forum acusticum 2026
8-12 September · Graz, Austria

# CLINICAL USE OF THE REVOLOUD LOUDNESS VALIDATION METHOD: A SURVEY OF HEARING CARE PROFESSIONALS

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This paper is a revised version of the authors' submitted manuscript that was peer-reviewed by at least two anonymous reviewers.



## Abstract

Currently, a typical hearing aid fitting procedure starts with amplification settings prescribed by audiogram-based fitting methods, followed by a subsequent, often iterative, fine-tuning phase. While technical procedures such as real-ear measurements are widely used to verify amplification, they do not directly assess perceptual dimensions. The revoloud method was developed to enable a rapid clinical assessment of aided loudness perception. During a measurement run, 60 natural signals covering three presentation levels and four frequency categories are presented. Patients rate the perceived loudness of each signal, and the results are visualized as a loudness map relative to a normal-hearing reference. To investigate the method's use in routine clinical practice, a survey among 125 hearing care professionals using revoloud was conducted. The results indicate frequent use of the method in daily practice, with 83 % of respondents reporting usage at least three times per week. A large majority of respondents reported perceived benefits, including fewer loudness-related complaints with hearing aids in daily life and improved patient understanding and involvement during the fitting process. These findings suggest that perceptual loudness assessment can support outcome-oriented hearing aid fitting in clinical practice.

**Keywords**: *hearing aid fitting, loudness perception, validation, outcome measure*

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## 1. Introduction

Restoring appropriate loudness perception is a central objective of hearing aid fitting [1], [2]. Hearing impairment typically results in elevated hearing thresholds combined with an altered growth of loudness, and hearing aids aim to compensate for these changes through frequency- and level-dependent amplification. In clinical practice, such amplification is usually prescribed based on the audiogram, including measured UCLs or UCL estimates, using gain-prescription formulas such as NAL-NL2 [3], [4] or DSL v5.0 [5], among others. However, different prescription methods can yield substantially different amplification targets for the same audiogram, and individual loudness perception may vary considerably across listeners with similar hearing thresholds [6], [4]. Consequently, achieving prescribed amplification targets does not necessarily guarantee that amplified sounds are perceived with normal loudness.

In clinical workflows, verification procedures such as real-ear measurements are widely used to confirm that hearing aid amplification matches prescribed targets. While such procedures are essential, they primarily verify the technical realization of amplification rather than its perceptual dimension as experienced by the listener. For this reason, there has been increasing interest in methods that directly assess perceptual outcomes of hearing aid fittings [7], [8]. In particular, assessing aided loudness perception can provide valuable information for the individual fine-tuning of amplification parameters independent from the gain-prescription formula chosen for the first-fit. The benefits of normalizing loudness perception with hearing aids are twofold: 1) audibility can be assumed, when loudness of different signals is normalized 2) normalized loudness perception prevents that hearing aids are perceived as "too loud" what might lower the acceptance of the hearing aid.

