Beyond the Audiogram: Using PROMs and AI Modelling to Characterise Age- and Sex-Specific Hearing Loss Needs in a Nationwide Study

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Abstract

Background: : Hearing loss (HL) affects 1.5 billion people globally, with significant economic and psychosocial costs. Traditional audiometric assessments often overlook psychosocial impacts, limiting intervention effectiveness. This study uses Patient-Reported Outcome Measures (PROMs), specifically the Client Oriented Scale of Improvement (COSI), and AI-based Natural Language Processing (NLP) to identify age- and sex-specific patterns in hearing-related needs and inform personalised care strategies.

Methods: We conducted a cross-sectional analysis of 273,861 COSI responses from a national database. Participants aged 18–99 years with symmetrical HL and first-time hearing aid use were included. NLP modelling classified responses into 16 standardized listening categories. Statistical analyses (Chi-Squared, ANOVA, regressions) examined associations between hearing needs, age, sex, and audiological outcomes, with clustering analyses exploring broader patterns.

Findings: : Among 91,297 participants, PROMs revealed key needs—understanding group conversations in noise, media listening, and reducing communication-related embarrassment—regardless of HL severity. Several PROMs significantly predicted pure-tone average, highlighting their clinical value. Signal-to-noise ratio emerged as an early marker of HL in younger adults. Sex-specific patterns showed women prioritized social and emotional needs, while men emphasized structured settings such as meetings and television. These differences varied by age and HL degree, underscoring the need for individualised care.

Interpretation: Integrating PROMs into audiological practice enhances decision-making by uncovering hidden needs, enabling more targeted and comprehensive interventions. PROMs provide essential context for understanding the lived experience of HL and support a shift toward personalised hearing care.

Keywords PROMs | Age-Related Hearing Loss | Natural Language Processing | COSI | Psychosocial | Rehabilitation

Highlights

- **Evidence before this study**
  Systematic searches were conducted in the PubMed and Cochrane databases using the following search terms: ("hearing disorders" OR "presbycusis" OR "hearing loss" OR "hearing impairment" OR "hard of hearing") AND ("Patient-Reported Outcome Measures" OR "Patient-centered care" OR "PROM") AND ("Natural Language Processing" OR "medical informatics" OR "NLP"). The search encompassed articles published in English or French from database inception up to August 8, 2024. Existing literature indicates that database sizes vary from 224 to 48,699 records, with utilization increasing since 2019. A consensus across all papers suggests that employing comprehensive databases supports future research and aids in developing evidence-based, individualized treatment plans. However, no studies have been conducted on large-scale populations of hearing-impaired individuals; research has predominantly focused on specific areas like tinnitus or hearing loss (HL) mechanisms. Adopting a integrated approach to patient care is essential, and developing concepts that address patients' long-term needs can unify various aspects of HL research and treatment.

- **Added value of this study**
  This study demonstrates the added clinical value of integrating Patient-Reported Outcome Measures (PROMs) with AI-driven Natural Language Processing (NLP) to enhance audiological care. Using over 190,000 Client Oriented Scale of Improvement (COSI) questionnaires from adults with symmetrical HL across France, we show that PROMs provide essential insights into real-life listening challenges that traditional audiometric assessments often miss. NLP allowed for the large-scale classification of patient needs into standardized categories, uncovering consistent trends in communication difficulties, emotional distress, and media-related challenges. Importantly, several PROMs significantly predicted pure-tone average, confirming their explanatory power beyond conventional thresholds. We also identified signal-to-noise ratio (SNR) as an early marker of HL in younger adults. Distinct sex- and age-related patterns emerged: women more frequently prioritized social engagement and emotional well-being, while men focused on structured communication contexts. These findings support the implementation of PROMs for individualized, sex-sensitive, and age-adapted interventions. Overall, integrating PROMs into audiological practice enhances decision-making by uncovering hidden patient needs, enabling more targeted and comprehensive care, and providing essential context for understanding the lived experience of HL.

