), with individuals feeling their personality traits better supported their ability to handle HL. Interestingly, level of education was also significantly associated with hearing and vestibular functions (b240). The higher the level of education, the less the individual experienced problems with tinnitus and dizziness. This indicates that level of education is a likely facilitating factor in managing tinnitus and dizziness. This concurs with findings by Kim et al. (2015) that found that individuals with higher levels of education experienced less tinnitus issues. These findings could suggest that individuals with higher levels of education have better foundation when it comes to using strategies for coping with and managing tinnitus problems. Additionally, education level was significantly associated with the impact of products and technology for communication (e125). Higher education levels were associated with fewer perceived impact from hearing aids and assistive technology, which may be attributed to higher self-efficacy and better health literacy for these individuals that support their outcomes in addition to the hearing aids (Meherali, Punjani, and Mevawala 2020).

Income bracket of country association to ICF categories

Participants in this study from higher-income countries (USA and Sweden) experienced less challenges in conversations (d350) in both quiet and noisy situations. This could be attributed to better access to hearing health care and associated resources, such as hearing aids, which are more readily available in higher-income countries (WHO 2021). In Sweden, hearing healthcare is subsidised through the public healthcare system, while in the USA, access depends on insurance coverage. In contrast, participants from South Africa and India face significant barriers, including limited access to affordable hearing aids, fewer trained professionals, and higher out-of-pocket costs, which hinder access to necessary hearing healthcare. Interestingly, sensations associated with hearing and vestibular functions (b240) were also significantly associated with income brackets. Respondents from high-income countries reported worse tinnitus and vestibular functioning than those from middle and low-income countries. This may be due to higher levels of education in high-income countries, which often correlate with better awareness and reporting of these issues. It would therefore be expected that the association of income bracket and level of education to the perception of hearing and vestibular functions would be consistent.

Limitations of this study

Despite its contributions, this study faced several limitations. The ICF category "school education" (d820) was excluded from analysis due to its irrelevance for 95% of respondents, given the adult demographic and the category's focus on primary school activities. Previous validation studies (Karlsson et al. 2021) have suggested broadening this category to encompass higher-level education categories (d810-d839) to enhance relevance for adults. However, the constraints of the Brief ICF Core Set for HL, which includes only second-level categories (ICF Research Branch 2017), preclude such modifications.

Not all categories of the Brief ICF Core Set were included. Categories pertaining to body structures were omitted due to their inherent inability to be self-assessed. While operationalising categories into specific questions deviated slightly from the original framework, this adaptation enhanced the study's reliability by making the core set more practical for self-assessment. This approach aligns with findings from prior core set studies in the hearing domain (Karlsson et al. 2021; van Leeuwen et al. 2017) and other rehabilitation fields.

The uneven distribution of participants across countries limited country-level analyses, hindering the exploration of potential contextual influences on self-experienced functioning. To enable contextual analysis, data were merged into low- and middle-income categories. Future research should investigate variations at the country level to enhance the generalisability of results. Despite these limitations, key demographic variables such as age and gender were well-represented, with gender showing an even distribution.

Conclusions

This study highlights the fact that factors beyond the severity of hearing loss (HL), such as the use of hearing aids, level of education, and age, significantly influence an individual's experience with their hearing abilities. These factors should be considered in the comprehensive evaluation of individuals with HL. The findings underscore the importance of personalised hearing care, tailored to address these diverse factors.

Moreover, the study validates the effectiveness of the International Classification of Functioning, Disability, and Health (ICF) framework as a valuable tool for comprehensively understanding the multifaceted impact of HL. The ICF framework facilitates a holistic approach to assessing and addressing the needs of individuals with HL, considering both personal and environmental factors.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

There are no data available to share as it was not included in the ethical application for this study. The data collection took place in 2018/2019.

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