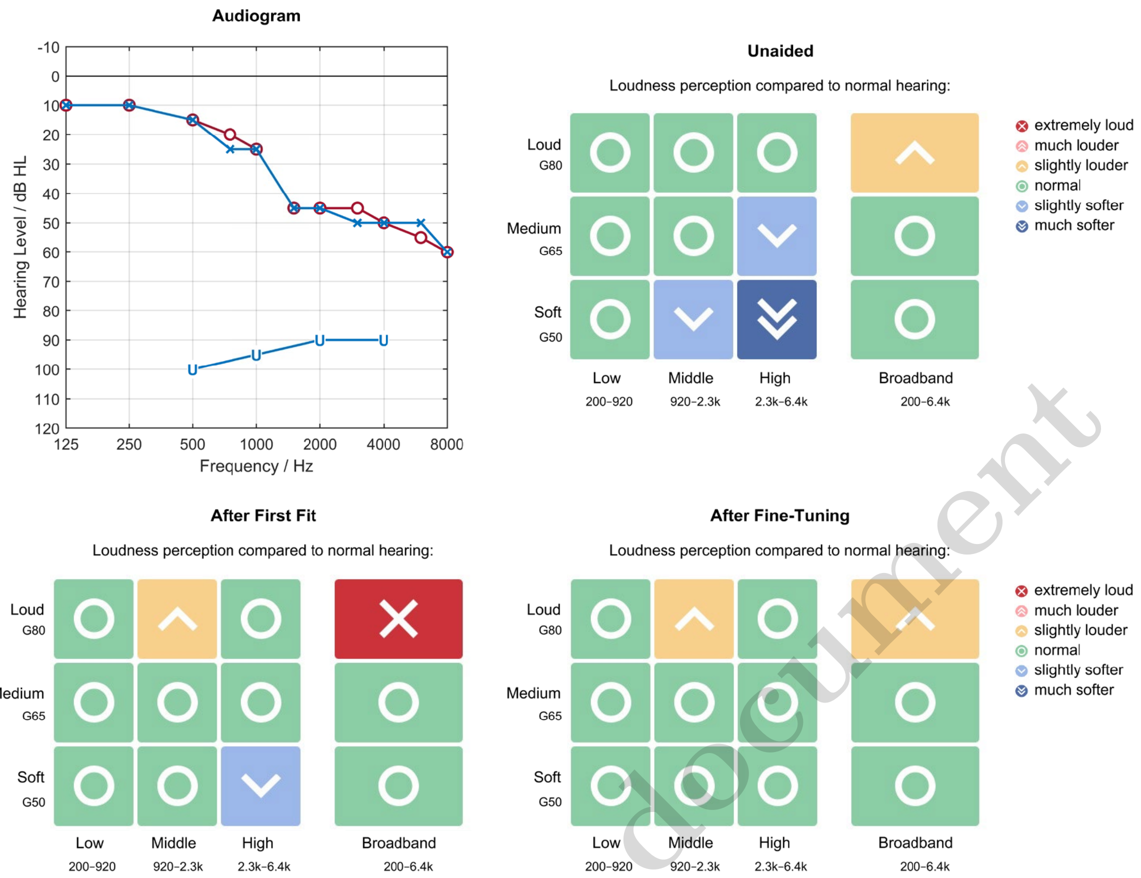


**Figure 1**. Pure-tone audiogram and revoloud loudness maps at different stages of hearing aid fitting for one hearing-impaired subject. The audiogram (upper left panel) shows air conduction hearing threshold levels and uncomfortable loudness levels for the right (red) and left ear (blue). The revoloud measurements evaluate perceived loudness for signals representing three presentation levels ($G_{50}$, $G_{65}$, $G_{80}$) and four frequency regions (low, middle, high, broadband). Colors (including optional symbols for color-blind persons) indicate deviations from loudness perception relative to a normal-hearing reference: Green denotes normal loudness, blue indicates signals perceived as too soft, and yellow to red indicate excessive loudness. In the upper right panel, a loudness map for the situation without hearing aids shows the subject's high-frequency hearing loss in the form of a dark blue tile for the "high/soft" condition. After performing a manufacturer's first fit (bottom left panel), audibility was improved in that condition, but stimuli in the "broadband/loud" condition were now perceived excessively loud. After fine-tuning the amplification settings based on this information, the loudness map shows balanced, normalized loudness perception across all conditions (lower right panel).



The revoloud[1] method was developed to enable a rapid clinical assessment of aided loudness perception using natural signals. A detailed description of the measurement principle and its evaluation was previously reported under the name Loudness Validation Method by Exter et al. [9]. The aim of the present contribution is to report first experiences with the method in routine hearing aid fitting practice based on a survey. Hearing care professionals using this method were asked: How is the method used in routine hearing aid fitting? How clinicians perceive its impact on fitting workflow, patient interaction, and fitting outcomes? The results are intended to provide an initial, practice-based perspective on the clinical role of perceptual loudness assessment in hearing aid provision.