- **Implications of all the available evidence**
  Incorporating PROMs into routine clinical practice not only enhances patient-centered care but also provides a comprehensive understanding of the challenges faced by those with hearing impairments. This approach surpasses traditional audiological assessments, offering a more nuanced and holistic view of patient needs, which can lead to more effective and individualized treatment plans. The integration of NLP further enriches this process, enabling the extraction of deep, actionable insights from large-scale narrative data. Future research should explore the application of these methodologies across diverse populations and settings, further refining the tools and approaches used to assess and address HL.

1 Introduction

Hearing loss (HL) affects 1.5 billion people globally [1] and is a growing public health concern, with its prevalence rising as populations age [2, 3, 4]. In France, over 50% of individuals aged 65 and older experience HL [5], contributing to an estimated €24 billion in annual healthcare costs from untreated cases [6, 7]. Beyond the economic burden, HL is associated with elevated risks of depression [8, 9, 10], social isolation [11, 12, 9, 13], and dementia [14, 15]. Recent studies [16] suggest that untreated HL contributes to approximately 7% of the modifiable risk factors of dementia, emphasising the need for early intervention to preserve cognitive health.

In clinical practice, HL is usually assessed using pure-tone audiometry (PTA), which determines the degree of HL based on the average of auditory thresholds at 500, 1000, 2000 and 4000 Hz. To evaluate speech comprehension, standardised speech tests are commonly used, typically in quiet environments. These tests aim to determine the Speech Reception Threshold (SRT)—the intensity level at which a patient can correctly repeat 50% of the presented words—and the level at which 100% of the words are understood. To improve ecological validity and sensitivity, speech-in-noise tests were developed in the 1970s[17]. These tests measure speech understanding in the presence of background noise, aiming to determine the signal-to-noise ratio (SNR) at which 50% of speech is understood. Speech comprehension testing in quiet is often used for moderate to profound HL, while speech-in-noise testing is considered more sensitive for slight to moderate sensorineural HL or early-onset age-related HL (ARHL). However, both PTA and speech understanding tests fall short in capturing the specific communication challenges, emotional burden, and daily-life difficulties experienced by patients [18, 19]. Key issues such as activity limitations [20], participation restrictions [21], and even personality changes [22] frequently go unaddressed, limiting the effectiveness of rehabilitation strategies.

To address these limitations, international organisations such as the World Health Organization (WHO) and the American Speech-Language-Hearing Association (ASHA) advocate for patient-centred care that incorporates Patient-Reported Outcome Measures (PROMs) [23, 24]. PROMs allow patients to directly report their lived experiences, uncovering difficulties that might otherwise remain hidden and improving communication between patients and providers [25, 26]. While PROMs are widely used in fields such as oncology and musculoskeletal medicine [27, 28], their application in audiology is still emerging. The Client Oriented Scale of Improvement (COSI)[29, 30], the only widely used PROM in audiology, supports personalised care and has been successfully implemented in countries such as Belgium [31].

In this study, we analyse a large national database of 700,000 COSI questionnaires to investigate whether integrating PROMs into audiological practice could enable a more personalized approach to hearing care, by providing insights that go beyond traditional audiological assessments. Additionally, we explore whether PROMs can uncover explanatory factors or specific patterns of patient-reported difficulties that are not captured by standard clinical measures. We used data from the largest French national network of audiological services, combining large-scale PROMs data with modern analytical approaches to address these aims.

To achieve these goals, we employed a multi-faceted analytical approach combining natural language processing techniques with traditional statistical methods. This integrated framework allowed us to first categorise free-text patient responses into standardised listening categories, then systematically analyse relationships between these patient-reported needs and objective audiological measures across demographic factors. By applying both classification and regression techniques, we were able identify patterns that would otherwise remain hidden in conventional audiological assessments.

2 Methods

2.1 Study design and data sources

We conducted a population-based cross-sectional comparative analysis of 723,255 individual COSI responses collected between 1st September 2020 and 31st December 2022 in 700 audiology centres in France. Data were extracted from the national database of France's leading hearing aid provider, Amplifon (Paris, France).

For the retrospective data analysis, the dataset was provided in pseudonymised form to the *Institut Pasteur* under the Big Data AP project. The national data protection agency (*Commission Nationale de l'Informatique et des Libertés*) authorised the processing of the Big Data AP project data on 5 April 2024.

This study follows the Reporting of Studies Conducted Using Observational Routinely Collected Data (RECORD) guidelines (Supplementary material (SI), Section 3).

2.2 Study population and data collection

Adults aged 18 to 99 years with symmetrical HL, who were first-time hearing aid (HA) users, were identified through the Amplifon database. Symmetrical HL was defined as a difference of less than 15 dB in PTA between both ears [32]. All participants had to have undergone speech-in-quiet [33, 34] and speech-in-noise tests [35]. Only individuals with an SNR ranging from -10 to +20 dB during the speech-in-noise test were included.

Participants' demographic characteristics (age and sex assigned at birth) as well as audiological information, degree of HL, and performance in speech tests were then collected from the database. The degree of HL was classified according to the ASHA classification [36].

Finally, the COSI responses of the participants were collected. During their initial appointment in an audiological centre, patients are asked to complete the first part of the COSI, which involves identifying up to five specific listening situations in which they wish to improve their hearing ability with the use of HAs. These situations are described in the patient's own words and ranked in order of importance, from most important (Q1) to least important (Q5).

2.3 Analytical framework

Our analytical approach was designed to systematically examine the relationship between PROMs and traditional audiological measures through three progressive steps: (1) standardisation of COSI responses through NLP classification, (2) identification of relationships between COSI and audiological measures through statistical testing, and (3) exploration of demographic-specific patterns through segmented analysis. This analytical framework is illustrated on the SI, section 6, demonstrating how each step addresses specific aspects of our research questions.

2.4 Standardisation of COSI responses through NLP classification

Since the first part of the COSI requires patients to describe specific listening situations in free-text format, the analysis of the COSI responses first required a classification step. To that end, the 16 standardized listening categories developed by Dillon et al. [30] was used. To efficiently classify the free-text COSI responses, we used CamemBERT, a transformer-based language model specifically designed for French language [37]. CamemBERT is built on the BERT architecture [38] and was selected for its strong performance in capturing contextual nuances in French-language clinical data and open-ended patient responses.

The classification process began with a manually labelled subset comprising 1% of the total dataset (approximately 7,200 responses), annotated according to the 16 predefined standardised categories. This labelled sample was used to fine-tune the model. We then applied a label projection method to classify the remaining 99% of the dataset (714,255 responses).

The model performance was then validated using cross-validation techniques and expert review. A random sample comprising 3% of the classified responses was manually verified by an expert audiologist (PM). The classification achieved a 93% accuracy rate, confirming the reliability of the model in assigning responses to the appropriate listening situations. More details are in the SI, Section 6.

2.5 Statistical analysis

2.5.1 Identification of relationship between COSI responses and audiological measures

We conducted a series of statistical tests to evaluate the relationships between audiological outcomes, COSI responses, and demographic factors. Chi-Squared Tests[39] were employed to determine whether categorical variables (sex, degree of HL) were associated with specific COSI responses, establishing whether patient-reported needs vary systematically by demographic and clinical factors. This analysis formed the foundation for understanding if PROMs capture information beyond standard audiometric measures. One-Way ANOVA [40] assessed whether means of continuous variables (PTA, SNR, SRT, age) differed significantly across COSI need categories. Proportion tests [41, 42] evaluated sex-based differences in COSI responses across age groups, helping identify whether personalized, demographic-specific approaches to audiological care might be warranted based on PROMs data. These first analysis formed the foundation for understanding if PROMs capture information beyond standard audiological measures.