## 2. The revoloud method

The method was designed to provide a time-efficient clinical assessment of aided loudness perception. The measurement is performed under free-field conditions

[1] The revoloud method is offered as a commercial product by Hörzentrum Oldenburg gGmbH.

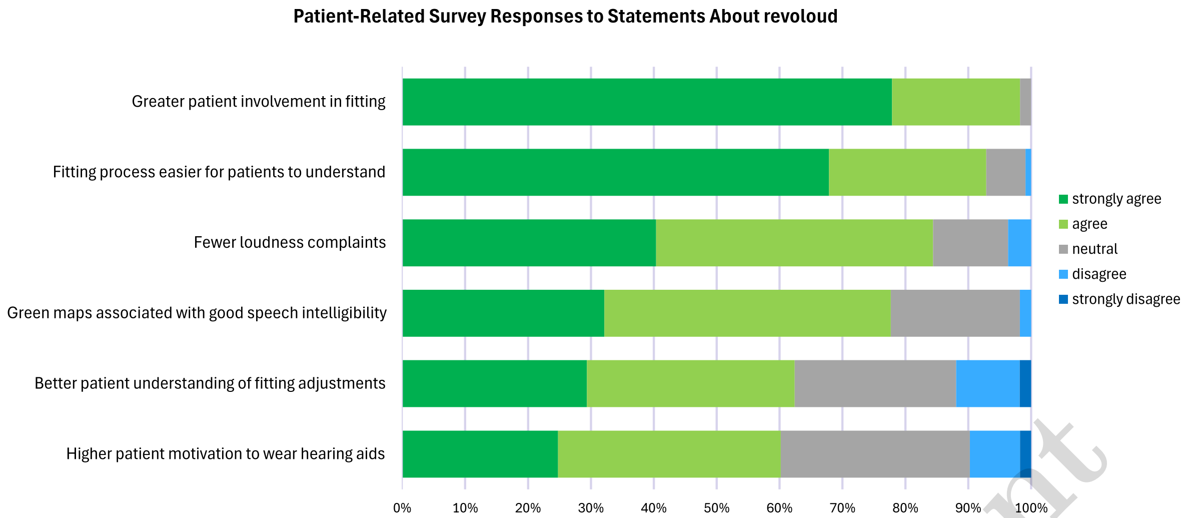


**Figure 2**. Selected patient-related results from a survey among hearing care professionals using revoloud (N = 125). Stacked bars show the distribution of responses on a five-point Likert scale (strongly agree to strongly disagree). The questionnaire contained eleven statements addressing different aspects of clinical use; six representative items are shown here, covering patient communication, patient involvement, and clinical outcomes. Statements are ordered by the proportion of positive responses (agree or strongly agree). The results indicate strong agreement that revoloud improves patient understanding of fitting adjustments and increases patient involvement.

and uses natural signals to evaluate how the signals are rated by hearing aid users in terms of perceived loudness.

The method presents a set of 60 signals. These signals are grouped into twelve categories defined by three presentation levels and four frequency regions. The presentation levels correspond approximately to typical levels used in hearing aid fitting ($G_{50}$, $G_{65}$, and $G_{80}$, corresponding to broadband presentation levels of 50, 65, and 80 dB SPL, respectively), while the frequency regions represent low (200–920 Hz), middle (920–2300 Hz), high (2300–6400 Hz), and broadband (200–6400 Hz) signal components. Each category contains five representative natural signals.

During the measurement, the listener rates the perceived loudness of each signal on a categorical loudness scale ranging from “not heard” to “extremely loud” [10]. The responses are compared with reference data from normal-hearing listeners and visualized as a loudness map (Fig. 1). In this representation, green fields indicate normal loudness perception relative to the reference, whereas blue and yellow to red fields indicate signals perceived as lower-than-normal or higher-than-normal, respectively.