2.5.2 Exploration of demographic-specific patterns through segmented analysis

To understand the relative contribution of multiple factors and quantify relationships that might not be captured by traditional audiological assessments alone, we constructed linear regression models [43] with PTA as the response

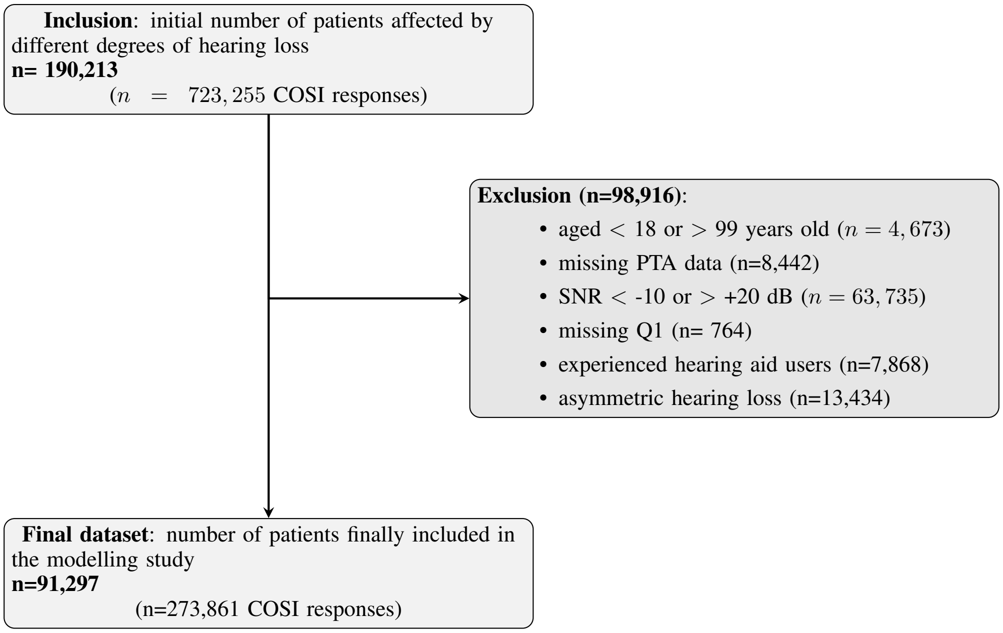


Figure 1: Study participant selection flow diagram showing exclusion criteria and final sample size.

variable and SNR, SRT, and COSI need categories as predictors. We isolate the unique contribution of each factor while controlling for others thanks to the multivariate approach. The age distribution in our dataset presented a methodological challenge, as certain age groups were underrepresented. To ensure robust estimates across all demographic segments, we applied the Synthetic Minority Oversampling Technique for Regression with Gaussian Noise (SMOGN)[44] in our age-specific analyses. This technique preserves the statistical properties of the data while balancing representation across groups, allowing us to draw reliable conclusions about age-specific patterns. More details are in the SI.

Our analytical framework was designed to progressively refine our understanding through increasingly targeted analyses: from population-level models to stratified analyses by sex, age (ten-year intervals), and degree of HL. This multilevel approach enabled identification of patterns that might be obscured in aggregated analyses. To validate inflection points in age-related patterns, we performed segmented regression analysis, with findings cross-validated using non-parametric tests (Wilcoxon [45], Kruskal-Wallis, and Brown-Mood median tests) to ensure robustness across different statistical assumptions. Full results of the statistical tests are provided in the SI, Sections 7 and 10. Results of the regressions are in the SI, Sections 8, 9 and 11.

Statistical analyses and data manipulation were conducted using R version 4.2.2, while Python version 3.9.7 was used for training and testing the CamemBERT NLP model. All analysis scripts and datasets are available for replication in a publicly accessible GitHub repository:
https://github.com/mcampi111/COSI.

3 Results

3.1 Study Sample and Participant Characteristics

After applying study exclusions, 91,297 patients were included, corresponding to 273,861 COSI responses (see Figure 1). Among the included participants, the majority (81%) exhibited mild to moderate HL, with an average hearing level of 42.87 ± 11.25 dB HL. The mean age of participants was 72.1 ± 11.81 years. The average speech comprehension in quiet (SRT) was 45.36 dB, while the mean speech-in-noise score (SNR) was 4.24 ± 3.74 dB RSB. The sex distribution was nearly equal, with 44,525 females and 46,762 males. The summary statistics are presented in Table 1 and Figure 2 B. Table 2 features distribution of responses across the COSI categories.