The measurement takes approximately 6–7 minutes and can be performed with the hearing aid set to the patient’s everyday program. The resulting loudness map allows clinicians to identify regions where amplification may be insufficient or excessive and to adjust gain parameters accordingly.

## 3. Verification, validation, and outcome measures

In hearing aid fitting, different terms are used to describe procedures that assess the quality of an individual fitting. In particular, the concepts of *verification*, *validation*, and *outcome measures* are sometimes used interchangeably, although they refer to different aspects of the fitting process [11], [12], [13], [14], [15], [16], [17], [18], [19].

*Verification* typically refers to procedures that confirm whether the technical characteristics of the hearing aid correspond to prescribed targets. Common examples are coupler or real-ear measurements, which are used to verify that the amplified sound pressure level matches the intended amplification targets derived from a fitting formula. Such procedures are essential to ensure that the hearing aid provides the desired acoustic output.

*Validation*, in contrast, refers to the assessment of whether the fitting achieves the intended benefit for the user in the intended domain (e.g., functional amplification, speech intelligibility, loudness perception, listening effort). This may involve questionnaires, speech tests, or other measures that evaluate the listener’s experience with hearing aids. In this sense, validation focuses on the perceptual or functional result of the fitting.

Finally, the term *outcome measure* is used here as a broader concept describing methods that assess the effectiveness of an intervention. In the context of hearing

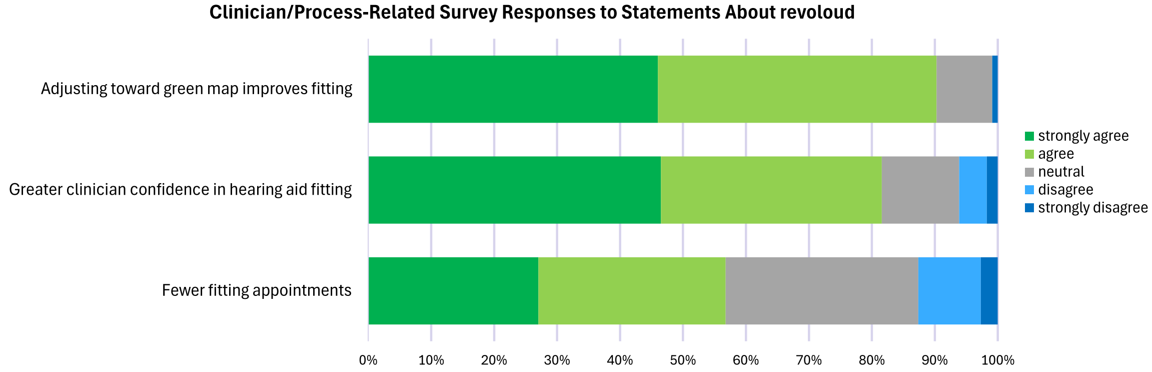


**Figure 3**. Selected clinician- and process-related results from the survey presented in Fig. 2. The results indicate that revoloud has a positive impact on the fitting process, increases clinicians' confidence when adjusting amplification, and leads to a more efficient fitting process overall.

aid fitting, outcome measures can include both subjective and objective assessments of listening performance and user satisfaction.

The revoloud method focuses specifically on aided loudness perception and therefore represents a perceptual validation method that can complement technical verification procedures in clinical practice.

## 4. Experience with revoloud in hearing aid fitting practice

To investigate how the method is used in routine hearing aid fitting, a voluntary survey among independent hearing care professionals was carried out in February 2026. Participants were recruited via newsletters by the companies selling the revoloud product, addressing active users of the method. In total, 125 hearing care professionals participated in the survey[2].