Variable	Sex	Min	1st Q	Median	Mean	3rd Q	Max	Sd
Age	Female	18	66	74	72.92	82	99	12.59
	Male	18	65	72	71.30	79	99	10.96
PTA	Female	5	35	42.5	42.47	50	108.75	11.13
	Male	5	35	42.5	43.22	50	115.00	11.32
SRT	Female	0	39	46	46.38	54	80	11.17
	Male	0	36	43	44.31	51	80	11.47
SNR	Female	-10	2	4	4.09	6	20	3.65
	Male	-10	2	4	4.37	6	20	3.73

Table 1: Summary statistics for Age, PTA (Pure Tone Average), SRT (Speech Reception Threshold), and SNR (Signal-to-Noise Ratio) by sex.

COSI Category	Q1	Q2	Q3
Conversation with one or two in quiet	17335	8779	2964
Conversation with group in quiet	6592	2850	1025
Conversation with group in noise	20711	16934	6275
Television/radio at normal volume	10929	26551	12222
Unfamiliar speaker on phone	1271	2990	3257
Increased social contact	863	1021	585
Feel embarrassed or stupid	8902	5558	2173
Listening in church or meeting	4163	3057	1305
Other	20521	20286	13582
NAs		3261	47899

Table 2: Counts of COSI responses across each question (Q1, Q2, Q3).

3.2 Added Value of PROMs in the Overall Population Compared to Traditional Audiological Assessments

All statistical tests—including the Chi-Squared Test of Independence and One-Way ANOVA were found to be significant, as detailed in SI, Section 6. We further explored these findings in the following sections.

Among the 91,297 participants analyzed, PROMs revealed prominent self-reported needs, particularly in the domains of speech perception in noise, social engagement, and communication-related embarrassment.

As expected, traditional speech tests—specifically SRT and SNR were significant explanatory variables for PTA. SRT and SNR showed strong positive associations with PTA, with coefficients of 0.57 ± 0.00 (p ¡ 0.001) and 0.63 ± 0.01 (p ¡ 0.001), respectively (Figure 2 C).

Importantly, several PROMs-derived functional and psychosocial needs also emerged as significant predictors of PTA in the general population. The need to better understand conversations with one or two people in quiet was the strongest PROMs-related predictor (1.12 ± 0.11, p ¡ 0.001), followed by group conversations in quiet (0.62 ± 0.15, p ¡ 0.001) and group conversations in noise (0.34 ± 0.10, p = 0.001). Other significant explanatory needs included improving television listening (0.41 ± 0.13, p = 0.001) and, notably, the psychosocial goal of no longer feeling embarrassed or stupid, which showed a strong positive association with PTA (0.83 ± 0.13, p ¡ 0.001).

These results (p-value and associations) are illustrated in Figure 2 A and in the SI, Section 11.

To go further in the analysis, we sought to determine whether these results vary according to age, degree of HL, and sex.

3.3 Specific Patterns Identified Through PROMs

Statistical tests including proportion tests were found to be significant, as detailed in SI, Section 7.3. Notably, we identified significant differences between males and females across COSI needs and age groups. We further explored these findings in the following sections.

To investigate sex-based differences in self-reported hearing needs, we first conducted a two-proportion test[41, 42] cross age groups segmented into ten-year intervals. This preliminary step established the statistical significance of sex differences in response patterns prior to regression analysis.

We then performed a second multiple regression analysis using the SMOGN technique, controlling for age and degree of HL. This allowed us to assess whether men and women with similar audiological profiles report different hearing-related needs and performance on speech tests.