Most respondents reported substantial practical experience with the method. 54 % indicated that they had been using revoloud for more than six months, while 40 % reported experience of one to six months and 6 % had started using the system within the previous month. In addition, the method appears to be used regularly in hearing aid fitting: 83 % of respondents reported using revoloud at least three times per week, including 43 % who indicated using it more than five times per week. Fig. 2 (patient-related questions) and 3 (clinician- and process-related questions) show a selection of the results (questions related to marketing or branding are not included here). The survey addressed clinicians' perceptions of the method's role in hearing-aid fitting. The results indicate strong agreement among hearing care professionals that the loudness map supports communication with patients and facilitates the fitting process. More than 90 % of respondents agreed that the method helps patients better understand adjustments made during fine-tuning and increases patient involvement. In addition, many clinicians reported that the use of the loudness map increases their confidence when adjusting gain parameters.

Regarding clinical outcomes, a large majority of the respondents reported that loudness-related complaints from hearing-aid users were less frequent when adjustments were guided by revoloud. These observations represent clinicians' subjective experiences in routine practice.

An additional observation reported by many clinicians is a perceived improvement in speech intelligibility when using the method. This finding should be interpreted with caution, as speech intelligibility was not directly measured in the present study and is influenced by multiple interacting factors beyond loudness perception (e.g., audibility, spectral and temporal resolution, and cognitive processing) and speech enhancement settings of hearing aids. Nevertheless, this observation may provide a hypothesis for future controlled studies investigating potential relationships between loudness normalization and speech perception outcomes.

Overall, the survey results suggest that perceptual loudness assessment can play a useful role in routine hearing aid fitting and may complement established verification procedures by providing additional outcome-oriented information, namely validation of loudness perception.

## 5. Discussion and conclusion

The results reported in this paper indicate that the revoloud method can be integrated into routine hearing-aid fitting workflows and is used regularly by clinicians who have adopted it. The survey responses show

[2] We can only estimate the response rate by the known number of revoloud set-ups (288) times an average of three users per set-up yielding a response rate of 14.5%.

that assessing aided loudness perception provides clinically relevant information that seems to improve both amplification adjustments and communication with patients. In particular, the visualization of loudness perception in the form of a loudness map appears to facilitate the explanation of fitting decisions and to increase patient involvement in the fitting process. This may also cause the reported higher self-confidence of the clinicians during the fitting process. According to Varela et al. [20], communication and partnership, therapeutic alliance and trust are important factors of patient empowerment. There is at least qualitative evidence that effective communication and patient involvement are linked to successful audiological rehabilitation [21], [22]. From a clinical perspective, the observations regarding speech intelligibility performance are consistent with the rationale of the revoloud method. Deviations from normal loudness perception may lead to reduced speech intelligibility when amplification is insufficient for soft inputs or to decreased acceptance when loud sounds are perceived as excessively loud.
The present survey captures clinician-reported observations from routine practice. While such reports do not replace patient-level outcome data, they may provide ecologically valid, practice-based indications of impact. This approach allows for the aggregation of experience across a relatively large number of fittings and patients[3], potentially mitigating some of the variability inherent in individual patient self-reports. It is well established that the assessment of hearing-aid outcomes in real-world settings via questionnaires is methodologically challenging. As discussed by Cox et al. [16] and also visible by the variety of self-report tools (e.g. [15], [16], [17], [18], [19]), there is currently no consensus on optimal questionnaire approaches. Partly, because responses based on patient self-reports are influenced by non-auditory factors such as personality-related response biases. Since there is mostly no direct correspondence between dimensions asked for in the self-report and adjustable parameters in hearing aid fitting, it is difficult to directly conclude modifications of the individual fitting. By directly assessing aided loudness perception, outcome-oriented information is provided that can directly be linked to the amplification settings of hearing aids and complement established verification procedures.
The present results provide preliminary, practice-based evidence that optimizing the loudness dimension of a hearing-aid fitting may have beneficial effects beyond loudness perception alone. One possible interpretation is that improved loudness normalization facilitates more appropriate audibility and balanced loudness across frequencies and levels, thereby indirectly supporting speech intelligibility.