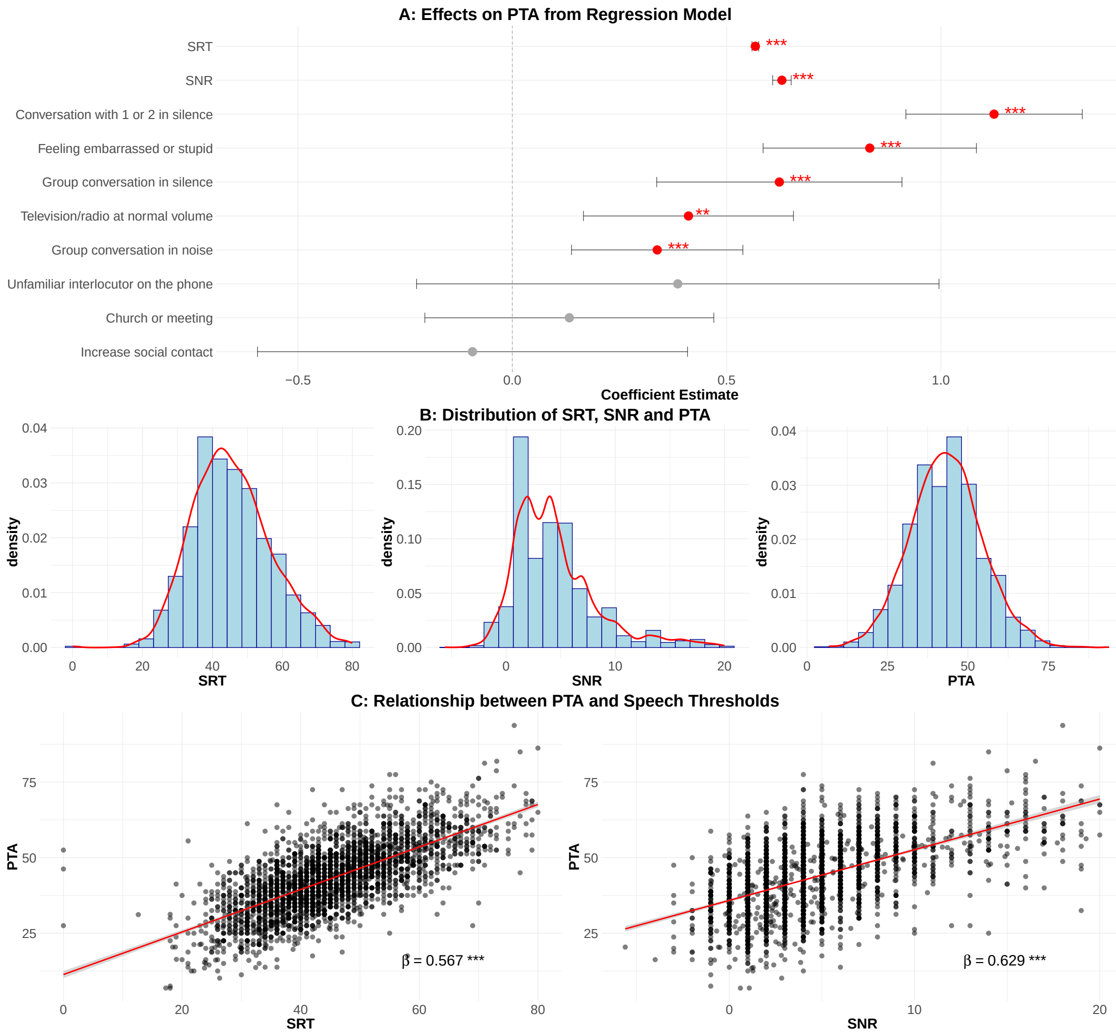
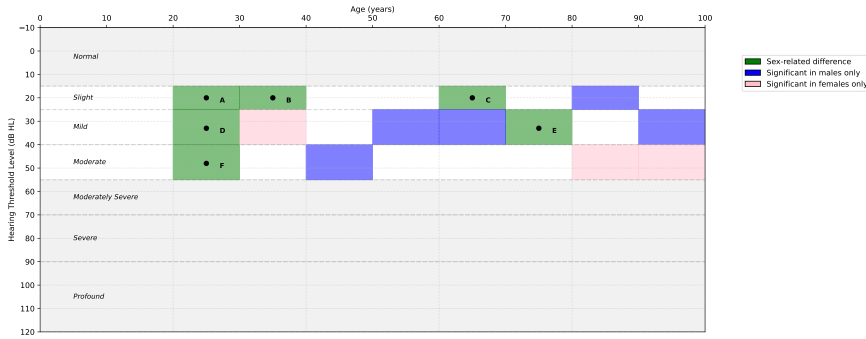


Figure 2: Comprehensive analysis of hearing-related factors and their relationships. **A**: Effects of various factors on PTA from SMOGN regression model, showing coefficient estimates with 95% confidence intervals. Red points indicate statistically significant effects (*p ¡ 0.05, **p ¡ 0.01, ***p ¡ 0.001). **B**: Distribution histograms for SRT, SNR, and PTA with density curves (red lines). **C**: Scatter plots showing relationships between PTA and hearing thresholds (SRT and SNR) with linear regression lines. Coefficient values (Coef) represent the strength of association, with significance indicated by asterisks (***p ¡ 0.001). Positive coefficients indicate that higher SRT and SNR values are associated with higher PTA values, suggesting a consistent relationship between speech perception measures and hearing sensitivity.



Label	Men	Women
A	Church / meetings, Understanding in group in silence, TV / radio	Conversation 1-to-1, Groupe noise
B	Groupe noise	Church / meetings, Conversation 1-to-1, Embarrassed, Understanding in group in silence
C	Church / meetings, Groupe noise, Social Contact	Conversation 1-to-1
D	Groupe noise	Church / meetings
E	Church / meetings, Conversation 1-to-1, Embarrassed, Groupe noise, Groupe silence, TV / radio	Embarrassed
F	Church / meetings, Groupe noise	Social Contact, Phone Interlocutor

Figure 3: Patterns of auditory needs across age, sex and degree of HL.

For clearer interpretation, results are visualized in Figure 3, where each initial COSI response is plotted alongside its associated p-value for males and females. The figure illustrates that sex-specific priorities vary significantly depending on the auditory context.

Notably, among young adults (18–29 years old) with slight HL, distinct patterns emerged between men and women. Women were more likely to prioritize understanding one-on-one conversations ($p = 0.007$), reducing embarrassment in communication ($p = 0.008$), and improving speech perception in noise ($p = 0.031$). In contrast, men placed greater emphasis on understanding speech during meetings ($p = 0.022$), avoiding embarrassment ($p = 0.050$), group conversations in quiet (p ¡ 0.001), and television listening ($p = 0.010$).

Similar patterns were observed across other subgroups defined by age and degree of HL. For instance, in the same age group (18–29 years) but with mild HL, women prioritized speech comprehension in meetings ($p = 0.001$), while men reported greater difficulty with group conversations in noise ($p = 0.005$). Among individuals aged 30–39 years with slight HL, women expressed challenges with meetings ($p=0.017$), one-on-one conversations ($p=0.046$), group conversations in quiet ($p=0.028$), and reducing embarrassment in communication ($p = 0.002$) whereas men primarily struggled with group conversations in noisy environments ($p=0.015$). As HL severity increased, self-reported needs expanded: women more often prioritized social interactions and phone use, while men focused on structured settings such as meetings and group discussions. In older adults (60–79 years), women continued to emphasize close personal communication and emotional comfort, while men reported broader communication difficulties across nearly all listening situations. For a detailed breakdown of all subgroups and statistical results, refer to the SI, Section 11.

4 Discussion

Hearing loss is a growing public health concern with significant socioeconomic and health implications, expected to increase substantially in the coming decades[46]. As highlighted by Maidment[47], adopting a holistic and person-centered approach to hearing healthcare is essential to address the diverse needs of individuals with HL.

This study aims at assessing whether the integration of PROMs into audiological care could (1) enhance clinical management by complementing traditional assessments, and (2) uncover explanatory patterns—especially demographic or psychosocial—that are not captured by standard audiological measures.

Our analysis shows that incorporating PROMs into audiological care provides critical insights that complement traditional metrics such as PTA, SRT, or SNR, and allow for personalized interventions tailored to specific patient needs. PROMs effectively uncovered hidden psychosocial needs often overlooked by traditional audiological assessments.

In addition to demonstrating their independence from PTA, PROMs revealed explanatory patterns—particularly related to sex and age—that provide a deeper understanding of patients' functional hearing difficulties. Our analysis underscores the value of PROMs in identifying hidden psychosocial challenges associated with HL, which are often overlooked by conventional audiological assessments.