As the results presented here are based on a voluntary survey among hearing care professionals, several limitations need to be considered. The findings reflect subjective reports from users of the revoloud method and may be influenced by selection effects, response biases, and the absence of a control condition. In addition, no patient-level outcome data or performance measures were collected. Therefore, the present results alone do not allow causal conclusions regarding the effect of the method on hearing-aid outcomes. Also, the patient-related observations were collected from the clinicians' perspectives only.

Overall, the findings suggest that perceptual loudness assessments with the revoloud method may usefully complement to established verification procedures by providing additional, outcome-oriented information from the clinician's perspective that also facilitates communication with the patient and improves patient involvement. Further controlled studies incorporating performance measures and patient-reported outcomes are required to evaluate the extent to which such approaches translate into measurable improvements in hearing-aid fitting quality.

## 6. Acknowledgments

This study was supported by the German Bundesministerium für Wirtschaft und Energie (BMWE, Federal Ministry for Economic Affairs and Energy), Project ID 49MF240044, INNO-KOM Project "OLFIT"; and by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), Project ID 352015383, SFB 1330 Project C4 and under Germany's Excellence Strategy – EXC 2177/2 - Project ID 390895286.

## References

[1] R. M. Cox, G. C. Alexander, I. M. Taylor, and G. A. Gray, "The Contour Test of loudness perception," *Ear and Hearing*, vol. 18, no. 5, pp. 388–400, 1997, doi: 10.1097/00003446-199710000-00004.

[2] G. Keidser and F. Grant, "Comparing loudness normalization (IHAFF) with speech intelligibility maximization (NAL-NL1) when implemented in a two-channel device," *Ear and Hearing*, vol. 22, pp. 501–515, 2001, doi: 10.1097/00003446-200112000-00006.

[3] G. Keidser, H. Dillon, M. Flax, T. Ching, and S. Brewer, "The NAL-NL2 prescription procedure," *Audiology Research*, vol. 1, no. 1, article e24, 2011, doi: 10.4081/audiores.2011.e24.

[3] Due to the survey response about usage of the method per week and time of overall usage we estimate the number of fittings to minimum 6682 fittings with revoloud by only taking the minimum boundaries of chosen response categories into account.

[4] G. Keidser, H. Dillon, L. Carter, and A. O'Brien, "NAL-NL2 empirical adjustments," *Trends in Amplification*, vol. 16, no. 4, pp. 211–223, 2012, doi: 10.1177/1084713812468511.

[5] S. Scollie et al., "The desired sensation level multistage input/output algorithm," *Trends in Amplification*, vol. 9, no. 4, pp. 159–197, 2005, doi: 10.1177/108471380500900403.

[6] H. Dillon, *Hearing Aids*, 2nd ed. Sydney: Boomerang Press, 2012.

[7] D. Oetting, V. Hohmann, J.-E. Appell, B. Kollmeier, and S. D. Ewert, "Restoring perceived loudness for listeners with hearing loss," *Ear and Hearing*, vol. 39, no. 4, pp. 664–678, 2018, doi: 10.1097/AUD.0000000000000521.

[8] F. Kramer, M. R. Schädler, V. Hohmann, D. Oetting, and A. Warzybok, "Speech intelligibility and loudness perception with the trueLOUDNESS fitting rule," *Proc. of DAGA*, vol. 46, pp. 114–117, 2020, https://pub.dega-akustik.de/DAGA_2020/data/articles/000354.pdf.

[9] M. Exter, T. Jansen, L. Hartog, and D. Oetting, "Development and evaluation of a loudness validation method with natural signals for hearing aid fitting," *Trends in Hearing*, vol. 28, pp. 1–22, 2024, doi: 10.1177/23312165241299778.