Sex differences emerged as a key determinant of listening priorities. Women more frequently prioritized social engagement and interpersonal communication across diverse settings, reflecting a need for audiological care that supports emotional connection and active participation in group conversations. These findings align with evidence howing that women's social needs are more likely to influence their emotional well-being [48]. In contrast, men emphasized support in structured environments such as meetings and television listening, where visual and cognitive reinforcement (e.g., directional microphones and audio streaming) can improve comprehension. These results confirm that even among individuals with comparable audiological profiles, sex strongly influences the nature and prioritization of reported hearing needs. Notably, the greatest differences were observed in the 50–59 and 70–79 age groups, where we observed significant sex-based differences in reported needs for social contact.

These results confirm that sex plays a significant role in shaping self-reported hearing needs, even among individuals with similar age and degree of hearing loss. Women tend to emphasize emotional and social aspects of communication, whereas men focus more on performance in structured listening environments. Such consistent, sex-related differences across age and hearing loss severity underscore the value of PROMs in identifying individualized care priorities and tailoring audiological interventions accordingly.

Our results also reinforce longstanding findings that some individuals with normal audiograms experience significant difficulties in communication, often due to deficits in central auditory or cognitive processing [49, 50]. These findings emphasize the need to expand audiological assessments beyond pure-tone thresholds [49], by incorporating evaluations of central processing and cognitive function, as well as rehabilitative strategies such as auditory training or cognitive enrichment programs [51, 52].

Consistent with this, our study found that COSI-reported needs were independent of PTA: individuals with slight, mild, or moderate HL reported similar degrees of functional and emotional challenges, across all age groups and sexs. This further highlights the relevance of subjective, patient-centered assessments to capture dimensions of HL that are often missed by traditional audiometry.

4.1 Limitations of the Study

Several limitations should be acknowledged. First, approximately 22–24% of identified COSI needs remain uncharacterised by the current classification system, suggesting that contemporary listening challenges may not be fully captured. Second, the study primarily included first-time HA users with presbycusis and excluded individuals with asymmetric HL. Future research should broaden the scope to capture a more comprehensive profile of the hearing-impaired population.

5 Conclusion

This study highlights that traditional audiological assessments like SRT and SNR, while essential, do not fully capture the complex psychosocial challenges faced by individuals with HL. PROMs provide a critical complementary perspective, revealing significant needs for social contact and context-specific support that correlate with HL but remain independent of PTA. PROMs also reveal sex-specific differences, with women prioritizing social engagement and men requiring support in structured settings. Our study confirms that PROMs not only offer insights beyond PTA, but also uncover demographic and psychosocial factors that shape individual listening needs—underscoring their role in advancing personalized audiological care. By integrating PROMs into clinical practice, audiologists can design personalized, patient-centered interventions that improve both auditory and psychosocial outcomes, ultimately enhancing patients' quality of life.

Authors contributions

P.M.: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Writing—original draft preparation, Writing—review and editing.
M.C.: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing—original draft preparation, Writing—review and editing
G-W.P.: Supervision, Investigation, Validation, Writing—review and editing
H.T-V.: Conceptualization, Supervision, Validation, Writing—review and editing.

M.C., P.M., H.T-V. confirm that they had full access to all the data in the study. All authors have read and agreed to the published version of the manuscript.

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Supplementary Information

The following supporting information are provided in the attached document to this manuscript

1. Introduction
2. Acronyms & Abbreviations
3. Data Sharing Statement
4. Descriptive Statistics
5. Text Classification Procedure of COSI Responses
6. Results of Statistical Tests
7. Multiple Regression Analysis
8. Segmented Regression Analysis
9. Cross-Measure Validation of PTA Breakpoints with SNR and SRT Results
10. Multiple Regression Results with SMOG

Declaration of Interest

Author P.M. is employed by the company Amplifon. The remaining author declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Data Sharing Statement

The data provide is Amplifon France. More information is given in the Supplementary Information.