[10] T. Brand and V. Hohmann, "An adaptive procedure for categorical loudness scaling," *The Journal of the Acoustical Society of America*, vol. 112, no. 4, pp. 1597–1604, 2002, doi: 10.1121/1.1502902.

[11] American Speech-Language-Hearing Association (ASHA), "Guidelines for hearing aid fitting for adults," *American Journal of Audiology*, vol. 7, no. 1, pp. 5–13, 1998, doi: 10.1044/1059-0889.0701.05.

[12] S. Kochkin, "MarkeTrak VIII: Reducing patient visits through verification & validation," *The Hearing Review*, vol. 18, no. 6, pp. 10–12, 2011.

[13] C. V. Palmer, H. G. Mueller, and M. Moriarty, "Profile of aided loudness: A validation procedure," *The Hearing Journal*, vol. 52, no. 6, pp. 34, 36, 40–42, 1999, doi: 10.1097/00025572-199906000-00004.

[14] R. Cox et al., "Optimal outcome measures, research priorities, and international cooperation," *Ear and Hearing*, vol. 21, no. 4, pp. 106S–115S, 2000, doi: 10.1097/00003446-200008001-00014.

[15] R. M. Cox, D. Stephens, S. E. Kramer, "Translations of the International Outcome inventory for Hearing Aids (IOI-HA)," *International Journal of Audiology*, vol. 41, no. 1, pp. 3-26, 2002, doi: 10.3109/14992020209101307.

[16] R. M. Cox, G. C. Alexander, and J. Xu, "Development of the Device-Oriented Subjective Outcome (DOSO) Scale," *Journal of the American Academy of Audiology*, vol. 25, no. 8, pp. 727–736, 2014, doi: 10.3766/jaaa.25.8.3.

[17] H. Dillon, A. James, and J. Ginis, "The Client Oriented Scale of Improvement (COSI) and its relationship to several other measures of benefit and satisfaction provided by hearing aids," *Journal of the American Academy of Audiology*, vol. 8, pp. 27-43, 1997.

[18] W. Noble, N. S. Jensen, G. Naylor, N. Bhullar, and M. A. Akeroyd, "A short form of the Speech, Spatial and Qualities of Hearing scale suitable for clinical use: the SSQ12," *International Journal of* Audiology, vol. 52, no. 6, pp. 409-12, 2013, doi: 10.3109/14992027.2013.781278.

[19] T. Afghah, R. Alfakir, M. Meis, L. van Leeuwen, S. E. Kramer, M. Hammady, M. Youssif, and K. C. Wagener, "The development of a Self-Rated ICF-based questionnaire (HEAR-COMMAND Tool) to evaluate Hearing, Communication, and Conversation disability: Multinational experts' and patients' perspectives," *Frontiers in Rehabilitation Sciences*, vol. 3, 1005525, 2022, doi: 10.3389/fresc.2022.1005525.

[20] A. J. Varela, M. J. Gallamore, N. R. Hansen, and D. C. Martin, "Patient empowerment: a critical evaluation and prescription for a foundational definition," *Frontiers in Psychology*, vol. 15, 1473345, 2025, doi: 10.3389/fpsyg.2024.1473345.

[21] V. Manchaiah, M. L. Bellon-Harn, A. L. Dockens, J. H. Azios, and W. E. Harn, "Communication between Audiologist, Patient, and Patient's Family Members during Initial Audiology Consultation and Rehabilitation Planning Sessions: A Descriptive Review," *Journal of the American Academy of Audiology*, vol. 30, no. 9, pp. 810-819, 2019, doi: 10.3766/jaaa.18032.

[22] C. Grenness, L. Hickson, A. Laplante-Lévesque, C. Meyer, and B. Davidson, "Communication patterns in audiologic rehabilitation history-taking: audiologists, patients, and their companions," *Ear and Hearing*, vol. 36, no. 2, pp. 191-204, 2015, doi: 10.1097/AUD.0000000000000100.